1984

The effect of Nautilus training on baseball throwing velocity

Karl Steffen
Ithaca College

THE EFFECT OF NAUTILUS TRAINING ON BASEBALL THROWING VELOCITY

by

Karl Steffen

An Abstract

of a thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in the School
of Health, Physical Education,
and Recreation at
Ithaca College

September 1984

Thesis Advisor: Dr. Paul Thomas

ABSTRACT

This study was undertaken to determine the effect of a Nautilus training program on the velocity of thrown baseballs. The subjects (N = 9) were freshmen and sophomore members of the Ithaca College varsity and junior varsity baseball teams. To test the throwing velocities of the subjects, each subject was asked to throw a baseball with a maximal effort five times following an extended warmup. Each throw was measured in miles per hour (mph) using a Jugs radar gun. The subjects' baseball throwing velocities were tested in this manner prior to and following a 6-week Nautilus program. Mean throwing velocity of the five maximal throws and the single fastest throwing velocity were determined from the data. The data obtained from the pretest and posttest were compared and tested for significance using a two-tailed t-test for repeated measures. It was determined that Nautilus training produced a significant improvement in the average maximal throwing velocity ($p < .005$). The single fastest throwing velocity improved significantly at the .08 level.

THE EFFECT OF NAUTILUS TRAINING ON BASEBALL THROWING VELOCITY

A Thesis Presented to the Faculty of
the School of Health, Physical
Education, and Recreation
Ithaca College

In Partial Fulfillment of the
Requirements for the Degree
Master of Science

---

by
Karl Steffen
September 1984

Ithaca College
School of Health, Physical Education, and Recreation
Ithaca, New York

CERTIFICATE OF APPROVAL

MASTER OF SCIENCE THESIS

This is to certify that the Master of Science Thesis of

Karl Steffen

submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Health, Physical Education, and Recreation at Ithaca College has been approved.

Thesis Advisor:

Committee Member:

Candidate:

Chairman, Graduate Programs in Physical Education:

Dean of Graduate Studies:

Date: August 27, 1984

ACKNOWLEDGMENTS

The investigator would like to thank everyone who made this study a reality:

1. Dr. Paul Thomas, my thesis advisor, for his time, guidance and help given to me throughout the writing of this thesis.

2. Dr. Deborah Wuest for her suggestions, encouragement, and support.

3. The Ithaca College baseball players who participated in this study.

4. The staff at the Nautilus Conditioning Center for their help.

5. My parents, for their love and support.

DEDICATION

This thesis is dedicated to my wife Mary Beth Steffen who gave me the inspiration, love, support, and encouragement to bring this study to its conclusion.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

In the game of baseball the ability to throw with great velocity is critical to an individual's performance. The velocity of a pitcher's throw to a batter or a fielder's throw to a baseman is usually the difference between a hit or an out, a game won or a game lost. A strong throwing arm is a crucial element of a team's defensive strength. A strong throwing arm, with all other things being equal--range, quickness, running speed, and fielding ability--affords a defensive player the luxury of playing a deeper fielding position than a fielder with a weaker throwing arm. This deeper position allows the fielder more time to react to a batted ball and enables him to get more balls than a shallower playing fielder. A pitcher who possesses great velocity reduces the time a batter has to swing, thus making it more difficult for the batter to make solid contact with the baseball. A catcher with a strong throwing arm helps to keep base stealing to a minimum, thus reducing an opposing team's offensive capabilities. For these reasons baseball coaches and players are constantly in search of methods for improving throwing velocity and, in turn, performance.

In the area of improving baseball throwing velocity there has been considerable research with conflicting results. At the present time the most effective method of

improving throwing velocity has not been conclusively determined nor for that matter whether it is possible to improve velocity at all.

Since 1970, a new method of weight training and weight training principles has gained popularity. These weight training devices are known as Nautilus machines. The Nautilus program features pre-stretching of muscles, varying resistance, and full range of motion exercise. Each Nautilus machine is designed to exercise a specific muscle group and total body strengthening is emphasized. Riley (1977) stated "these machines have revolutionized many of the concepts and practices of 'muscular development' training" (p. 161). However, there has been little research undertaken to substantiate these claims. In an early study by Peterson (1975), subjects achieved vast improvements in their strength, cardiovascular fitness, flexibility, and body composition training with Nautilus machines.

Scope of Problem

This study was undertaken to determine the effect of a Nautilus training program on the velocity of thrown baseballs. The subjects (N = 9) were freshmen and sophomore members of the Ithaca College varsity and junior varsity baseball teams.

To test the throwing velocity of the subjects, each subject was asked to throw a baseball with a maximal effort five times following an extended warmup. Each throw was

measured in miles per hour (mph) utilizing a Jugs radar gun. The subjects' baseball throwing velocities were tested in this manner prior to and following a 6-week Nautilus training program.

Statement of Problem

This investigation was undertaken to determine the effect of a Nautilus training program on baseball throwing velocity.

Null Hypothesis

There will be no significant difference between the mean pretest and posttest maximal baseball throwing velocity in junior varsity and varsity baseball players who participated in a 6-week Nautilus training program.

Assumptions of Study

The following assumptions were made for the purpose of the study:

1. The subjects did not participate in strength training programs other than the Nautilus training program.
2. The subjects were motivated to train during the Nautilus training program.
3. The subjects trained utilizing Nautilus equipment twice a week.
4. The subjects did not throw baseballs during the 6-week training period.
5. The subjects' throwing velocities were a result of a maximal effort.
6. The 6-week Nautilus training program had an effect

on increasing muscle strength and joint flexibility.

7. The Jugs radar gun was an adequate device for measuring the velocity of thrown baseballs.

Definition of Terms

The following terms were operationally defined for the purpose of this study:

1. Throwing velocity is the speed in miles per hour (mph) the baseball attained when thrown as measured by the Jugs radar gun.

2. Nautilus equipment is weight training equipment manufactured by Nautilus Sports/Medical Industries, P.O. Box 1783, Deland, Florida, which allows full range of motion exercise with variable resistance throughout the range.

3. Nautilus training program is a type of circuit training using Nautilus machines and following Nautilus training guidelines (see Appendix A). The person works at a weight he/she can lift at least four times and not more than eight times. The exercises are performed slowly until the muscle group is totally fatigued and the lifter cannot execute another lift with proper form. When this occurs the lifter moves quickly to the next machine.

4. Jugs radar gun is a timing device that emits a radar beam that measures the speed of an object moving through the beam in miles per hour (mph). The radar gun is manufactured by Jugs, P.O. Drawer 365, 19460 S.W. 89th Street, Tualatin, Oregon.

5. Summation of velocities is explained by Northrip, Logan, and McKinney (1974) as a biomechanical principle which states "a whole body motion is added to the velocity of a body part relative to the whole body in order to produce the final specific velocity desired" (p. 177).

6. Force-velocity relationship is defined by Northrip et al. (1974) as a biomechanical principle which states "maximum force applied during ballistic motion may be limited by the rate at which power can be developed within a muscle group" (p. 200).

