This is to certify that the

thesis entitled

EFFECT OF THE "FLEXIBAT" T.M. ON BAT-HEAD VELOCITY

presented by

GARY CHARLES BOYCE

has been accepted towards fulfillment
of the requirements for

Masters degree in Physical Education

John L. Haubenstricker
Major professor

Date May 17, 1979

O-7639

EFFECT OF THE "FLEXIBAT" T.M. ON BAT-HEAD VELOCITY

By

Gary Charles Boyce

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Health, Physical Education and Recreation

1979

ABSTRACT

EFFECT OF THE "FLEXIBAT" T.M. ON BAT-HEAD VELOCITY

By

Gary Charles Boyce

Twelve Michigan State University baseball players were randomly selected from four stratified class groupings. The three players from each strata were then randomly assigned to one of two groups. The purpose of the study was to determine the effect of the "Flexibat" T.M. on bat-head velocity. All subjects participated in a 24 session training program. The subjects were pretested with a Maroth Velocity bat to establish their baseline bat velocity. The research hypothesis was that the "Flexibat" T.M. will develop the top hand movement pattern in the baseball swing and increase bat-head velocity through the integration of this movement pattern with the bottom hand action.

All subjects participated in a progressive batting drill that utilized: 1) two different hitting positions, 2) four bat type hitting devices, and 3) two different ball sizes. At the end of the 24 sessions, the subjects were post tested for bat velocity. A t-test for significant differences between two independent populations was used to analyze both the pretest and the post test data. A significance level of .10 was established for rejection of the null hypothesis. Analysis of the

post test data indicated that the experimental group had increased their bat velocity at a .05 level of significance. It was concluded that the "Flexibat" T.M. did develop the top hand action and the integration of the top and bottom hands in the bat swinging process led to a dramatic increase in bat-head velocity.

To Pam

for your love and support

in the development and completion

of this research endeavor

ACKNOWLEDGMENTS

The author wishes to extend sincere thanks to the following people:

To Dr. John L. Haubenstricker for his advice and direction throughout the preparation of this thesis and my graduate program.

To Daniel W. Litwhiler and Thomas W. Smith for their contributions in the development of this research project.

To Mr. John Paulson, President of JoPaul, Inc., for the use of the Maroth Velocity bat.

To the Department of Health, Physical Education and Recreation for allowing me access to the facilities at Michigan State University.

TABLE OF CONTENTS

CHAPTER Page

LIST OF TABLES

LIST OF FIGURES

Chapter I

THE PROBLEM

The general decline of batting averages at the Major League level has caused concern among professionals and amateurs alike. There have been countless discussions within fandom and within the heirarchy of the major leagues regarding the depressed batting averages over the past several decades. Figure 1-1 contains the composite American and National Baseball League batting averages for the years since 1900. It can be noted that the batting averages for the past decade have been the lowest since the first decade of this century. In point of fact, the American League batting averages reached an all-time low in 1968.

Numerous reasons have been proposed for this decline in batting averages. Koppett (42) suggested eight reasons: 1) better pitching, 2) hitting for distance/home runs, 3) bigger and better gloves, 4) more attention to defense, 5) night baseball, 6) coast to coast travel by air, 7) lighter and thinner bats, and 8) bigger and more symmetrical parks. Of these, improved pitching, attention to defense, hitting objectives and changes in bat models are the most directly influenced by the decisions of coaches, and therefore merit further consideration.

A major change in baseball has been the emergence of the relief pitcher. Increased use of the relief pitcher has had a tremendous impact

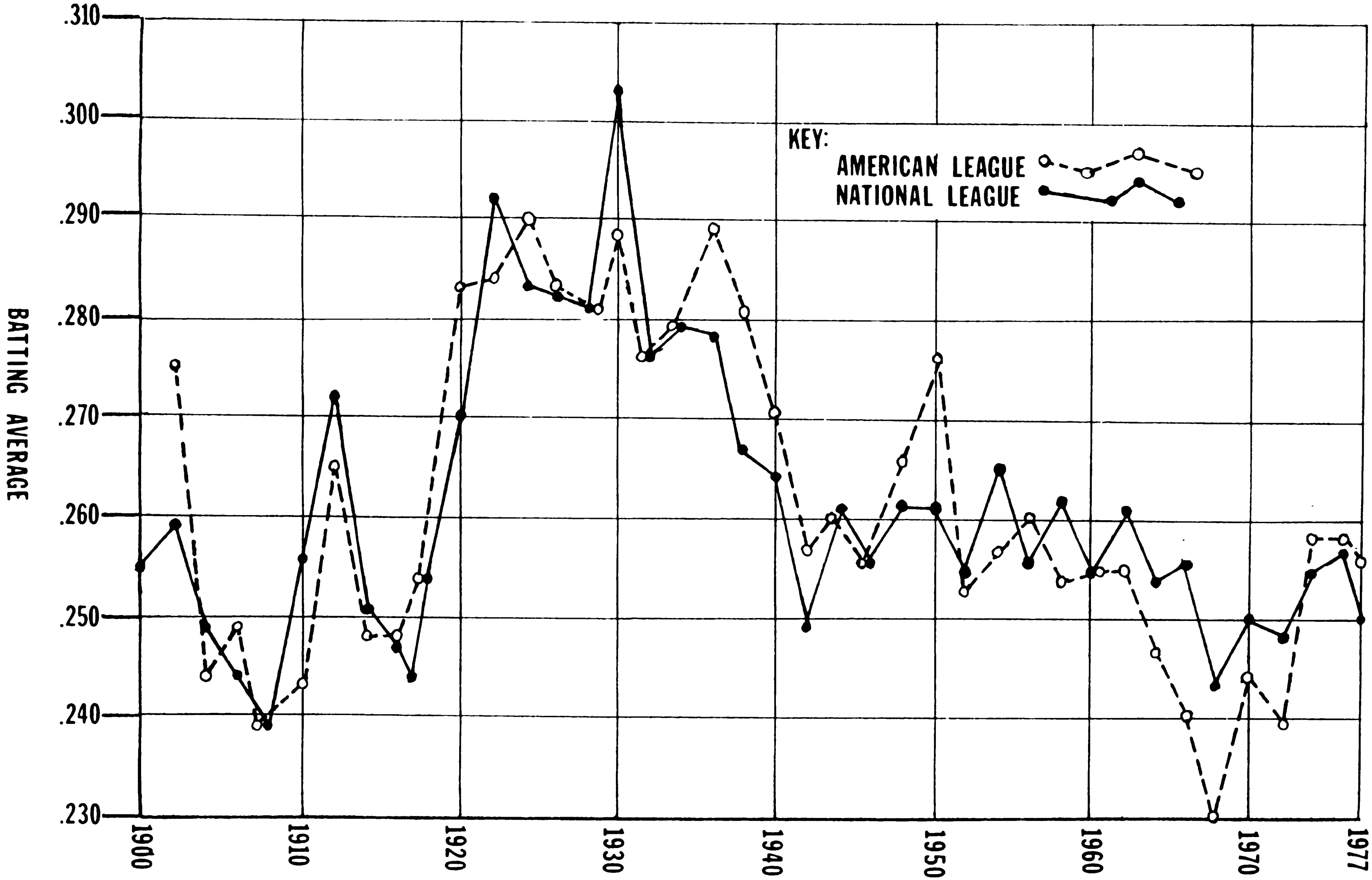

Figure 1-1. Composite averages for the American and National Leagues since 1900.

on the game of baseball. Batters, in particular, have been affected adversely by this change in defensive strategy. First, the starting pitchers no longer have to pace themselves in order to pitch nine innings. They can throw at optimum speed as long as possible knowing that a specialist is available to replace them when needed. Thus batters have fewer opportunities to swing at pitches to their liking. Second, the relief pitcher is fresh and is usually equipped with a special "out" pitch that is difficult to hit. Third, the relief pitcher called on for a given situation most likely will have been selected on the basis of intensive charting and scouting reports. These reports are used to match the strengths of the pitcher against the weaknesses of the hitter.

Improved defense also has resulted from the utilization of computerized charting techniques. Charts are maintained indicating where each player has hit each ball off each pitcher on a given major league roster. This data is fed into a computer and the resultant output is a game plan based on the scientific probability of predictable events occurring when the variables of a game situation are manipulated. Use of these techniques has enabled the defensive phase of the game to gain a decided advantage over the offensive segment.

A third practice that has adversely affected batting averages is the general change in batting objectives from those of securing base hits to those of hitting home runs. This emphasis on home run production can be traced to business and profit motives. Home runs cause excitement, and this above all else will put people in the seats at the various major league stadia. The average fan does not relate nearly as well to the nuances of baseball as he does to the power segments of the game. What the average fan wants is action, speed, and offensive performance. This is not to deny that spectacular defensive plays can create enjoyment and appreciation, but rather to point out that management is interested in emphasizing those aspects of the game that provide the greatest financial return.

In his study to determine the total offensive output of major league players, Akers (4) stated that Major League baseball is a business devoted to entertaining in the world of sports. Akers cited the categories of gross base average, slugging average, and on-base average as the most important in determining the level of success individual batters achieved when batting. Branch Rickey (56) maintained that a player's value to the total team performance rested in his ability to score runs, to advance bases, or to enable other runners to advance bases or score runs. Rickey cited several factors that related to offensive output. The first objective was to get on base in any method possible. The second priority was to hit with power, or for extra bases. This emphasis on power hitting has resulted in a change in the batting pattern of the modern baseball player.

Related to the change in batting objectives is a basic difference between the bats used during the early decades of this century and the present day models. Weiskopf (83) has shown that the thin handled bat used by the professionals today allows a better whip action to be generated than does the thicker handled and heavier model used during the pre-1930 era. Koppett (42) has cited the whipping action as beneficial in generating power for hitting home runs. Williams (89) also stated that the light, thin handled bat is superior to a heavier model for the same reason. In contrast, the thin handled bat provides less surface area along its longitudinal axis for contacting the ball. Thus, the ball is not hit solidly as often as is the case with the thicker handled bat, resulting in fewer base hits and lower batting averages.

Although improvements in the defensive aspects of the game undoubtedly have contributed to the lower batting averages, it is the opinion of this investigator that another major contributing factor to the decline of batting averages and batting performances has been the lack of proper hitting instruction. Al Campanis, Director of Player Personnel for the Los Angeles Dodgers, has stated that "baseball is perhaps the most overcoached and yet undertaught game that is played today" (5).

The basic batting objectives in baseball have changed to power oriented goals. However, the presentation of, and exposure to methods for improving power potential in the bat swinging process have been mislaid in the transition. The key to power batting is a sound swinging process based on physical mechanics which: 1) provide for maximum tracking and informational processing of the incoming pitch, 2) utilize the muscles in opposition to each other thereby enhancing power production, and 3) integrate the two previous sections to culminate in the attainment of high bat velocity. If both business and personal finances dictate general power hitting objectives, then a concurrent process to develop bat velocity must be instituted to expedite the achievement of these goals.

NEED FOR THE STUDY

The general decline in batting averages demonstrates the need for research to improve batting performance. Although the literature contains many relevant articles and studies concerning the component parts of successful batting, it does not include many references germane to the development of bat velocity. The focus of this study was to test a training device designed by the investigator to develop the top hand action in the baseball swing. The study was designed to test whether the integration of both hands during the swing would develop greater bat velocity.

A need for this type of device was first perceived while the investigator was still playing professional baseball. He began searching for a method that would improve his top hand action while swinging a bat. Finding no such device on the market, he began to think about the development of one. Two immediate qualities were necessary: 1) the device would have to force the top hand to perform during the baseball swing, and 2) the mechanism would have to be durable enough to withstand the stress of constant usage.

Henry Ford once said "genius is 99 percent perspiration and 1 percent inspiration". After two years of effort with only marginal success, the investigator understood the validity of his statement. Eventually, a workable model was designed. During the following two years, a series of modifications and "shake-down" trials were made. During this time period, a pilot study was conducted with the varsity baseball team at Lake Michigan Catholic High School in St. Joseph, Michigan. Radical, observable modifications took place in the bat

swing of the players. After using the device in a training program, both the top hand and the front hand were operating in coordination when the batters swung the bat. The device had enabled the players to develop better bat velocity. Consequently, a patent search was initiated. The search came up "clean" and a patent application was drawn up and filed.

The decline in overall composite league batting averages since 1900 led this investigator to speculate about the significance of a training device that could assist players who swing bats for enjoyment as well as those who swing bats for a living. Such a device possibly could also contribute to the development of batting skill in younger children and youth.

PURPOSE OF THE STUDY

The purpose of this investigation was to determine the effect of training with the "Flexibat" $_{T.M.}$ on bat-head velocity in a baseball swing.

RESEARCH HYPOTHESIS

The research hypothesis is that training with the "Flexibat" $_{T.M.}$ will develop the top hand movement pattern in the baseball swing. This development will promote the integration of the top hand and bottom hand action while swinging a bat, thereby significantly increasing bat-head velocity.

SUBPROBLEM

Hand-eye coordination has been demonstrated to be an integral component of the overall batting process (8). There was a desire to improve the hand-eye coordination of the subjects participating in the research program. Thus a special training program was developed for both the experimental and control groups involving modifications in stance, in the implements for striking and in the size of the balls used. The contact the subjects made when hitting plastic golf balls from a one-knee position and from the normal, standing stance was charted for future graphic display.

RESEARCH PLAN

The subjects were 12 Michigan State University baseball players, ranging in age from 18 to 21 years, with a mean age of 19.5 years. The subjects were randomly selected from stratified class standings. After random selection, the subjects were systematically assigned to a group. Finally, the two groups were randomly designated as either control or experimental. The independent variable in use during the training program was the "Flexibat" $_{T.M.}$ training device. The dependent variable was the effect that the training device had on bat-head velocity. It was theorized that an increase in velocity would be due to the integration of the top and bottom hands in the swinging process.

The collection of pretest and post test data was achieved through the use of the Maroth Velocity bat. This device measures bat velocity in miles per hour and has been found to be reliable for this

purpose (43, 74). The subjects were tested prior to the start of the programs and again after completing 24 training sessions. The pretest data was analyzed to establish whether there was a significant difference in bat velocity between the two groups. Analysis of the post test data was contingent upon the pretest results. Thus, the post test data could be analyzed by t-test, co-variance or gain score analysis. The level of significance established for rejection of the null hypothesis was .10.

RATIONALE FOR THE RESEARCH PLAN

The decision was made to utilize a four stage hitting drill to test the training device. A summary of the four stages and their respective objectives are presented in Table 1.2. The drill was used for several reasons. First, the investigator was familiar with portions of the drill from his own collegiate and professional pre-season training. Secondly, the utilization of a light weight broomstick during the first stage would allow a fast motoneuron firing sequence to be established while swinging. This implement would also force head stabilization and a high level of hand-eye coordination in order to consistently strike the plastic golf balls.

A third reason was that a medium sized, lathe-turned dowel would provide an orderly progression from the broomstick to a regulation bat in both size and weight overloading. This calibrated weight progression in the dowel would allow the hitter to retain the rapid firing sequence and also develop the recruitment of additional muscle fibers through the use of a specific overload mechanism. The third

Table 1.2. A summary of the four stage hitting drill.

Stages	Objectives
I. Broomstick Stage	a) establish a rapid firing sequence of motoneurons b) develop head stabilization and increase hand-eye coordination
II. Dowel Stage/Dowel "Flexibat"	a) allow the continuance of the rapid firing sequence b) recruit additional muscle fibers through overloading
III. "Flexibat"/Regulation Bat Stage	a) establish powerful sequential movement pattern of the top hand b) continue to recruit additional muscle fibers by employing overload
IV. Final Stage	a) provide for kinesthetic and proprioceptive sensory feedback of the top hand integration into the swinging pattern

stage was designed to the "Flexibat" or an equally weighted regulation bat. The objectives for this stage were to establish a powerful sequential movement pattern of the top hand; to continue to recruit additional muscle fibers through the use of a specific overload mechanism; and to increase the overall bat velocity through the integration of the top and bottom hand in the swinging process. The final stage of the training program involved swinging a regulation bat. This allowed the hitter to receive kinesthetic and proprioceptive sensory feedback while using the newly developed movement pattern.

The scope of the groups involved in this research program was initially limited to a single experimental group of four subjects and a single control group of four subjects. A second training program was subsequently added and consisted of two experimental subjects and two control subjects. This restriction in size of the groups was not due to design but rather to the limited access of the facilities allowed the investigator.

ASSUMPTIONS RELATED TO THE RESEARCH PLAN

The following assumptions which relate to the research program are offered:

1. The direction of flight of a ball that has been struck depends on the angle of deflection created by the striking device.
2. The development of a movement pattern with the capacity to change the striking angle of the bat would aid consistency in hitting the ball at an optimum angle.
3. Power hitting is a function of mass and velocity. Assuming a constant mass, the force applied to the ball by the bat will increase proportionally to the increase in bat velocity.

4. When all other variables remain constant, the bat with the highest bat-head velocity will give the highest power potential.

5. Utilization of good hip and shoulder rotation, coupled with prestride looping of the bat and a quick swing upon striding, will produce the most consistent power swing.

6. It is easier to speed up accurate movements than to correct inaccurate movements.

7. The rate of improvement relates directly to the intensity of the training program.

8. The overload principle must be utilized in order to develop optimum output from a training program.

9. The Maroth Velocity Bat provides a valid and reliable method of testing for bat velocity.

LIMITATIONS OF THE RESEARCH PLAN

The following limitations were noted in the development of the training program:

1. The scope of the study was limited due to restricted access to facilities.

2. Sample size was a limitation of this program.

3. The inability to effectively generalize the results to a larger population due to the limited sample size and age range included in the sampling was a limitation of the research plan.

SIGNIFICANCE OF THE STUDY

"When all other things remain constant, the bat with the highest velocity will give the highest power potential." (85) The significance of a training device that could simultaneously integrate the top and bottom hand in the swinging process, develop a movement pattern designed to allow the batter to change the effective striking angle of the bat, and also increase the bat-head velocity is infinite.

The immediate implications are addressed to the world of physical education and sports. Professionals and amateurs alike who swing bats or similar implements could benefit from the marketing of a training device such as the "Flexibat" $_{T.M.}$. It is therefore conceivable that the resultant impact on the physical education profession and on the general world of sports could be significant.

DEFINITIONS

The following list of definitions is provided to assist the reader:

1. Front leg cocking action. The slow, and controlled inward rotation of the lead knee prior to the initiation of the forward stride. This helps develop rotary hip action and facilitates both transfer of weight to the back leg, and front shoulder rotation away from the pitcher. This action shall here-after be referred to as "cocking".

2. Hand action. The combined action developed by both the hands when they apply force to the bat to initiate movement.

3. Bat-head velocity. The highest speed attained by the bat during the swing, expressed in miles per hour.

4. Speed overload. Increasing the rate of muscle contraction in a power activity.

5. Power. The maximum effective force which a muscle or group of muscles are able to exert against a fixed or movable object at a maximum rate of contraction.

6. Power factor/potential. The number of total bases, divided by total hits. This figure represents hitting power and is actually the probability of total bases compared to total hits. It serves to delineate the force with which a properly timed, squarely hit baseball is propelled into the field by the hitter (16).