Delimitations

The delimitations of this investigation were as follows:

1. Nine volunteer freshmen and sophomore Ithaca College varsity and junior varsity baseball players served as subjects.

2. Only a 6-week Nautilus training program was completed.

3. The subjects performed between four and eight repetitions for each exercise.

4. The subjects trained twice a week.

Limitations

The limitations of this investigation were as follows:

1. The results can only be generalized to baseball players who are considered similar to athletes in this study.

2. A longer or shorter training period may yield different results.

3. Less than four or more than eight repetitions for each exercise may yield different results.

4. Training more or less than twice a week may yield different results.

5. Maturation and motivational factors could not be controlled.

Chapter 2

REVIEW OF RELATED LITERATURE

In the past 20 years a considerable amount of research has been undertaken relevant to the effect of various overload training programs upon the improvement of baseball throwing velocity. This investigation utilized a relatively recent advance in weight training, the Nautilus program, and studied its effect upon the velocity with which a baseball can be thrown.

For the purpose of clarity and order, the review of literature has been divided into three major sections. The first is concerned with muscle strength and its relationship to speed of muscular contractions. The second part deals with the effects of various exercise programs upon throwing velocity, while the third section is devoted to Nautilus training studies. A summary is also provided.

Strength and Speed

The overarm baseball throw is a very complex athletic skill requiring extreme muscle coordination. According to Northrup, Logan, and McKinney (1974), "the final velocity of most sports objects is actually the result of a summation of several previous velocities developed sequentially in moving joints" (p. 57). The throwing motion is begun with a weight shift and body rotation which increases the backswing of the arm, the legs then drive the body towards

the target, and a step is taken in the direction the ball is to be thrown. This force and joint velocity of the legs is then transferred to the hips, trunk, shoulder, elbow, and wrist. Each joint in this chain adds velocity to the next until the wrist, the fastest joint in the chain, imparts the final velocity upon the ball. "For maximum throwing velocity each body part must come into the action at the time the part below has reached its maximum speed" (Broer, 1973, p. 235).

It has therefore been theorized that improving the joint velocities, by increasing the speed of muscle contractions in the chain, would result in improvement in the final velocity applied to the baseball. Several studies have investigated the effect of improved muscle strength and the relationship to speed of movement.

Wilkin's (1952) study utilized three groups. The first experimental group had no previous weight lifting experience. The second experimental group were chronic weight lifters. A control group was chosen from beginning swimming and golf classes. Speed of muscular contraction was determined by the speed of movement in turning a hand crank. The first experimental group exercised for 1 hour 15 minutes per week using weights. The chronic weight lifters group trained for 1 hour a day with weights. The control group participated in swimming and golf classes. After 2 months of training, the two weight training groups were compared to the control group for speed of movement in turning a hand

crank. Wilkin determined that the experimental group, with no previous weight training experience, showed no significant difference when compared to the control group for speed of turning the hand crank. When the chronic weight lifting group was compared to the control group the chronic group showed a slight but nonsignificant increase over the control group.

Pierson and Rasch (1962) tested limb strength development on reaction time and speed of arm extension. Twenty-six students from third and fourth year classes of the College of Osteopathic Physicians and Surgeons served as subjects and were tested for arm strength, reaction time and speed of arm extension prior to a 4-week training program. Following the 4-week training program the subjects were again measured. It was concluded the 4-week program improved the subjects' strength significantly, but this did not effect the speed of reaction or arm extension.

Capen (1950) studied the effect of systematic weight training on athletic power. The experimental group consisted of 42 subjects who trained using weights. The control group of 29 subjects were members of a conditioning class which performed exercises other than weight training. Both groups exercised for 40 minutes, twice a week, for 11 weeks. Each group exhibited increases in muscle strength and endurance. To determine athletic power the standing broad jump, standing high jump test, running high jump test, and

8-pound shot put throw were utilized. In each test the experimental group showed greater improvement than did the control group.

Smith (1964) tested the effect of strength training on pre-tensed and free arm speed. The subjects were 26 male volunteers who trained using a program of standardized weight exercises for two 30-minute sessions each week during a 12-week semester. Prior to and following the strength training program the subjects were tested for arm strength and free and pre-tensed speeds of lateral adduction of the arm. It was determined that the strength training program produced significant improvements in free and pre-tensed speeds of movement.

Zorbas and Karpovich (1951) studied the effect of weight training on the speed of muscular contraction using an apparatus which measured the speed of rotary movements of the arm. From their findings, they concluded that the weight lifting group were faster in their rotary arm movements than were non-lifters.

Utilizing a weight training program, Clarke and Henry (1961) studied the effect of improvement in arm strength upon arm speed. Following the weight training program a significant improvement in arm strength was measured. With this improvement in arm strength there was a corresponding improvement in the speed at which subjects laterally adducted their arms.

As a result of the above studies it can be concluded from the literature that weight training appears to have a favorable effect upon the speed of muscular contractions. The significant improvements in muscle contraction speed obtained by Capen (1950), Clarke and Henry (1961), Smith (1964), and Zorbas and Karpovich (1951) established the foundation for other studies which investigated the effects of weight training on athletic skills.

The Effects of Overload Training Upon Throwing Velocity

The importance of strong throwing arms to playing the game of baseball is without question. According to Haldeman (1969), "Major league managers generally agree that pitching is from 50 to 80 percent of the game, and that the prime requisite of the pitcher is velocity--the ability to throw a live fastball" (p. 31). Because of the importance of a strong throwing arm it is little wonder that studies dealing with baseball are almost entirely related to improvement in throwing velocity.

Eckstrom (1955); Hooks (1959); Lewallen (1978); Logan, McKinney, and Rowe (1966); Railey (1964); Rowlands (1962); Sinks (1964); Sullivan (1970); Thompson and Martin (1965); and Van Huss, Albrecht, Nelson, and Hagerman (1962) studied the effects of overload training upon throwing velocity and concluded overload training had a significant contributing influence.

Logan et al. (1966) studied the effect of resistance training through the throwing range of motion on the velocity of a thrown baseball. Thirty-nine varsity baseball players from Southwest Missouri State College served as subjects. The subjects were tested prior to and following a 6-week training period using a Velocitimer. The 39 subjects were divided into three equal sized and statistically equal groups (matched triplets) for the 6-week training period. Group I trained with an Exer-genie and exercised through the throwing range of motion 30 times per day, 5 days per week. Group II trained by throwing 30 times per day, 5 days per week. Group III took the pretest and posttests only. Following the posttest it was determined that Group I obtained a significant improvement in throwing velocity compared to Groups II and III. Logan et al. then compared Group II to Group III and found no significant difference between the two groups. It was concluded that resistance training through the throwing range of motion produced a significant increase in throwing velocity.

In a study by Sullivan (1970), eight experimental conditions were devised to study the effects of the type of training program, throwing practice with training, and resistance progression with training on throwing velocity and selected strength measures. The types of training programs studied were weight training and training with resistance through the throwing range of motion (simulative

training). Forty-eight male undergraduate students took part in the investigation and were assigned to one of eight experimental conditions. Prior to and following the 6-week training program the subjects were tested for throwing velocity, grip strength, wrist flexion strength, and medial arm rotation strength.

Following the posttest Sullivan determined that the subjects in all eight experimental conditions improved their throwing velocities significantly from pretest to posttest. He also found that resistance progression with training and throwing practice with training did not significantly improve throwing velocity. It was also noted that grip strength, wrist flexion strength, and medial arm rotation strength had a nonsignificant effect on the improvement of throwing velocity.

Lewallen (1978) conducted a study to determine the effect progressive resistance isotonic weight training, designed to improve upper body strength, and maximal throwing at progressively increased distances had on throwing velocity. Results revealed the weight training and maximal throwing at progressively increased distance groups improved subjects' velocities significantly over the control group subjects who participated in baseball practice alone. The control group subjects achieved no improvement in throwing velocity. The weight trained group achieved significantly greater throwing velocity improvements than the maximal throwing group.

Lewallen concluded that weight training was superior to maximal throwing at progressively increased distance and regular baseball practice for the improvement of throwing velocity.

Van Huss et al. (1962) investigated the effects of overload during warmup to determine if it had a beneficial effect on the velocity and accuracy of throwing. Fifty members of the Michigan State University freshman baseball team served as subjects. Following a warmup period the subjects were timed using a chronoscope to determine their pretest throwing velocity. Following a 10-minute rest period the subjects warmed up with 15 throws with an 11-oz. baseball followed by 10 maximal throws with the same baseball. Immediately following the 10 maximal throws with the 11-oz. baseball the subjects threw 10 maximal throws with the regulation baseball, 5-oz., with the velocity again measured using the chronoscope. Van Huss et al. concluded the overload applied during warmup significantly improved the velocity of throwing.

Rowlands (1962) performed a study similar in nature to Lewallen's. Rowlands utilized 12 subjects divided into two equal groups for a 5-week training period. Group A was a control group and participated in baseball skills practice. Group B, the experimental group, engaged in five progressive resistance exercises designed to strengthen the upper body. Group B trained 3 days a week for the period of 5 weeks

while simultaneously participating in baseball practice. The subjects were pretested and posttested for medial rotation strength and throwing power. Rowlands determined that the experimental group obtained significant improvement over the control group in both velocity and medial rotation of the arm strength.

Thompson and Martin (1965) studied the effect of four training exercises, selected because they involved the muscles used in throwing, on throwing velocity. These exercises were the clean and press, straight-arm pullovers, supine press, and alternate press. The subjects for this experiment were 22 members of the varsity baseball squad at Mankato State College. The subjects were divided into two groups, a 12-subject experimental (weight training) group and 10-subject control (baseball practice) group. For a period of 4 weeks the experimental group, in addition to regular baseball practice, participated in the weight training program 3 days a week for 20 to 30 minutes.

The pretest and posttest data revealed the experimental group achieved a significant improvement in throwing speed over the 4-week period. It was noted that the control group also improved throwing speed but not significantly. Thompson and Martin concluded that weight training was a factor in improving baseball throwing velocity.

Hooks (1959) utilized a basic body conditioning program for 6 weeks on a group of 30 freshmen baseball players at

Wake Forest College. The experiment was undertaken to determine the effect of weight training on hitting for distance and throwing for distance. The subjects were pretested and posttested using the baseball skills of hitting for distance and throwing for distance. The subjects were not allowed to practice the skills during the 6-week training period. At the end of 6 weeks the pretest results revealed marked improvements in strength, hitting distance and throwing distance, with only three of the 30 subjects failing to improve their previous score on the distance throw.

Railey (1964) studied the effect of isotonic and isometric exercise programs on baseball throwing velocity. The subjects were 30 freshmen and varsity college baseball players. The subjects were randomly assigned to one of three groups. The three groups included an isotonic exercise group which used wall pulleys to simulate the throwing motion, an isometric exercise group, and a control group which participated only in the pretest and posttest. The experimental groups trained 4 days a week for a period of 7 weeks.

From the results of the posttest Railey determined the isotonic group achieved a significant improvement from the pretest throwing velocity. Conversely, the isometric group showed no significant difference, and the control group showed a significant decrease. Railey then compared the isotonic experimental group, isometric group, and control

group using the analysis of variance and found a significant difference between the groups. The isotonic exercise groups' ball throwing velocity improvement was significantly greater than the isometric and control groups.

The effects of improvements in upper-extremity and shoulder-girdle strength on baseball throwing velocity were studied by Eckstrom (1955). The subjects were divided into two groups: an experimental group, which participated in the weight training program, and a control group, which participated in regular physical education classes. The experimental group trained for 12 weeks, 3 days per week. The weight training program consisted of the pullover, forearm press, wrist curl, supine lateral press, and the situp. Following the 12-week training period, the experimental group showed significant improvements in strength and throwing velocity when compared to the control group.

Sinks (1964) utilized 14 college freshmen pitchers to determine the effect of progressive overload on the velocity of a thrown baseball. Following the pretest, each of the subjects were matched and control and experimental groups of seven subjects were formed. The experimental group threw weighted baseballs for 20 minutes a day, twice a week, for 6 weeks with additional weight added to the baseballs every 2 weeks over the 6-week period.

At the conclusion of 6 weeks the subjects took the

posttest which consisted of 10 pitches at maximal speed, the velocity of which were recorded. It was concluded that baseball throwing velocity could be increased by a player throwing a weighted baseball.

As was the case with studies dealing with the effects of strength improvement on speed of muscle contraction, the results obtained from studies dealing with overload training and its effect on throwing velocity are also conflicting. Studies by Bostwick (1961), Brose and Hanson (1967), Elias (1964), Minor (1956), Rasmussen (1962), Straub (1968), and Wescott (1965) concluded overload training had a nonsignificant effect on improving throwing velocity.

Straub (1968) performed a study using weighted baseballs as the overload training device to determine the effect of overload training procedures upon velocity and accuracy of the overarm throw. The study contained two aspects, a 2-week short-term phase and a 6-week long-term phase. The subjects were 108 males selected from a 1000 pupil public high school.

Sixty subjects served in the short-term phase of the investigation. Following the pretest the subjects were assigned into two groups, with the 30 fastest throwers assigned to the high velocity group. The remaining 30 subjects were assigned to the low velocity group. The two experimental groups were further divided into three subgroups each. Two of the subgroups received experimental

treatments while one subgroup served as a control.

The first subgroup trained using 15-oz. weighted baseballs, the second subgroup threw regulation baseballs, and the third subgroup trained with 10-oz. baseballs. Following a warmup, all subgroups trained by throwing their respective baseballs 20 times at maximum velocity.

Following the posttest, Straub concluded overload warmup had little or no immediate effect upon the velocities of high and low velocity throwers. He also concluded that no significant difference occurred between the groups in throwing accuracy.