7. Hands position. The position where, after the shoulders have rotated, the hands are at the back of the lettering of the uniform. The top arm and elbow are extended away from the body, prestretching the musculature and thereby increasing the power potential of subsequent contractions.

Chapter II

REVIEW OF THE LITERATURE

The general decline of batting averages in professional baseball has been attributed to changes in the defensive aspects of the game. However, this decline has also been attributed, in part, to a change in offensive philosophy. The basic objective of most professional baseball players today is to hit for power (i.e., home runs) as opposed to the objective of obtaining a base hit.

If the offensive phase of baseball is to improve, players must become more adept at hitting with power. This review of literature will focus on two major areas: 1) those variables that may increase the statistical probability of success in power hitting, and 2) an examination of the nature of the batting swing. Other areas such as motivation, information processing capacities, feedback systems and physical growth factors, while important, will not be included in this review.

Preswing Batting Components

There are numerous components related to the preparatory phase of batting that must be symbolically coded in the mind of the hitter before the mature movement pattern of the swing phase can be effectively developed. Among these preswing components are: 1) warmup and training program effectiveness, 2) stance and positioning in the batter's box, 3) readiness in the batter's box, 4) effective swing development and pitch selection, and 5) ball velocity and its relationship to visual reaction time and movement time.

The Effectiveness of Warm-up and Training Programs

The period of warm-up prior to engaging in an activity is generally designed to allow the athlete to prepare for and approach peak operating capacity. Its purpose is to permit the development of a state of physiological as well as psychological readiness (53).

A number of studies have been conducted to determine the validity of warm-up periods, and the resultant data provide some interesting information. The available data germane to the effectiveness of warm-up sessions generally do not confirm their value. Warm-up periods do not necessarily promote effective performance, nor are injuries necessarily minimized through their use.

In order to maximize the effectiveness of a warm-up period, the warm-up activity must relate directly to the task that will be performed (62, 77). Singer (62) cites the probability that precision skills, those skills requiring both timing and coordination for successful execution, will most likely benefit from specific, task-related warm-up. He also maintains that the psychological effects of warm-up potentially outweigh their "real" value. Positive belief in the value of an exercise may well contribute to an increased output. In a summary of research findings, Singer suggests that warm-up practice prior to competition may have value in the following ways:

1. by activating (elevating), or reducing (diminishing) the level of arousal necessary for task performance

2. by reducing the performance decrement that occurs over time

3. by increasing the "set" of the performer, which reinstates appropriate task adjustments and the readiness to perform

4. by promoting any combination of the above.

The effect of warm-up on the velocity of the baseball swing was investigated by Brown (13). He determined that there is a direct relationship between the intensity of the warm-up and the speed of the baseball swing.

The research findings of several studies have provided conflicting information regarding the relative effects of various training programs on the velocity generated in a baseball swing (27, 81). Flaherty (27) found that relatively short duration programs do little to improve bat velocity. Weems (81) concluded that strength training methods such as weight lifting, isometric drills, overload bat techniques, and regulation bat swinging drills will not increase the velocity of a baseball swing. Similar results were obtained in investigations by Hooks (32), Kuklenski (43) and Swangard (74). In contrast, Deese (20) and Wertich (87) found that improved bat velocity resulted from the training programs that they employed.

Stance, and Positioning in the Batter's Box

The location of the batter in the batter's box and the particular stance used for hitting is generally left to the discretion of the

individual hitter. However, there are considerations relative to stance and position that can affect performance that need to be examined.

There is conflicting opinion concerning the relative advantages of various types of stances, particularly the open and closed stance (1, 19, 44, 84). A partial listing of arguments for the utilization of the open or closed batting stance include: 1) head positioning for proper alignment of the dominant eye, 2) optimum tracking time, 3) body positioning to allow swinging the bat through an optimum plane with the greatest freedom of movement, and 4) compensation for mechanical faults.

There is also some controversy over the optimum position the batter should assume in the batter's box. Bunn (14) maintains that there is a necessity for the hitter to stand close enough to the plate to reach the outside corner effectively. However, this investigator believes that the hitter must take a position based on his self-acknowledged strong and weak hitting zones. He must locate the position that will enable him to fully extend his arms when swinging the bat.

Readiness Inside the Batting Box

There is one general principle of hitting that Lau (11), Moses (50) and Williams (89) all agree is essential to superior batting performance. The batter must be ready to swing his bat when he enters the batting box. Once the hitter enters the box, he does not have the time to begin orienting himself; all preparation must be accomplished prior to assuming his stance.

Pitch Selection, and Effective Swing Development

The variables that influence a hitter's swing change from pitch to pitch. It is of great importance for the hitter to constantly work to improve his overall swing mechanics. By increasing the number of effective swing planes in his strike zone, the hitter can decrease the potential advantage a pitcher has when facing him.

Perhaps one of the most rudimentary parts of hitting is the knowledge of the strike zone. Williams (89) suggests that the hitter should work out his own percentage scheme for swinging at balls in his strike zone. Another very essential attribute of a good hitter is being able to discipline himself to wait for his pitch and avoid swinging at the pitcher's pitch (23, 89). Ellis (23) states that by tapering his strike zone to his preferred strike zone, the hitter can increase his chances of hitting the ball effectively. Ellis, after analyzing taped interviews with major league batters, presented three reasons for the hitter to taper his swing zone:

1. The ball is in the zone he likes best.
2. The batter's swing is geared to that particular zone.
3. The batter is anticipating a ball thrown into that zone.

This investigator agrees that the hitter should develop and refine his batting stroke to the point where he has a favorite hitting zone. However, he also maintains that hitters need to develop effective swings for all areas in their strike zone. Situations occur where the hitter does not have the option of conceding pitches to the pitcher. A swing must be developed to effectively fight off those pitches that enter a hitter's weak zones. These swings for the weaker areas need to approach a level of competency that will enable the batter to consistently develop efficient power potential in his movement pattern.

The decrease in overall batting averages in the major leagues suggests that among the variables that affect batting performance is the frequency with which the pitchers are able to spot the ball within the weak areas of the batter's strike zone. Sufficient need has been demonstrated to require refinement of zone swinging as well as the development of effective swings for the entire strike zone.

Relationship of Ball Velocity to Visual Reaction Time and Movement Time

Eye dominance and head position have been considered essential components for tracking an object in flight. Numerous studies have investigated the effect of eye dominance on batting performance (1, 7, 24, 33, 55). Adams (1) examined the batting performance of unilaterals and cross-lateral hitters to test the theory that cross-lateral hitters were better than unilateral hitters. He reported that unilateral hitters performed as well as the cross-lateral batters. He also reported superior batting performance for those hitters using the open stance. He believed that the latter findings gave credence to the old adage "two eyes are better than one". The existence of a correlation between head stabilization and optimum tracking ability has been supported by hitting instructors and researchers alike (8, 33, 50, 88, 89). Ted Williams (89) advocated visually locating the point of release of the ball and concentrating on the elimination of distracting variables such as excessive motion of the pitcher. He further coded the point of release by suggesting the hitter think of it as a fifteen-inch square over the pitcher's shoulder (see Figure 2-1).

Other investigators have researched the effect of ball velocity on reaction time and movement time (33, 40, 63, 76, 90). Electromyography has been utilized to establish the visual movements of batters (40). The eye movements of batters were found to track ball movement, especially during the last few feet before the ball reached the plate. This study established that visual tracking did not continue until contact was made with the ball. Hubbard and Seng (33) found that the start of the batter's step was linked to the release of the baseball. In addition, the finish of the stride and the length of the stride were directly related to the ball velocity. The start of the swing and the forward movement of the bat were found to start about .04 second after completion of the stride (33).

There is agreement among several investigators that a prime attribute of a successful hitter is the ability to complete his swing, from movement time until contact is made, in a very short period of time (12, 20, 33, 88). Breen (12) reported the time required by outstanding major league players for the swing phase of batting. These were: 1) Stan Musial, .19 second, 2) Willie Mays and Mickey Mantle, .21 second, 3) Henry Aaron and Ernie Banks, .22 second, and 4) Ted Williams, .23 second. Hay (31) has illustrated and interpreted Breen's findings to show that the faster a player's swing time, the longer the tracking and ultimate decision time, and thus, the higher the level of performance that he can produce.

Reaction time and movement time are variables that affect batting performance. The faster a batter's reaction and movement time, the longer he can track a pitch before deciding whether to swing (88).

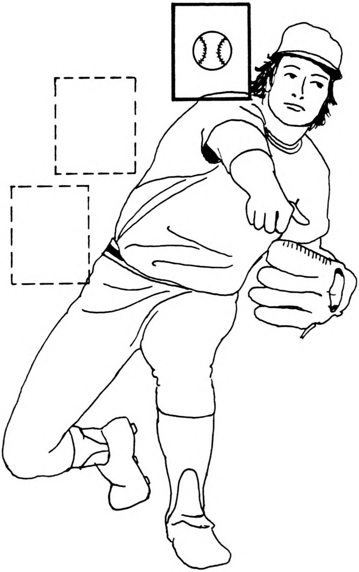

Figure 2-1. The Point of Release.

Mean reaction time has been established at .21 second, and mean movement time was listed at .27 second (65). Using this and related information as a guide, if the baseball travels at 80 miles per hour, a player with a bat movement time computed to contact at .21 second would be required to start his forward bat movement when the ball was 24 feet from the plate. If we accept .27 or .28 second as representative of the average time for bat movement to take place, then the batter must begin his swinging process when the ball is still 33 feet away from the plate (20, 65). An interpretation of this information indicates that the batter has just under a half second to track the ball, make the decision to swing, initiate bat movement and make contact. This investigator interprets this information as general support for starting the cocking process just prior to the release of the ball by the pitcher. This interpretation also is supported by the suggestion by Slater-Hammell that the hitter make his reaction time to a ball in flight a starting time reaction (65). The slow and controlled front leg cocking action will allow for variations in the pitching deliveries of different pitchers and different velocities of thrown balls.

Summary of the Preswing Batting Components

Research studies relating to the improvement of bat velocity through weight training programs, and several other lead-up components to swinging a bat were perused. A summary of the findings and resultant implications follow:

1) The effects of weight training are specific to the muscles overloaded, and to the angle at which they were trained.

2) The rate of bat movement increase is directly related to the intensity level of the warm-up utilized.

3) The batter must find a position in the batter's box where he can effectively, fully, extend his arms during the swing.

4) The hitter must attend to personal idiosyncracies, symbolic coding, and visual cues prior to entering the batter's box.

5) The eyes are used to track ball movement, especially in the last few feet in the approach of the ball to the plate.

6) The batter must make his reaction time to a ball in flight a starting time reaction.

7) The start of the striding process is related to the release of the ball by the pitcher.

8) The finish of the stride, and the length of the stride are directly related to the velocity of the thrown ball.

9) Bat movement begins about .04 of a second after completion of the forward stride.

10) The ability to complete the swing process in the shortest length of time is considered an essential attribute of successful hitters.

The Baseball Swing Sequence

The synchronization of the component parts of the batting swing mechanics contribute to consistent batting performance. The following section isolates the component parts of the swing sequence and provides relevant data for improving the batting phase of baseball. The areas considered essential to the development of a mature swinging pattern are: 1) initiation of the swing, 2) hip rotation and leg interaction, 3) shoulder rotation away from the pitcher and bat barrel cocking toward the pitcher, 4) coordination of front arm and front leg extension, 5) hand action and development of the power hand, and 6) balance, body control and relaxation.

Initiation of the Swing

In commenting about the start of the baseball swing, Johnny Sain (57) stated that "everything starts when the pitcher points his butt at the batter". All subsequent actions are then reactionary and of an adjusting nature. Wally Moses maintained that the most important aspect of hitting was "to get your striding process started" (50, 83).

These statements refer to the preparatory phase of hitting involving the transfer of body weight to the back leg prior to striding. This transfer begins with a slow, controlled front leg inward rotation. This inward rotation action shall hereafter be referred to as "front leg cocking action", or just "cocking". Ted Williams (89) refers to this action as a pendulum action. He symbolically codes the action as a mechanical metronome, with its movement and countermovement. The slow, controlled, front leg cocking action allows the hitter maximum time to track the ball, to decide whether or not to swing, and in what plane to swing the bat and when to initiate the swing. This controlled cocking action also allows the hitter to adjust to the velocity of the baseball by either cocking through a greater range of motion, or by immediately getting the front foot down on a high velocity pitch.

The stance of the batter should be slightly wider than shoulder width in the initial phase. The extra width allows for greater stability during the cocking and transfer of weight segment of the swing sequence. Bethel (11) reports that Charley Lau, hitting instructor for the Kansas City Royals, considers balance prior to the swing, during the swing, and after contact to be a vital component of hitting.

Hip Rotation and Interaction of the Legs

The front leg cocking action permits the powerful rotary hip action to be developed. As the leg cocks, the hips begin a rotary action away from the pitcher. This action places the hips in optimal position to contribute to the force production phase of the swing. The hips complete their rotary action away from the pitcher as the transfer of weight is accomplished. The legs then contribute to further development of power by working in opposition to each other. When transfer of weight to the back foot is accomplished, the batter drives off this base by moving his front foot and shoulder into the ball. This forces the batter to step into the ball, and it also stabilizes his head and eyes on the ball. As the front foot touches down ending the stride, there is an immediate and violent reverse driving action applied to the body. Newton's law of interaction is functioning through the legs to develop the powerful hip "pop" that is the basis of power in the baseball swing (14, 16, 50, 55, 89). Williams symbolically codes this hip action by instructing hitters to lead out with their belly buttons (89). This investigator believes that if the hitters are additionally instructed to coordinate throwing the back hip out front with the belly button lead, it will facilitate a more complete pivot of the rear foot, thereby allowing greater power development in the hip "pop".

The importance of proper weight distribution in the striding process needs to be established to provide an over-view of the sequential process. The stride is completed with the weight distributed on the ball of the front foot. This distribution is stressed for several reasons:

1) it allows for maximum balance, 2) the additional balance allows extra moments to track the ball prior to violently pushing back with the front leg and initiating the swing, and 3) from the bent-knee stride ending position, where the weight is distributed on the ball of the foot, the batter has the best chance to block forward movement of the body and still utilize some rotary hip action as he pushes back to start his swing on a mis-timed pitch (11, 14, 50, 81, 89).

A summary of the front leg cocking action shows that it is instrumental in: 1) initiating the transfer of weight in the swing process, 2) developing maximum rotary hip action and "pop" through the pendulum hip cock and resultant power generation through the interaction of the legs, and 3) allowing the hitter to develop a process whereby he can consistently keep his body weight behind a braced front leg, and get his hands out in front of the body to swing the bat.

Shoulder Rotation and Barrel Cocking

The sequential cocking action of the various body parts involved in the baseball swing have been researched. Reports have indicated both the order of the sequence and its potential to increase power (16, 81, 89).

Conard (16) states that skilled hitters systematically cock the pelvis, forearms and hands during the swing sequence (16). Coordinated with the slow, controlled cocking of the front leg is an equally controlled cocking of the front shoulder, lead forearm and the hands (see Figure 2-2). These actions get the bat into position to swing. This cocking action can also be symbolically coded as a coiling spring action, or as a coiling cobra, waiting to attack with lightning quickness.

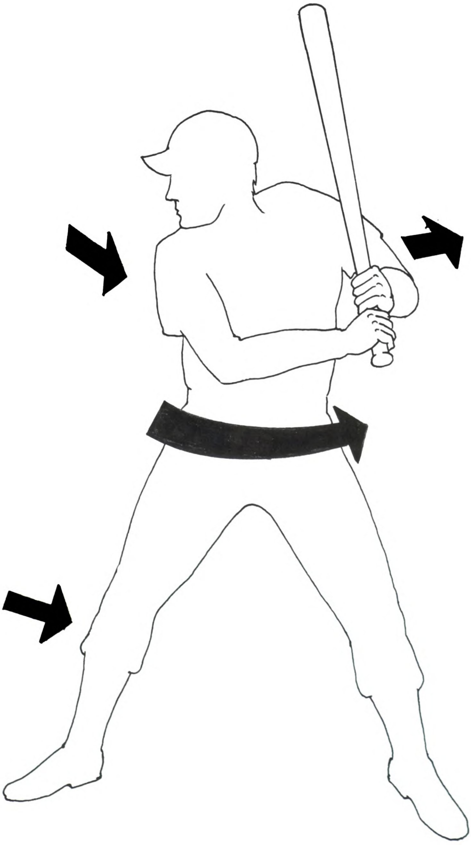

Figure 2-2. Sequential Cocking of Body Parts.

Bethel (11) with Charley Lau, has stressed that when the front foot touches down, ending the stride, the hands must be positioned at the letters near the back shoulder. This position shall hereafter be referred to as the "hands" position.

The 1973 major league All-Star game was filmed so that a camera was trained simultaneously on both the pitcher and the batter. The films showed that as the pitcher reached the point of release, the batter had to react to get the bat into position to hit. Through this method of filming, it was established that every batter who batted in this midsummer spectacle assumed a "hands" position prior to swinging the bat. While the batter is sequentially cocking his body parts in order to achieve this "hands" position, the arms are extending away from the body. The effect of this additional stretching of the muscles serves to add power potential to the swing.

When the "hands" position is reached, the hands also begin to cock the barrel of the bat toward the pitcher. The motion of the barrel of the bat toward the pitcher by hand cocking shall be referred to hereafter as "barrel cocking". This aspect of the cocking sequence of body parts also adds another power dimension to the baseball swing. Barrel cocking helps overcome the principle of inertia since the bat is already in motion before the ball is released. Barrel cocking also increases the arc of the bat. Studies have indicated that skilled performers move their bats through a greater distance before making contact with the ball than do either semi-skilled or non-skilled hitters (16, 75, 78, 82). The conciseness of the stroke will not be lengthened by the arc of the bat.

One important aspect to consider when using the barrel cocking technique is the establishment of proper synchronization of the swing components. In short, the hitter wants to develop a swing sequence through the proper range of motion, and at the proper angle of motion. Weems (82) refers to the bat returning to its original "hands" position and then continuing through the normal range of arc it would usually prescribe. He cites the late Roberto Clemente as an example of a player who achieved success with this technique. Clemente's style utilized a calculated and deliberate cocking speed. This presumably allowed greater maintenance of control through the swing sequence.

Coordination of Front Arm and Front Leg Extension

In order to develop a superior batting stroke, the lead forearm of the hitter must straighten immediately at the onset of the swing (9, 16, 50, 87, 89). Various studies have established that the triceps brachaii muscles are instrumental in the development of the powerful forearm extension (31, 40). Mike Marshall (45) developed for Michigan State University head baseball coach Danny Litwhiler an overload weight training exercise that promotes the explosive extension of the lead arm or forearm in the swinging process.

Other studies have established the existence of a relationship between the extension of the front leg and the almost simultaneous forceful extension of the lead forearm at the onset of the swing (2, 33, 65, 74). These findings tend to confirm the theory of hitting against a solid, braced front leg.