In the long-term phase of the experiment, 48 subjects, following a pretest, were ranked fastest to slowest and randomly assigned to experimental and control groups. The control group threw regulation baseballs while receiving equal speed-accuracy emphasis throughout the 6-week training period. The three experimental groups threw progressively heavier baseballs beginning with 7-oz. baseballs and increasing the weight of the balls 2 oz. a week thereafter. Each experimental group received a different emphasis on speed and accuracy. The subjects were tested for velocity and accuracy following weeks 3 and 6 of training. In both cases the one way analysis of variance indicated no significant differences between groups on speed and accuracy measures.

Rasmussen (1962) studied the effect of isotonic and

isometric resistance exercises upon the velocity of a thrown baseball. The subjects were divided into two groups which trained 2 days a week for 4.5 weeks. The subjects performed exercises designed to strengthen areas of the body involved in the baseball overarm throw. A pretest and posttest revealed the nine workout sessions did not contribute significantly to increased throwing velocity.

Minor (1956) studied the effect of weight training on the throwing power of high school baseball players. Three groups of six junior varsity high school baseball players served as subjects and were divided equally on the basis of initial throwing power. Group A trained using a 2.5 lbs. steel ball and 15 speed throws for the first seven sessions and 20 speed throws for the second seven sessions over a period of 5 weeks. Group B trained using dumbbells with a weight of 4 lbs. for the first seven sessions and 8 lbs. for the final seven sessions. The subjects in Group B simulated their throwing motion while holding the dumbbells in their hands. Group C participated in baseball practice alone. Groups A and B also participated in baseball practice along with weight training.

From the results of the investigation Minor concluded some improvement may result from the use of the weighted balls. Although the results of the experimental groups showed improvement over the control group, the differences were not significant.

Elias (1964) conducted an investigation to determine the effect of throwing progressively heavier baseballs for a 6-week period on the throwing velocity of 12 freshmen pitchers. These subjects were divided into two equal-sized control and experimental groups. The six subjects in the control group threw regulation baseballs (5 oz.) three times a week for 6 weeks. The experimental group three 7-oz. balls the first 2 weeks, 9-oz. balls the second 2 weeks, and 11-oz. balls the final 2 weeks. The experimental treatment group trained three times a week for 6 weeks.

Both groups were tested for throwing velocity prior to and at the completion of training. The data obtained showed no significant difference between the two groups. However, each group improved significantly from the beginning to the end of the training period, the control group at the .05 level and the experimental group beyond the .01 level of significance.

Brose and Hanson (1967) utilized weighted baseballs and a wall pulley, with 10 lbs. of weight attached, as the experimental treatment to determine the effect of overload training on throwing velocity and accuracy. The subjects were 21 male baseball candidates at the University of Maryland. The subjects were assigned to one of three groups on the basis of their pretest data. One experimental group trained by throwing a 10-oz. baseball 25 times a day while the other experimental group trained using a wall pulley

with a 10-lbs. weight attached and lifted through the throwing range of motion. The control group threw regulation baseballs exclusively. The subjects in all groups trained 3 days a week for 6 weeks.

The investigators determined by analysis of variance that no significant difference occurred between the three groups on accuracy or ball velocity. However, between group analysis, using the t-test, showed that the experimental groups improved velocity significantly while the control group did not. Brose and Hanson concluded that weight training programs did not alter throwing velocity or accuracy.

Bostwick (1961) studied the effect of weight training on baseball speed and endurance. The subjects for this investigation were 10 pitchers at the University of Illinois who had no previous weight training experience. The researcher divided the 10 subjects into two equal-sized treatment and control groups. Both groups were pretested and posttested using a velocity testing device developed at the University of Illinois. Each subject was asked to throw, with an all-out effort, 30 pitches at a distance of 30 feet.

The treatment group participated in weight training for 5 weeks, 3 days per week. Two sets of the following exercises were performed: sit-up, arms sideward lift, arms forward lift, military press, shoulder shrug, wrist curl, and tricep curl. The subjects trained at a weight they could lift for 10-15 repetitions. When repetitions exceeded

15, weight was added to reduce the repetitions to 10. The control group only participated in regular baseball practice. Bostwick determined from the posttest data that the experimental group improved velocity significantly ($p < .05$). The control group also improved but the result was not significant. When the control and experimental groups were compared no significant difference was found between groups.

Wescott (1965) used cylindrical strips of latex rubber which when stretched produced the overload through the throwing range of motion. Seventy-three college freshmen served as subjects. The subjects were assigned to one of four groups: (a) a control group which received no treatment, (b) an experimental group which trained throwing regulation baseballs, (c) an experimental group which trained with latex tubing pulled through the throwing range of motion, and (d) an experiment group which used latex tubing in addition to throwing with regulation baseballs. Following the posttest, it was determined through analysis of variance that no significant difference with respect to throwing velocity had occurred with any of the training methods.

In summary, the studies by Minor (1956), Rasmussen (1962), Straub (1968), and Wescott (1965) found that overload training had a nonsignificant effect on producing increased baseball throwing velocity. The training devices used in their various studies included: weighted baseballs, 2.5 lb. steel balls, dumbbells, wall pullies with weights, and latex

rubber tubing. These researchers concluded overload training showed no significant difference in throwing velocity when comparing the experimental groups' gains with those of the control groups'. However, the results obtained by Bostwick (1961); Brose and Hanson (1967); Elias (1964); and Minor (1956) did find that their weight training groups improved throwing velocity from pretest to posttest considerably more than their control groups.

Nautilus Training Studies

Due to the fact that Nautilus is a relatively recent innovation in weight training the research literature on Nautilus is scarce. After an exhaustive review of the literature only three studies dealing with Nautilus training were found.

Coleman (1977) compared the effects of the Nautilus training program to isotonic training, using a universal gym, to determine the effect of Nautilus and Universal gym training on muscular strength, body composition, and anthropometric measurements. Sixty male students at the University of Texas served as subjects. The subjects were tested prior to and following the 10-week training period for muscular strength, body composition (percent body fat) and girth of body parts. Coleman concluded that one set of 10 to 12 maximal repetitions performed on Nautilus machines was equal to Universal gym training composed of two sets of between 8 to 10 repetitions in producing significant

increases in muscular strength and body part size and significant decreases in absolute body fat, relative body fat, and skinfold thickness.

Stiggins (1978) compared the effects of Nautilus and free weight programs on the development of elbow flexion strength at four angles in the range of motion. The 48 male subjects were tested for elbow flexion strength and randomly assigned into one of four groups. The groups trained for 8 weeks with three training periods per week. Group 1 subjects trained with free weights performing one set to exhaustion. Group 2 trained with free weights executing three sets of six repetitions. Group 3 subjects performed one set to exhaustion on the Omni biceps machine, while Group 4 performed three sets of six repetitions on the Nautilus machine.

Following the 8-week period the investigator found the subjects showed similar improvement in elbow flexion strength. Stiggins also concluded that one set to exhaustion was just as effective as three sets of six repetitions in producing strength gains.

Peterson (1975) reported on a study performed at West Point in conjunction with representatives of Nautilus Sports/Medical Industries. The study was undertaken to answer several questions associated with weight training. The questions focused on the following areas: intensity and length of training, cardiovascular fitness, flexibility,

body composition, and the effect of strength training on functional performance.

Twenty-one varsity football players at West Point were chosen for the total conditioning (whole body) aspect of the study. For comparative purposes a control group of 14 intercollegiate football players was also used. The pretest, which consisted of an extensive battery of tests, was administered 2 weeks after the experimental group had begun training. The posttest was administered following the 8th week of training.

The results of this investigation indicated that weight training bouts of high intensity and short duration produced an average of 50% improvement in muscle strength. The whole body group showed significant improvement over the control group in cardiovascular fitness, flexibility, and lean body mass. In the functional tests of athletic ability (the 2-mile run, 40-yard dash, and vertical jump) the experimental group exhibited a considerable improvement from pretest to posttest as opposed to the control group.

Summary

The results of studies by Capen (1950); Clarke and Henry (1961); Smith (1964); and Zorbas and Karpovich (1951) clearly established that strength development is associated with increases in speed of movement. These findings have helped to dispel the belief once held by coaches that weight training causes a tightening of muscles and in effect reduces

the speed of movement and athletic performance.

With the knowledge of the improvement in movement speed had been obtained from weight training, investigators began experimenting with weight training programs to determine if they would produce improvement in athletic skill. Many of the investigators chose throwing velocity as the skill to examine because of its importance to success in the game of baseball. Several studies have shown a beneficial effect of weight training on throwing velocity. Eckstrom (1955), Hooks (1959), Lewallen (1978), Logan et al. (1966), Railey (1964), Rowlands (1962), Sinks (1964), Sullivan (1970), Thompson and Martin (1965), and Van Huss et al. (1962) achieved significant improvements in velocity with various weight training devices. The researchers studied the use of weighted baseballs, progressive resistance exercise, isometric training, isotonic training, dumbbells, Exer-genies, and task specific distance throwing.

Bostwick (1961), Brose and Hanson (1967), Elias (1964), Minor (1956), Rasmussen (1962), Straub (1968), and Wescott (1965) concluded overload training had a nonsignificant effect on improving throwing velocity. However, it should be noted that in studies by Bostwick, Brose and Hanson, Elias, and Minor the experimental groups improved considerably more than the control groups. Of the investigations reviewed, only Hooks (1959) and Thompson and Martin (1965) performed studies in which the weight

training program was designed to strengthen the total body.

Studies devoted to Nautilus training were severely lacking in the literature and it should be noted that further study of Nautilus training is needed. Nautilus weight training has been shown by Coleman (1977), Peterson (1975), and Stiggins (1978) to be an effective tool for producing strength gains, improving flexibility, increasing lean body mass, and improving functional performance (2-mile run times, 40-yard sprint, and vertical jump).

Chapter 3

METHODS AND PROCEDURES

The following chapter will describe the methods and procedures used in this study. The selection of subjects, the Nautilus training program, the measuring devices, the testing procedures and method of data collection, and the treatment of data will be described.

Selection of Subjects

The subjects for this investigation were nine males randomly selected from 12 freshmen and sophomore varsity and junior varsity baseball players at Ithaca College. Nine were chosen for final analysis and testing using the lottery method of random sampling with replacement of the lot after drawing. The number of subjects ($N = 9$) was an arbitrary number chosen by the investigator. Each athlete was asked to read and sign an informed consent form if he was willing to participate (see Appendix B).

Nautilus Training Program

The program of Nautilus training for the athletes was developed and supervised by the staff of the Nautilus Conditioning Center, Ithaca, New York. The subjects trained 2 days a week for 6 weeks on Wednesday and Sunday nights.

The training program consisted of two separate circuits of 11 exercises designed to exercise the muscles of the legs, hips, back, shoulders, chest and arms. The subjects trained

using a different circuit on each visit. Circuit A consisted of the following Nautilus machines: duo-hip and back, leg extension, leg curl, pull-over, double shoulder, double chest, plate loading biceps and triceps, and the multi-exercise machine. Circuit B consisted of the super hip and back machine, leg extension, leg curl, double torso, infimetric bench press, multi-exercise machine, and plate loading bicep and tricep machine.

In the first training session the subjects were instructed in the proper use of each machine (see Appendix A). The subjects were instructed to lift plates slowly without stopping and hold the peak contraction for 2 seconds before lowering the weight as slowly as possible without stopping. The subjects were instructed to use a weight setting they could lift between four and eight times with a maximal effort and to raise the weight when eight repetitions were achieved. Upon completion of the exercises on one machine they were instructed to move quickly on to the next machine and exercise. The subjects were monitored by the staff of the conditioning center to make sure the exercises were performed properly to insure full range of motion and maximal effort.

Measuring Device

The measuring device used to measure the velocity of the thrown baseball was a Jugs radar gun. This radar gun is the same as ones used by major league teams and college coaches

to measure the throwing velocities of their pitchers, potential prospects, and players. This gun is also used by law enforcement agencies to catch speeding motorists.

Prior to each testing period the gun was tested for accuracy by using a tuning fork which when struck and held in front of gun would cause the gun to read out 50 mph if it was operating properly. The timing and testing was carried out by the investigator who, at the time of the study, had 4 years of experience in timing pitchers with a Jugs radar gun.

Testing Procedures and Methods of Data Collection

Prior to the Nautilus training program the subjects were tested to determine their baseball overarm throwing velocity, thus providing baseline data. After an extended warmup period each subject was asked to give a maximal throwing effort. Each subject made a total of five maximal throws from a line drawn on the floor to a baseball player who was stationed at a point 70 feet away. The subjects were not allowed to make a running start; instead, one step back and one forward toward the catcher was allowed. This is the same procedure a pitcher would use throwing to a catcher. Throwing velocities were recorded from a position behind the throwing arm side of each subject in a direct line with the catcher. After the 6-week training period (during which time the subjects were not allowed to throw) the posttest was taken in the same manner explained above. The initial tests as well as the posttests were taken in the Ben Light

gymnasium at Ithaca College.

Treatment of Data

The mean throwing velocity, reported in mph from five maximal throws, and the single fastest throw from each subject were calculated in both the pretest and the posttest. The mean and high scores were matched and fed into a computer which compared and tested the data for significance using a two-tailed t-test for repeated measures at the .05 level of significance. The t-test was performed by using the Minitab computer program from Pennsylvania State University (1981).

Summary

A total of nine male freshmen and sophomore varsity and junior varsity baseball players at Ithaca College were tested to determine if a Nautilus training program had an effect on their baseball throwing velocity.

The subjects trained under the supervision of the staff of the Nautilus Conditioning Center twice a week for 6 weeks, and were not allowed to throw a baseball during this time.