Hand Action, and the Power Hand

The action of the hands and the resultant influence that the power hand has on the trajectory of the bat are critical components of the baseball swing. Swimley (75) has stated that the onset of hand action must be delayed until the arms are fully extended and well into the hitting zone. Moses (50, 83) postulates that ground balls are a result of the lead hand and arm not fully extending. This lack of full extension causes the top hand to prematurely interact in the swing process. The result is an overspin trajectory imparted by the bat on the ball causing a ground ball.

To assure maximum transfer of force from the bat to the ball, the batter should limit the amount of recoil at the point of contact (14, 89). The bat should be gripped in a relaxed manner, with the middle joint of the fingers of both hands in alignment (15). Carroll (15) found that this method allowed greater range of wrist joint movement during the swing process. Litwhiler (18) has found that the grip can be made with the middle knuckles of the top hand aligned anywhere from the middle knuckles to the base knuckles of the bottom hand. The most used position was mid-way between the knuckles of the bottom hand. The hands stay loose and relaxed only retaining enough tension to hold the bat in the preparatory stages of the swing process. Race (54) summarizes the grip section by citing preparedness, alertness, free movement, relaxation and comfort as essential aspects of this stage of hitting. In order to initiate bat movement, the hands, wrists and fingers contract and apply force to the bat. At the moment of contact with the ball, the bat is held firmly both to absorb shock and to avoid recoil. In order to assure maximum transfer of force from the bat to the ball, the back foot must remain in solid contact with the ground until the ball is hit. The rear foot will definitely pivot, facilitating hip "pop", but it should remain in contact with the ground (15).

The debate over which hand is the power hand in the baseball swing has never been resolved. Equivocal beliefs are commonplace among the leading hitting instructors and researchers (11, 50, 89). Moses (50, 83) states that the bottom or front hand is the most important, while Lau (11) in concurring, in certain cases, suggests allowing the hitter to release the top hand after contact is made with the ball.

This investigator agrees that the front arm extension is essential to hit line drives, however, he tends to concur with the overall top hand theory espoused by Ted Williams. Williams (89) states that, in order to achieve maximum power and efficiency in the swing, the stronger hand should be closest to the point of contact. He emphasizes his point by citing the fact that seven out of nine of the most outstanding left-hand hitters in the history of the game were naturally left-handed. This investigator believes that the top hand serves a two-fold purpose: 1) it serves to drive the head of the bat out in front of the body, and 2) the power potential that this hand can develop serves to allow the batter to change the bat-head angle prior to contact with the ball. A key question that research needs to answer is, "Can this action be developed further?" One method advocated for teaching young players the technique of getting the head of the bat out in front of the plate is to stress "throwing" the end of the bat out in front of the body and at the ball (59).

Balance, Body Control and Relaxation

Equilibrium is probably the most important of all the physical principles involved in sports techniques (14). Research findings indicate that the position from which a player may move the quickest in any direction is with his feet placed shoulder width apart. The weight is equally distributed on each foot, and the weight of each foot should be distributed between the ball of the foot and the heel (18, 64). The expression, "keep on your toes" then, is symbolic of the center of gravity as opposed to a literal translation. The center of gravity of the batter's stance is the point where effective weight of the body is centered. This position is a prime factor in determination of the soundness of the stance. The selection of shoulder width alignment is based on two characteristics of stability and one general principle of equilibrium: 1) stability is directly proportional to the area of the base on which the body rests, and 2) for equilibrium to exist, the center of gravity must fall within its base (14). These statements combine to form a general principle that for greatest stability, you increase the area of the base and lower the center of gravity as much as is consistent with the activity involved. When the hitter begins his front leg cocking, he will decrease his base of stability. However, this can be compensated for by slightly increasing the area of the base in the stance segment. Given a starting base slightly wider than shoulder width, when the hitter cocks his front leg, he will decrease the base, but, the area of the base will now fall within the acceptable guidelines for quickest movement. Supplementary to the base concept, the front shoulder and hip rotation

both can function to lower the center of gravity as the batter coils his body in preparation to "exploding" on the ball.

The field of relaxation and specifically the area of differential relaxation hold several interesting concepts for the hitter. The most common reference to relaxing while hitting occurs when the hitter is instructed to flex his knees to unlock the knees and relieve lower leg tension. Other concepts involve keeping the hands relaxed prior to starting the bat movement, or resting the bat on the shoulder to eliminate upper arm tension and to conserve energy (11, 14, 50, 89). The idea of avoiding the bound-up muscle syndrome, promotes the concept that the best swing is made with the least unwanted physical or mental exertion (45).

Jacobson (34) has shown that athletes as a group tend to be more successful in relaxing specific muscle groups to a fuller and more sustained state than ordinary subjects. Why do athletes exhibit superior abilities to relax when compared to the average subject? Jacobson states that the most plausible reply would seem to relate to the daily exercises promoting relaxation. He also cites the concept that habitual exercise tends to avert prolonged reflection, in effect, decreasing muscular contraction potentials that obstruct the achievement of a state of relaxation (35). The recognition and ability to reduce unwanted skeletal muscle tension is of importance to the athlete. Steinhaus and Norris (70) have shown that ordinary teachers and other intelligent persons can be taught to teach neuromuscular relaxation with satisfactory results. The acquisition of this skill would allow the athlete to exercise greater control over his body movements and concentration during competition.

The powers of concentration and the effective use of the mind also seem to improve with the use of progressive relaxation. The relaxation course designed by Dr. Steinhaus is based on the following assumptions which relate to physical activity: 1) man can learn to increase his sensitivity or awareness to the point where he will identify these tensions consciously, and 2) upon becoming aware of the muscular tension sensation, a person can learn to increase or decrease the initiating muscular activity in any or all muscles, at will. The implications of these statements are that athletes could minimize the muscular tension that prevents superior or successful motor performance. At the same time, the athlete could increase activity of those muscles directly related to the skill being performed, thereby enhancing performance (70).

Summary of the Baseball Swing Sequence

In summary, the following sequential segments are necessary to become proficient at swinging a bat:

1. Sequentially cock the front leg, pelvis, lead forearm and then the hands in a slow and controlled manner. Incorporate balance and body control prior to, during, and after contact is made with the ball.

2. Utilize a dramatic and powerful rotary hip action and interaction of the legs to develop powerful hip "pop".

3. Coordinate immediate powerful extension of both the front leg and front forearm at the onset of the swing. Through this coordination, develop the ability to hit with a braced front leg, and let the front arm extension interact with the front leg extension to develop a more forceful arm extension (see Figure 2-3).

4. Stabilize the head to allow optimum tracking time and develop better hand-eye coordination.

5. When the upper torso has rotated and the "hands" position is achieved, cock the barrel of the bat toward the pitcher. This action will increase the arc of the bat and add power potential to the swing.

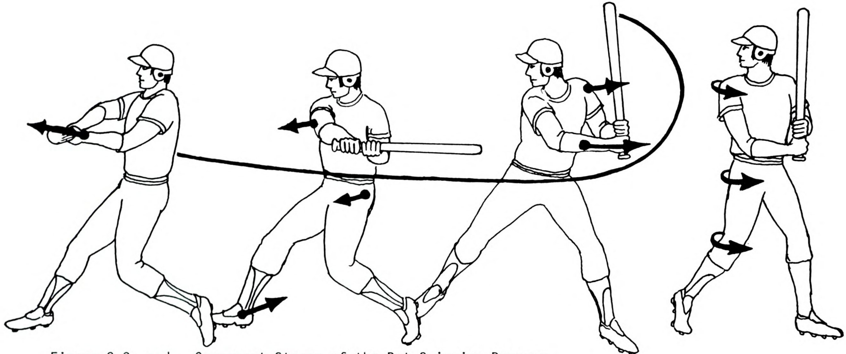

Figure 2-3, a-d. Component Stages of the Bat Swinging Process.

a. Sequential cocking of the front knee, hips and front shoulder.
b. Pulling the bat into the "hands position", and trunk rotation.
c. Violently pushing back the weight with the front leg; simultaneously throwing the back hip forward, generating hip "pop"; fully extending the front arm at the onset of the swing.
d. Developing rapid top hand action during the movement pattern of the bat. This stage also demonstrates the batter hitting against a braced, fully extended front leg.

The complete sequence demonstrates the batter maintaining body balance in the cocking phase, during the swing movement pattern, and after contact with the ball.

6. Develop a strong hand action after the arms are well into the hitting zone.

7. Develop the top hand movement pattern to improve bat-head velocity and allow the hitter to change the bat angle prior to making contact with the ball.

8. Develop the ability to differentially relax and achieve control over muscular tension, thereby enhancing mental and motor patterns of the body.

Chapter III

METHODS AND PROCEDURES

The objective of this research endeavor was to ascertain if use of the "Flexibat" $_{T.M.}$ would result in greater bat-head velocity. It was theorized that use of this training device would facilitate top and bottom hand integration thereby enabling a batter to swing a baseball bat with greater velocity.

SUBJECTS

The subjects were twelve Michigan State University baseball players. They ranged from 18 to 21 years of age, with the mean age established at 19.5 years. The players were randomly selected from stratified class groupings (3 freshmen, 3 sophomores, 3 juniors, and 3 seniors) and systematically assigned to one of two groups. Finally, the two groups were randomly designated as either control or experimental.

TRAINING ENVIRONMENT

The research training program took place in a well lighted paddleball court in Jenison Fieldhouse, located on the main campus of Michigan State University. The court had dimensions of 31'8" by 19'1". The location of the court in the basement of Jenison Fieldhouse also provided excellent control over noise and other disruptive variables.

The court environment also was very conducive to providing augmented feedback to the subjects. Modeling, behavior modification, visual imagery and symbolic coding were used with both groups to enhance learning. The dimensions of the court were also conducive to working in pairs, and that method therefore was adopted for both groups during the training program.

THE "FLEXIBAT" T.M. APPARATUS

The Principal objective of the "Flexibat" T.M. is to provide a new coaching tool in baseball which is adaptable to individual batting styles and to enable the batter to achieve proper bat acceleration prior to impact with the ball. It is a training device that is designed to coordinate the function of the two hands and, in conjunction with the shoulders, wrists and arms, to provide a dynamic and dramatic upgrading of the velocity of the swing. Another objective is to provide a practice bat which, when swung, immediately provides tactile feedback regarding the degree of hand, wrist, arm and shoulder coordination present. The "Flexibat" T.M. essentially has three parts: 1) a head part, 2) a grip portion, and 3) an articulating joint which attaches the head portion to the grip portion (see Figure 3-1). The joint may be flexed by differential thrust applied at the grip portion and at the head portion. The grip portion of the bat accommodates the full grip of the lower hand of a hitter. In a left handed hitter the lower hand is the right hand. In a right handed hitter the lower hand is the left hand. The upper hand of the hitter grips the head portion of the bat at the lowermost end.

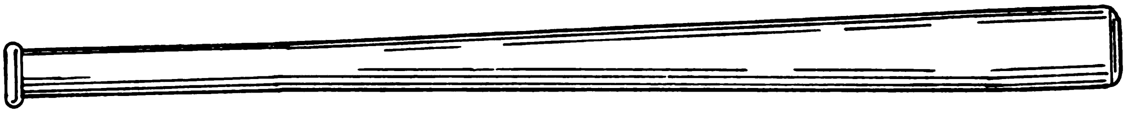

Figure 3-1A

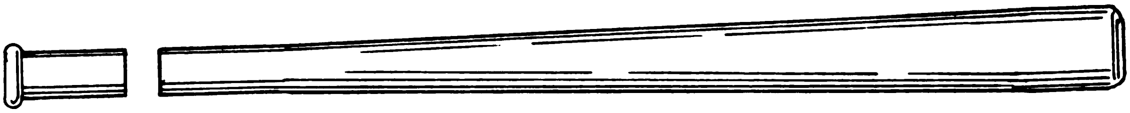

Figure 3-1B

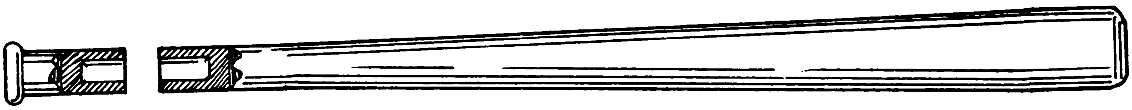

Figure 3-1C

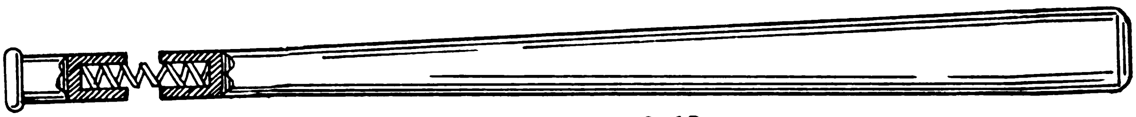

Figure 3-1D

Figure 3-1A to 3-1G. Sequential stages in the development of a "Flexibat" T.M.

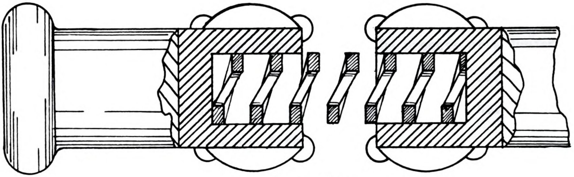

Figure 3-1E

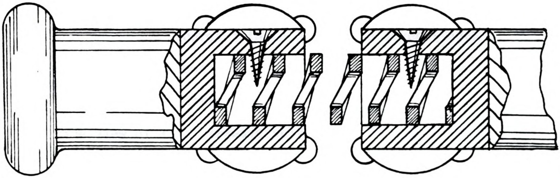

Figure 3-1F

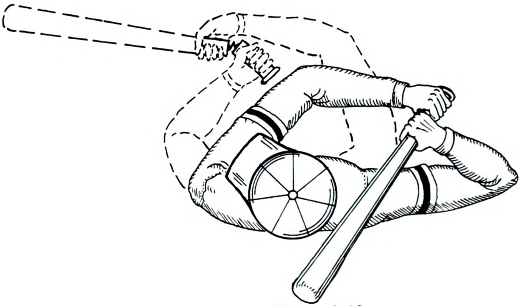

Figure 3-1G

A bumper is situated on both sides of the articulating joint so that the fingers of the batter will not be pinched during the process of swinging. The articulating joint is a resilient element consisting of a coil spring with its ends secured to the handle portion and to the head portion of the bat with both epoxy and transverse pins.

DIAGRAM OF THE "FLEXIBAT" T.M.

A sideview of the sequential stages for producing the "Flexibat" T.M. is presented in Figures 3-1A to 3-1G. The seven stages of the figure are explained as follows:

1A A side view of a normal bat

1B A side view of a bat transversely cut to form a handle portion and a head portion

1C A side view of a bat with the handle and head portions partially cut away to reveal the axial openings in the adjacent ends of the respective head and handle portions

1D The cut away portions with a spring inserted in the axial openings of both the head and handle ends

1E A partially cut away portion of the "Flexibat" T.M. enlarged to show the spring potted and embedded in a silicone filler and matrix, plus illustrating the protective bumpers surrounding the cut portions

1F The potted spring with screw fasteners providing transverse anchorage for the spring into the matrix

1G A top view of a batter gripping the "Flexibat" T.M. The solid lines show the start of the swing and the broken line depicts the follow through and the flexure at the spring joint between the hands. The top hand drives the head portion out in front of the posting lower hand. This motion imparts desired hand coordination and integration required for maximum acceleration of the bat at the zone of impact.

THE TRAINING PROGRAM

The training program was scheduled for 24 sessions, spaced over a nine week period. Sessions generally were conducted three times per week.

The training program consisted of a lead-up batting drill that was conducted in a series of progressive stages. There were three bi-level stages and one single level stage in the batting drill. The table 3.1 shows an overview of the batting drill which was repeated during each of the 24 training sessions.

STAGE I, LEVEL 1 AND LEVEL 2

In level one of the batting drill, the batter was situated on one knee, in an otherwise normal batting stance. The hitter's front leg was used to push against the floor as the swing took place. The hitter used a broomstick for a bat and swung at 25 plastic golf balls thrown by a "feeder". The broomstick was 34 inches long and had a hole drilled in the handle with a thong attached which was placed around the wrist of the batter for safety purposes. The "feeder" was located 15-20 feet in front of the hitter; he was also situated on one knee and additionally was positioned behind a protective screen. The "feeder" delivered the golf balls in a rapid sequential pattern, using a "dart throw" release and moderate ball velocity. The "dart throw" release allowed the batter to focus on a consistent point of release throughout the training program. Controlling the point of release utilized by the "feeder" allowed the

Table 3.1 Overview of the batting drill

		Experimental Group	Control Group
Stage I	Level 1	Stance - one knee	Stance - one knee
	Level 2	Stance - standing	Stance - standing
		Equipment: 34" broomstick 25 plastic golf balls	Equipment: 34" broomstick 25 plastic golf balls
Stage II	Level 1	Stance - one knee	Stance - one knee
	Level 2	Stance - standing	Stance - standing
		Equipment: modified "Flexi-bat" dowel 25 tennis balls	Equipment: weighted dowel 25 tennis balls
Stage III	Level 1	Stance - one knee	Stance - one knee
	Level 2	Stance - standing	Stance - standing
		Equipment: "Flexibat"T.M. 25 tennis balls	Equipment: Weighted bat 25 tennis balls
Stage IV	Level 1	Stance - standing	Stance - standing
		Equipment: regulation bat 25 tennis balls	Equipment: regulation bat 25 tennis balls

hitter to develop both his concentration and isolation capacities. The rapid sequence forced a speed overload on the hitter by not allowing time to fully return the bat to the "hands" position before another ball was released. The hitters were instructed to strive for maximum contact with the golf balls.

After the first batter completed his turn swinging from one knee, he proceeded to the second level of Stage I. At this level, the hitter assumed the normal upright stance. The "feeder" still pitched from behind the protective screen, and he continued to utilize a rapid sequence of delivery with medium ball velocity when throwing.

During level one and level two of the initial stage, the investigator recorded the number of contacts each batter made with the golf balls. This raw data was charted and recorded for future graphic display as a measure of the progress made in hand-eye coordination during the program.

Instruction during the initial stage was directed at development of rapid hand action, the utilization of shoulder rotation to reach the "hands" position, and pushing back with the front leg to allow interaction between the front arm extension and the front leg extension. When in the upright position, the hitters incorporated <u>slow</u> and <u>controlled</u> front leg cocking action and hip/pelvic rotation away from the pitcher in the initiating stage of the stride.

STAGE II, LEVEL 1 AND LEVEL 2

During Stage II of the batting drill, the stance on one knee (level 1) and the normal batting stance (level 2) were used again.

During this stage of the drill the batter was situated on one knee with the front leg extended toward the pitcher. The control group used a larger weighted dowel to hit 25 thrown tennis balls. The experimental group used a dowel that had been modified into a "Flexibat" T.M. and was equally weighted to that of the control dowel. The experimental group also swung at 25 thrown tennis balls.

All other conditions of Stage I were repeated. Ball velocity and rate of sequential delivery were standardized as much as possible throughout the stages of the training program. After the first batter had finished level 1, he continued on to level 2. The subjects exchanged places after the first batter had completed both levels of the second stage of the drill.

The techniques that were stressed in the one knee position were: 1) development of rapid hand action, 2) utilizing shoulder rotation to reach the "hands" position, and 3) pushing back with the front leg to allow interaction between the front arm and the front leg extension.