The subjects pre-training and post-training average and maximal overarm throwing velocities were determined and compared. The t-test for repeated measures was used to determine if a significant difference between the pretest and posttest velocities existed.

Chapter 4

ANALYSIS OF DATA

This study was undertaken to determine the effect of the Nautilus training program on baseball throwing velocity. The subjects ($N = 9$) were tested prior to and following a 6-week training period using the Nautilus machines. The subjects' mean pretest and posttest maximal throwing velocities were compared and tested using a two-tailed t-test for repeated measures. In this study a t-test score beyond the .05 level of significance was needed to reject the null hypothesis that there would be no significant difference between the mean pretest and posttest throwing velocities.

The mean pretest and posttest throwing velocities, measured in mph, are presented in Figure 1. The pre- and post-Nautilus training mean throwing velocities were compared and tested using a two-tailed t-test for repeated measures with a score beyond the .05 level of significance needed to reject the null hypothesis. The results of the t-test showed the mean increases in maximal throwing velocity between the pretest and posttest were significant at the .005 level. This finding led to the rejection of the null hypothesis that there would be no significant difference between the average pretest and posttest baseball maximal throwing velocity in junior varsity and varsity baseball players who participated in a 6-week Nautilus training program.

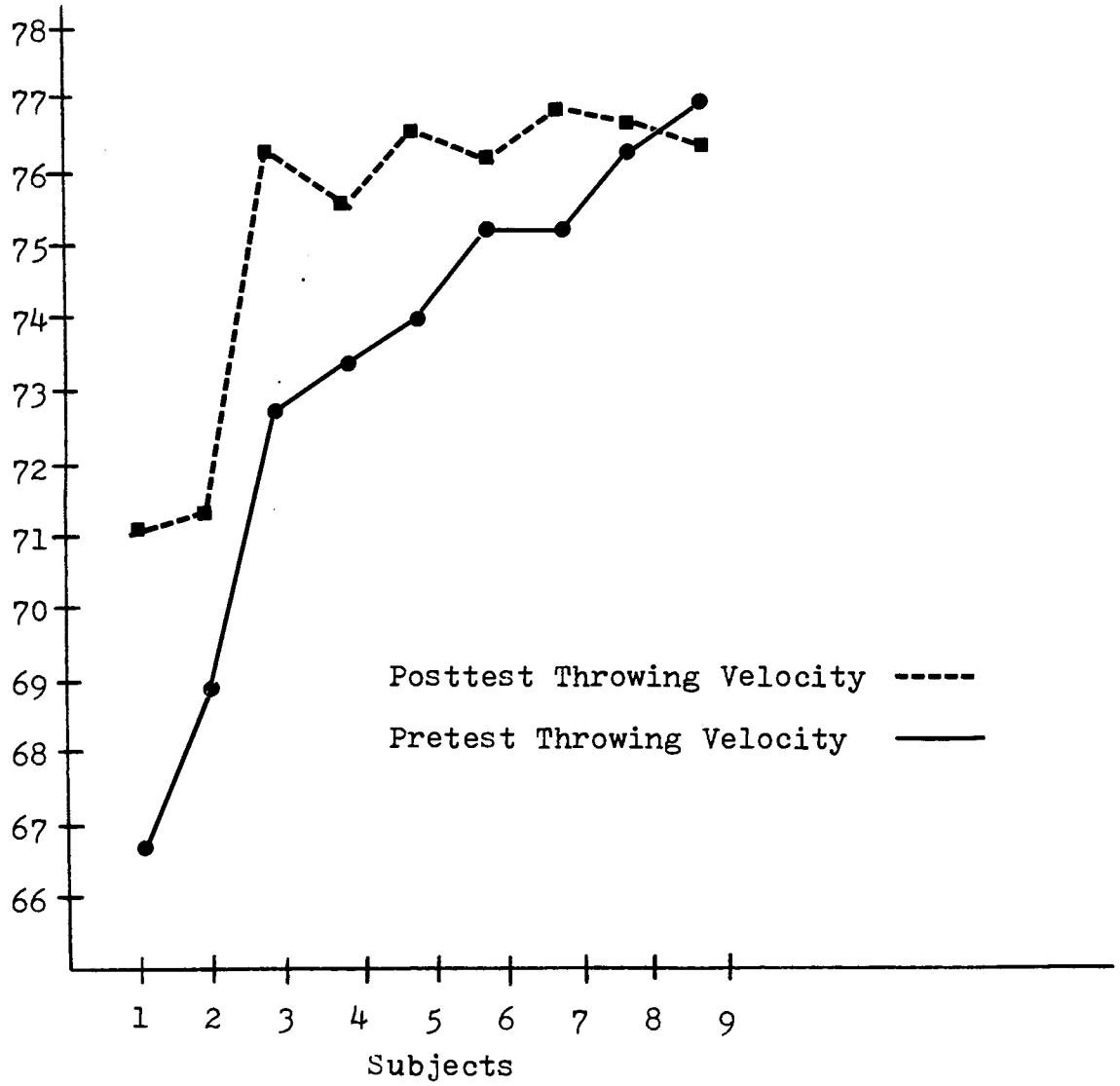

Figure 1. The effect of nautilus training on mean pretest and posttest maximal throwing velocities.

After it was determined that the average throwing velocity of five maximal throws was significant ($p < .05$) the researcher compared the single fastest throw pre- and post-training. The two-tailed t-test for repeated measures was used to determine if a significant difference existed between the pretest and posttest maximum throwing velocities of the subjects. From the posttest data it was determined that the maximum velocities improved at the .08 level of significance. Although this is not significant ($p > .05$) it does illustrate a trend that not only was the average maximal velocity improved following Nautilus training, but that the single fastest throw that subjects were able to produce showed a tendency to increase which almost reached statistical significance (see Table 1).

Summary

The t-test for repeated measures determined that the average pretest and posttest throwing velocity differences from the five maximal throws were significant at the .005 level. This finding led to the rejection of the null hypothesis that there would be no significant difference between the average pretest and posttest maximal baseball throwing velocities. It was also determined that the subjects' pretest and posttest single fastest throwing velocities improved significantly at the .08 level.

Table 1

Subjects' Pretest and Posttest Maximum Throwing Velocities (mph)

Subjects	Pretest	Posttest
1	76	77
2	77	77
3	74	79
4	79	77
5	75	77
6	69	72
7	77	78
8	77	77
9	71	73

Chapter 5

DISCUSSION OF RESULTS

This investigation studied the effect of a twice a week, 6-week, Nautilus training program on overarm throwing velocity. The results of this investigation will be discussed in this chapter.

At the present time the author was unable to find any research which studied the effects of Nautilus training on baseball throwing velocity. For this reason no comparisons can actually be drawn between this research and other research presently in the literature. Two studies which come closest in nature to this investigation were performed by Hooks (1959) and Thompson and Martin (1965) who used conditioning programs with free weights and a total body training program. The results of this investigation support their findings that weight training had a positive influence upon throwing velocity.