When the hitters were in the upright, standing position, incorporation of a slow, controlled front leg cocking action and pelvic/hip cocking away from the pitcher were synchronized with prior techniques to develop the mature striking pattern.

STAGE III, LEVEL 1 AND LEVEL 2

Stage III was the final bi-level stage of the leadup batting drill. In this stage, the control group used a regulation bat and the experimental group used a regular "Flexibat" T.M. . The "Flexibat" T.M.

had a weight overload mechanism built into the bat which was established at 52 ounces. The control bat was altered so that its weight was equal to that of the "Flexibat" T.M. .

The first batter was again situated on one knee and instructed to use the hands and front arm extension in opposition to the front leg extension to develop more power in the swing. The "feeder" still threw at medium speed and maintained a fairly rapid sequence pattern of delivery. This sequence was structured to allow the hitter to return the bat to the "hands position" before another ball was released. After the first batter had hit from both the one knee position and upright position, the subjects switched places and repeated the entire sequence of events.

Incorporation of proper batting mechanics during the upright position of the second level were stressed throughout the training program. When the batters were situated on one knee, front arm extension, shoulder rotation, rapid hand action and front leg extension were equally stressed throughout the program.

STAGE IV

The final stage of the batting drill was performed with a normal weighted and regulation length bat. This stage was developed to allow the hitter, from an upright stance, to receive kinesthetic and proprioceptive sensory feedback from the newly developed movement pattern. The rate of delivery in this stage was somewhat slower, providing the hitter with sufficient time to prepare himself mentally and physically for the next delivery. The intention was to allow time for visualization and synchronization of the component parts of the swing, and through this synchronization, maximize the feedback received by the hitter while executing the baseball swing.

TESTING PROCEDURES

The testing procedure for obtaining the pretest and the post test data involved the use of the Maroth Velocity bat (see figure 3-2). This device measures bat velocity in miles per hour. Prior research projects by Kuklenski (43) and Swangard (74) have established the validity and the reliability of the Velocity bat.

The subjects were instructed on how to use the Velocity bat prior to the pretest session. Each subject was allowed one practice swing. The actual test required the subjects, in groups of four, to swing the bat in sequential order until each subject had registered five scores. The sequential rotation procedure was used to eliminate any possible fatigue effects. Both the pretest and the post test were conducted in the same manner and took place in the same location as the training program.

STATISTICAL ANALYSIS

The data from the pretest was used to establish the pretraining bat velocity for each subject. The mean bat velocity of each subject was computed and the results were analyzed with a t-test for significant differences between the two groups.

The post test data will be gathered and analyzed contingent upon the pretest results. The level of significance established for the rejection of the null hypothesis was .10.

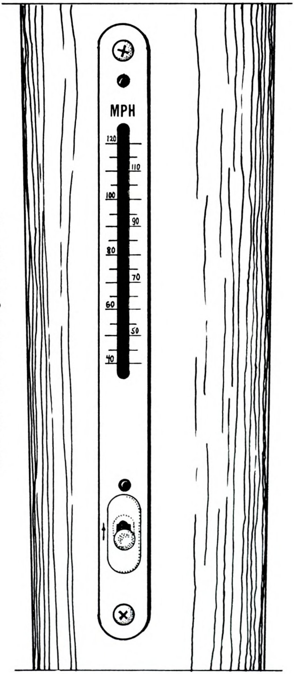

Figure 3-2. The maroth velocity bat.

The raw data from levels one and two of the initial stage will be graphically displayed. Should apparent differences result, a Repeated Measures ANOVA will be utilized to analyze the data from the two groups.

CHAPTER IV

RESULTS AND DISCUSSION

This study was designed to determine: 1) the effect of training with the "Flexibat" $_{T.M.}$ on developing and integrating top hand action with bottom hand action in the baseball swing, and 2) the effect this resultant integration had on bat-head velocity.

This chapter will begin with a presentation of descriptive statistics pertaining to the performance of the experimental and control groups on bat velocity. This will be followed by results relating to the hypothesis under investigation and by graphic representation of the pattern of responses for each group when striking from the two stances included in the training program. The chapter concludes with a brief discussion of the results.

Results

Twelve Michigan State University baseball players ranging in age from 18 to 21 years were involved in the study. The subjects were randomly selected from stratified class standings and then systematically divided into two groups. Each subject was given two practice swings with the Maroth Velocity bat to become familiar with the procedure used to establish baseline bat velocity. Following the warm-up and the practice swings, the players took five swings with the velocity bat

to determine their initial bat velocity. The players then participated in a twenty-four session training program conducted over a nine-week period. At the conclusion of the training program, the subjects were retested with the Maroth Velocity bat to establish their final bat velocity. These data were then analyzed using a t-test for significance between two independent groups.

Descriptive Statistics

The means and standard deviations for the pre- and post-test bat velocity scores are presented in Table 4.1. The results indicate that the pretest means of the two groups are nearly identical. The post-test scores indicate that the mean bat velocity of the experimental group is substantially higher than that of the control group. The results also show that mean bat velocity of the experimental group increased 11.9 miles per hour after participation on the training program compared to 3.5 miles per hour for the control group.

Table 4.1 Means and standard deviations for bat velocity of the experimental and control groups. (Figures in miles per hour.)

Group	Pre-Test		Post-Test		Gain Scores	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Experimental	89.7	8.1	101.6	8.8	11.9	6.1
Control	89.0	5.2	92.4	10.2	3.5	6.5

Inferential Statistics

The data were analyzed by a t-test for significance between the means of two independent groups. The pretest data were subjected to analysis to determine if the mean bat velocities of the two groups were significantly different. The results of this preliminary analysis showed that the difference in the starting mean bat velocities of the two groups was not statistically significant at the .10 level.

The first hypothesis was that use of the "Flexibat" T.M. would develop the top hand movement pattern in the baseball swing. This top hand movement pattern was theorized to drive the bat head forward in the movement pattern of the bat, and any subsequent development of this movement pattern would create a dramatic and significant upgrading of bat velocity as the integration of the top hand and bottom hand action occurred. This hypothesis was tested through use of a t-test for significance between two independent groups. The means were established from the scores of five sequential swings by each subject participating in the study (see Appendix A). An alpha level of .10 was selected to determine statistical significance.

Analysis of the bat velocity data revealed that there was a statistically significant difference between the experimental subjects and the control group subjects, t=2.362 (see Table 4.2). The original alpha level selected to determine statistical significance was .10. The analysis revealed that the t value actually computed to slightly better than the .05 level of significance.

Table 4.2 T-test for significance between means of two independent groups.

Bat Velocity						
Group	Post-test		Gain Scores			
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	t	P
Control	92.4	10.2	3.5	6.5		
Experimental	101.6	8.8	11.9	6.1	2.362	.05

A second problem undertaken in the study was to determine if hand-eye coordination would be improved through the use of a hitting drill using modified striking implements and altered ball sizes (in this case a broomstick and plastic golf balls). It was assumed that an increase in the number of contacts made with the golf balls as the training program progressed would represent an improvement in hand-eye coordination. Table 4.3 depicts the progress of both the control and the experimental groups during the initial, middle and final thirds of the training program. The data from Table 4.3 indicate that both the control and experimental groups progressively improved their hand-eye coordination throughout the training program. However, these data also show that gains between each phase of the program and over the entire program generally favor the experimental group.

Table 4.3 Mean percent of contacts made with the plastic golf balls.

		Training Program					
Group	Stance	Initial Third	Middle Third	Gain	Final Third	Gain	Total Gain
Control	1-Knee	71	78	7	83	5	12
Experimental	1-Knee	70	79	9	85	6	15
Control	Upright	72	78	6	83	5	11
Experimental	Upright	70	81	11	85	4	15

The range of contact scores for both the control and the experimental groups drawn from the raw data in Appendix B are presented in Table 4.4. This table illustrates the disparity in intragroup scores and intergroup scores during various phases of the training program. The data indicate that both groups made substantial progress in contacting a greater percentage of golf balls during the program. It also shows that the range of performance for both groups was greatly reduced during the final third of the training program.

Table 4.4 Range of contact scores within groups for each third of the training program (expressed in percent values).

Group	Stance	Initial Third	Middle Third	Final Third
Control	Kneeling	61-76	75-84	78-89
Experimental	Kneeling	60-83	68-84	78-90
Control	Standing	60-73	77-83	78-86
Experimental	Standing	41-83	77-84	77-90

Table 4.5 illustrates the range of gain scores within groups for the middle third, final third and total training program. While no clear pattern of response is evident from the data presented, certain observations can be made from this information. First, the range of initial gain scores in striking the golf balls was diverse. Second, some individuals decreased in their ability to contact the golf balls during the middle third of the training program as denoted by the negative values. Third, at least one performer in the experimental group failed to improve during the training program. However, other individuals made gains up to 43 percent.

Table 4.5 Range of gain scores within groups for the middle third, final third and total training program (expressed in percent values).