The production of throwing velocity, according to Northrip, Logan and McKinney (1974), "is the result of a summation of several previous velocities developed sequentially in moving joints" (p. 57). The throwing motion is begun with a weight shift and body rotation which increases the backswing of the arm, the legs then drive the body towards the target and a step is taken in the direction the ball is to be thrown. This force and joint velocity of

the legs is then transferred to the hips, trunk, shoulder, elbow and wrist. Each joint in the chain adds velocity to the next until the wrist, the fastest joint in the chain, imparts the final velocity to the baseball. Broer (1973) stated that the total shoulder, elbow, wrist, and finger action account for approximately one-half the force produced and the body rotation and step the other half. Understanding this biomechanical principle it becomes evident that the total body action plays an integral part in the production of maximum throwing velocity.

The significant improvement in throwing velocity by the subjects in this study, significant at the .005 level, can be attributed to improvements in the joint velocities of the legs, hips, trunk, shoulder, arm and wrist which transferred greater velocity to the baseball. It is theorized that the improvement in joint velocity speed achieved in this investigation is due to improvements from strength training and flexibility of the total body brought about by the Nautilus training program. Studies have shown that improvements in strength have led to increases in the speed of movement. The claim can be made for strength improvement of the subjects in this study because of the increase in resistance with which the subjects trained during the 6-week program (see Appendix C).

Peterson (1975) determined that Nautilus training produced a 10% improvement in the subjects' flexibility.

The improvement in flexibility associated with Nautilus training gives another reason for the improvement of throwing velocities by subjects in this study. Using the biomechanical principle of force-velocity relationship, the improvement in the subjects' throwing velocities could be in part due to increased flexibility in the subjects brought about by full range of motion exercise. Exercising the full range of motion may have caused an increase in the length of the muscles which allowed more force to be developed within each muscle group and in turn applied to the baseball.

The skill level of the subjects in this investigation was perhaps another reason for their great improvement in throwing velocity from a total body conditioning program. Since throwing velocity is the result of a summation of velocities timed in sequence it is paramount that the subjects have the skill to apply the increases in joint velocities to the overarm throw. Because these subjects were highly skilled baseball players they were able to utilize the strength and flexibility improvements in a positive manner. Weight training of unskilled subjects utilizing the total body conditioning approach would probably yield changes of a lesser magnitude.

Summary

The results of this study showed that a general total body conditioning program using Nautilus machines produced significant improvements in throwing velocity. The results

achieved were significant at the .005 level which led to the rejection of the null hypothesis that there will be no significant difference between the mean maximal pretest and posttest baseball throwing velocities.

It was theorized that improvements in muscle strength and flexibility of the total body brought about by Nautilus training was the contributing factor in velocity improvement in the highly skilled subjects. The biomechanical principles of summation of velocities and force-velocity relationship were used to explain how the improved total body strength and flexibility caused the increase in baseball throwing velocity of the subjects.

This study makes the assumption, based on research performed using Nautilus machines and the subjects' improvement in strength, that strength and flexibility improvements were the reasons for the increase in the subjects' throwing velocities. Although it cannot be conclusively determined what caused the subjects' throwing velocity improvement, this study did illustrate that the Nautilus training program is an excellent off-season conditioning program for the improvement of throwing velocity and further research is warranted.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was undertaken to determine the effect of a Nautilus training program on the velocity of thrown baseballs. The subjects (N = 9) were freshmen and sophomore members of the Ithaca College varsity and junior varsity baseball teams.

To test the throwing velocities of the subjects, each subject was asked to throw a baseball with a maximal effort five times following an extended warmup. Each throw was measured using a Jugs radar gun. The subjects' baseball throwing velocities were tested in this manner prior to and following a 6-week Nautilus training program.

The data obtained from the pretest and posttest were compared and tested for significance using a two-tailed t-test for repeated measures. Mean throwing velocity of five maximal throws and the single fastest throwing velocity were determined from the data and tested for significance ($p < .05$). It was determined that Nautilus training produced a significant improvement in average throwing velocity (.005 level) while the single fastest throwing velocity improved significantly at the .08 level.

Conclusions

The results of this study yielded the following conclusions regarding the relationship between Nautilus

training and baseball throwing velocity:

1. The Nautilus weight training program was an effective method for the improvement of baseball throwing velocity.

2. Training the total body with heavy weights stressing full-range-of-motion exercise for 6 weeks produced an increase in throwing velocity.

Recommendations

The following recommendations for further study were made after the completion of this investigation:

1. A study similar to the present one should be conducted with the inclusion of pretest and posttest strength and flexibility measures recorded.

2. A study should be conducted which examines the effect of a flexibility improvement program designed to stretch the shoulder medial rotator muscles and the effect on throwing velocity.

3. A study should be performed comparing a free weight total body conditioning program and the Nautilus training program for throwing velocity improvement.

Appendix A

NAUTILUS TRAINING PRINCIPLES

According to the Nautilus Sports/Medical Industries "a clear understanding of the following principles will assure you the best possible results from using Nautilus Machines" (Darden, 1980, p. 19).

1. Intensity--to be of sufficient intensity performance of each exercise should result in momentary muscular fatigue.

2. Form--all exercises must be performed in a strict exacting fashion making sure that:

a. on any machine where seat adjustments of body positioning can be varied, the rotational axis of the cam must be directly parallel to the rotational axis (joint) of the body part being moved.

b. twisting or contorting the body is avoided.

c. other parts not being exercised are relaxed (in particular hand gripping).

3. Supervision--an instructor is needed to supervise and urge most trainees to work at the required level of intensity.

4. Speed of movement--lift resistance in a slow, even fashion avoiding the use of momentum. A good guideline is to do concentric work to a count of two seconds, pause at the position of full muscular contraction, then do eccentric

Appendix A (continued)

work to a count of 4 seconds.

5. Flexibility--range of movement on each exercise machine should be as great as possible allowing the resistance to stretch the muscles at the completion of the eccentric phase of work.

6. Progression--each exercise should be performed between 8 to 12 repetitions beginning with a weight you can comfortably perform for 8 repetitions and staying with that weight until 12 repetitions can be done. After 12 repetitions can be performed, the resistance should be increased. Ideally, on every workout progress in repetitions and/or resistance should be made.

7. Order--the larger muscle groups should be exercised first proceeding down to the smaller muscle groups on a circuit consisting of a minimum of 10 and a maximum of 12 exercises (4 to 6 for the lower body and 6 to 8 for the upper body).

8. Duration--for best cardiorespiratory conditioning, the exerciser should move quickly from machine to machine with an entire workout taking from 20 to 30 minutes.

9. Frequency--a time lapse of at least 48 hours and not in excess of 96 hours should take place between workouts with the Nautilus machines.

Appendix B

INFORMED CONSENT FORM

Purpose of the study

This study is being conducted to determine the effects of weight training, in particular Nautilus training, on baseball throwing velocity. With this study I hope to determine what effect weight training has on throwing velocity. The results of this study will be of importance to baseball players and coaches to help them to determine whether weight training should be undertaken to increase throwing velocity.

Method

You will be asked, following an extended warmup, to throw a baseball with a maximal effort five times prior to a 6-week weight training program. The velocity of the throws will be measured using the Jugs radar gun. You will be asked to weight-train utilizing Nautilus training equipment twice a week for 6 weeks. After the 6-week period your velocity will be tested again to determine if there occurs any changes in throwing velocity with weight training.

Potential Consequences

It is important for you to know that with any type of maximal throwing you as the subject should be aware that there is always the possibility of arm injury. Also, you should know that with weight training there exists a possibility of injury. Before you sign this consent form

Appendix B (continued)

take these factors into consideration.

Need more information?

If you have any questions pertaining to this study please feel free to ask. If you wish information about the findings from this research you can contact me or Ithaca College.

Withdrawl from the study

You should know that you are under no obligation and are free to withdraw at any time. Participation in this study is strictly voluntary and refusal to participate will involve no penalty. You can cease participation at any time.

Will the data be maintained in confidence?

The velocities recorded by you will be shared with the baseball coaches here at Ithaca College. When the thesis is written, your confidentiality will be maintained by the use of numbers instead of your names. But, due to the sharing of the velocity scores with the baseball coaches here at Ithaca College, your confidentiality cannot be guaranteed. Please consider this before participating in this study.

Please consider the time commitment of this study before you decide whether or not to participate. Indicate your decision below. Thank you.

Karl Steffen, Graduate Student

Dr. Paul Thomas, Advisor

Appendix B (continued)

_____Yes, I voluntarily choose to participate in this study.

_____No, I do not wish to participate in this study.

_____ _____

(signature) (date)

Appendix C

A COMPARISON OF SUBJECTS' (N = 9) AVERAGE WEIGHTS LIFTED, IN POUNDS (LBS.), BETWEEN THE FIRST AND 12TH WORKOUTS

Nautilus Machines	1st Workout M	12th Workout M
Hip and Back	51.1	69.4
Leg Extension	57.7	73.3
Leg Curl	38.7[a]	47.5[a]
Pullover	32.2	38.8
Behind Neck	17.7	27.7
Torso Arm	31.1	43.3
Shoulder Raises	27.7	40.5
Shoulder Press	26.6	40.5
Chest Machine	25.5	32.7
Bicep Curl	22.7	31.1
Tricep Extension	23.3	29.4

[a]Based on 8 subjects because one subject failed to record final workout.

REFERENCES

Bostwick, W. The effects of weight training on speed and endurance in baseball pitching. Unpublished master's thesis, University of Illinois, 1961.

Broer, M. R. Efficiency of human movement (3rd ed.). Philadelphia: Saunders, 1973.

Brose, D. E., & Hanson, D. L. The effects of overload training on velocity and accuracy of throwing. Research Quarterly, 1967, 38, 528-533.

Capen, E. K. The effect of systematic weight training on power, strength, and endurance. Research Quarterly, 1950, 21, 83-93.

Clarke, D. H., & Henry, F. M. Neuromuscular specificity and increased speed from strength development. Research Quarterly, 1961, 32, 315-325.

Coleman, E. A. Nautilus vs universal gym: Strength training on adult males. American Corrective Therapy Journal, 1977, 31, 103-107.

Darden, E. The nautilus book. Chicago: Contemporary Books, 1980.

Eckstrom, C. T. A study of the effects of increased upper-extremity and shoulder girdle strength on the velocity of a thrown baseball. Unpublished master's thesis, State University of Iowa, 1955.

Elias, J. The effect of overload training on speed in

baseball pitching. Unpublished master's thesis, Springfield College, 1964.

Haldeman, N. Pitching velocity: Can you increase it? Scholastic Coach, April 1969, pp. 31-33.

Hooks, G. Weight training in baseball. Athletic Journal, December 1959, pp. 42-44.

Lewallen, W. C. A study of the effect of selected training methods on overarm throw baseball velocity. Unpublished master's thesis, Purdue University, 1978.

Logan, G. A., McKinney, W. C., & Rowe, W. Effect of resistance through a throwing range-of-motion on the velocity of a baseball. Perceptual and Motor Skills, 1966, 23, 55-58.

Minor, D. L. The effect of weight training on the throwing power of high school baseball players. Unpublished master's thesis, University of Wisconsin, 1956.

Northrip, J. W., Logan, G. A., & McKinney, W. C. Introduction to biomechanic analysis of sport. Dubuque, Ia.: Brown, 1974.

Peterson, J. A. Total conditioning: A case study. Athletic Journal, October 1975, pp. 40-55.

Pierson, W. R., & Rasch, P. J. Strength and speed. Perceptual and Motor Skills, 1962, 14, 144.

Railey, J. H. The effect of two methods of resistance exercise on baseball throwing velocity. Unpublished master's thesis, Arizona State University, 1964.

Rasmussen, D. A. The effect of resistance exercises upon the velocity of a thrown baseball. Unpublished master's thesis, Eastern Illinois University, 1962.

Riley, D. Strength training by the experts. West Point, N.Y.: Leisure Press, 1977.

Rowlands, D. J. The effect of weight training exercises upon throwing power and strength of college baseball players. Unpublished master's thesis, University of Wisconsin, 1962.

Sinks, M. C. The longitudinal effect of progressive overload on speed and accuracy in baseball pitching. Unpublished master's thesis, Michigan State University, 1964.

Smith, L. E. Influence of strength training on pre-tensed and free-arm speed. Research Quarterly, 1964, 35, 554-561.

Stiggins, C. F. Nautilus and free weight training programs: A comparison of strength development at four angles in in the range of motion. Unpublished master's thesis, Brigham Young University, 1978.

Straub, W. F. Effect of overload training procedures upon velocity and accuracy of the overarm throw. Research Quarterly, 1968, 39, 370-379.

Sullivan, W. J. The effects of three experimental training factors upon baseball throwing velocity and selected strength measures. Unpublished doctoral dissertation, Indiana University, 1970.

Swangard, T. M. The effect of isotonic and isometric training programs on the development of bat swinging,

throwing, and running ability of college baseball players. Unpublished master's thesis, University of Oregon, 1965.

Thompson, C. W., & Martin, E. T. Weight training and baseball throwing speed. Journal of Association for Physical and Mental Rehabilitation, 1965, 19, 194-196.

Van Huss, W. D., Albrecht, L., Nelson, R., & Hagerman, R. Effect of overload warm-up on the velocity and accuracy of throwing. Research Quarterly, 1962, 33, 472-475.

Wescott, R. T. The effect of an imitative type of resistance exercise on throwing skill. Unpublished doctoral dissertation, Indiana University, 1965.

Wilkin, B. M. The effect of weight training on speed of movement. Research Quarterly, 1952, 23, 361-369.

Zorbas, W. S., & Karpovich, P. V. The effect of weight lifting upon the speed of muscular contractions. Research Quarterly, 1951, 22, 145-148.