Group	Stance	Middle Third	Final Third	Total Gain Scores
Control	Kneeling	3 to 21	-4 to 10	5 to 18
	Standing	- 4 to 17	1 to 17	9 to 18
Experimental	Kneeling	-15 to 20	1 to 12	-5 to 24
	Standing	- 6 to 38	0 to 10	-6 to 43

The results of the contact made with the thrown golf balls during individual sessions (in sets of 25 thrown golf balls) are graphically illustrated in Figures 4-1 and 4-2. These figures show a general upward trend in striking performance and suggest that learning was still occurring during the final sessions of the training program. Figure 4-1 indicates that there was an upward trend in successful contacts from the kneeling

position as the training program progressed. However, the scores reflect a slower pattern of development for hand action and trunk rotation than what occurred with the upright stance (Figure 4-2). During the initial third of the training program (sessions 4-10) for the upright stance, there was great fluctuation in performance as techniques were presented and contingently reinforced. During the middle third of the program (sessions 11-17), the experimental group exhibited an upward trend in performance while members of the control group continued to fluctuate in their ability to contact the golf balls. However, during the final third of the program there was still considerable fluctuation in the group scores - they were ranging between the eightieth and eighty-eighth percent success marks. Thus, while fluctuation of scores continued throughout the program, the range within which the fluctuations occurred progressively diminished and the percent of successful contacts increased. Table 4.6 depicts the range of fluctuation for the initial, middle and final segments of the training program. The data reveals that the groups progressed from a percent level of success in the mid-sixties during the first third of the program to a level representing from eighty to ninety percent success at the conclusion of the training program.

Table 4.6 The range of fluctuation in striking success from the kneeling and standing positions during segments of the training program (expressed in percent values).

Group	Stance	Initial Third	Middle Third	Final Third
Combined	Kneeling	64-76	68-88	80-90
Combined	Standing	60-79	72-88	80-88

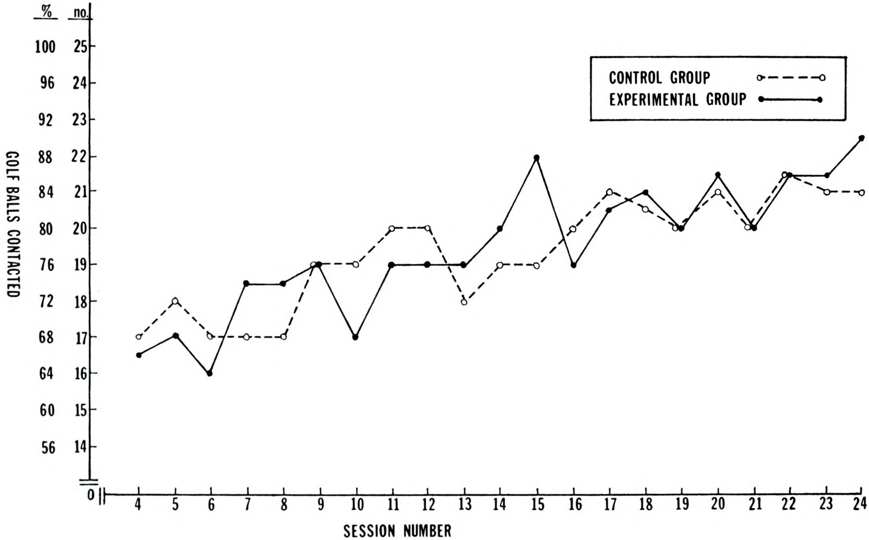

Figure 4-1 Successful contacts with golf balls from the kneeling stance (expressed in terms of absolute and relative scores).

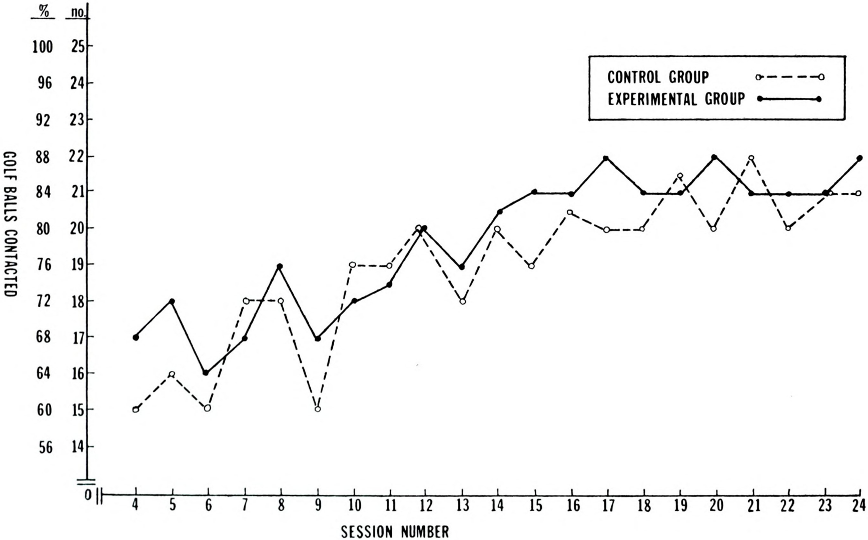

Figure 4-2 Successful contacts with golf balls from the standing stance (expressed in terms of absolute and relative scores).

In summary, the first hypothesis was that training with the "Flexibat" $_{T.M.}$ would develop the top hand movement pattern in the baseball swing. The subsequent integration of this newly developed movement pattern with the bottom hand was theorized to cause a statistically significant increase in bat velocity. This hypothesis was supported by the results obtained from the velocity data.

The second hypothesis was that modification of striking implements and ball sizes would lead to an increase in hand-eye coordination. The data presented in Table 4.6 support this hypothesis by illustrating the increased consistency in performance as well as the increased level of performance during the training program for both the kneeling and standing positions. Similar support for the hypothesis was presented in Figure 4-1 and 4-2 where progress in hand-eye coordination for successfully striking golf balls was plotted on a session by session basis. The rankings by percentages presented in Appendix C also support the hypothesis regarding an improvement in hand-eye coordination.

Discussion

The purpose of the study was to determine the effect of training with the "Flexibat" $_{T.M.}$ on the development of the top hand movement pattern in the baseball swing. A dramatic upgrading of bat velocity was theorized to occur when the top hand pattern was integrated with the bottom hand action of the swinging process.

The results of this study support the contention that the "Flexibat" $_{T.M.}$ will develop the top hand movement pattern in the baseball swing. The results also support the theory that the subsequent integration of this newly developed top hand action with the bottom hand action will result in a dramatic, statistically significant improvement in bat velocity.

A second concern of this study was to determine if the modification of both the striking implement and the ball size would lead to an increase in hand-eye coordination. The results of this portion of the study indicate that the subjects did improve their overall hand-eye coordination during the training program. However, the rate of improvement was not identical. The performance level of the control group was higher in the kneeling stage for the first half of the training program, whereas the experimental group had the higher performance level for the entire second half of the training program. Neither group showed a higher level of performance using the upright stance during the initial one-third of the training program, however the experimental group had the higher level of performance during the middle third of the training

program. By the end of the final third of the training program the performance levels of the experimental and control groups were very similar. There were problem areas, however, within the modified striking portion of the training program with both control group and experimental group subjects. One experimental subject demonstrated a higher initial contact percentage than he did in either the middle segment or the final third of the program. In addition, two control group subjects decreased their bat velocity during the training program.

The experimental subject who decreased in performance throughout the program initially had a stabilized "hands position" in his stance. However, this "hands position" was held tightly against his body which restricted the top arm extension during bat swinging process. As development of trunk rotation and the subsequent hand movement into a more fully extended position occurred, the subject temporarily decreased his bat control and subsequently exhibited a variety of arcs with his bat during the swinging process. This variability in the range of motion throughout which his bat moved continued as he incorporated the additional motor units necessary to accomplish the task at hand, and the ability to eliminate those motor units that were obstructing his swing movement pattern. This subject also experienced a decrease in contact accuracy and began to lose confidence in himself. However as reinforcement, application of bio-mechanics, symbolic coding of the various stages of hitting and practice took place the performance level of the subject began to improve. The subject was approaching his initial level of performance as the program concluded its final sessions.

One of the control subjects who decreased in final bat velocity had a problem with anxiety level and muscular tension during the swinging process. Excessive force applied by the hands while gripping the bat caused the arm and upper torso muscles to exhibit a high state of tension. When a swing was initiated by the subject the entire upper torso and arms rotated as one unit.

The second control subject who decreased his final bat velocity had difficulty developing the rapid hand action during the kneeling phase of the training program. This subject developed the front leg cocking process early in the training program. However, he was never able to demonstrate a slow and controlled front leg cocking action. The problems this subject had stemmed from: 1) having too fast a front leg cocking process, 2) landing flat footed thereby restricting the amount of braking action and reverse push he could develop, and 3) collapsing the top arm against the side of his body immediately preceding bat movement, thus virtually eliminating effective use of the driving action of the top hand and causing the front arm to pull the bat through the swinging process. The ineffective use of the top hand causes this motion to be labeled as "sweeping". These mechanical faults combined to cause the subject to reduce the overall velocity generated during his swing.

The general increase in the experimental group's contact percentage indicates that this group developed the rapid hand action at a faster pace than did the control group. The ability to utilize the top hand action to drive the bat-head forward, and to change the striking angle of the bat-head so it more closely approximated 180 degrees at the

point of contact with thrown balls were capacities concurrently developed through the use of the "Flexibat" T.M.. The value of the "Flexibat" T.M. appears to be in the domain of developing the ability to: 1) increase the top hand action during the bat swinging process, 2) maximize force production during this process by allowing the hitter to extend the striking lever to an angle very closely approaching the 180 degree mark at the point of impact, and 3) to increase actual bat velocity through the integration of the top hand action with the bottom hand action during the bat swinging process. The capacity to alter the striking angle of the bat is interpreted as being of equal importance to increasing the actual bat velocity when considering the potential of the "Flexibat" T.M. training device.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

The purpose of the present investigation was to determine the effect of training with the "Flexibat" T.M. on developing the top-hand action in the baseball swing, and then to determine what effect the subsequent integration of the top hand pattern with the bottom hand pattern would have on bat-head velocity. Two groups of Michigan State University baseball players ranging in age from 18 to 21 years participated in the study. Each group of six subjects was pretested with a Maroth Velocity bat to determine their baseline bat velocity. The subjects then participated in a twenty-four session training program that was spaced out over a nine week period. The training program consisted of a lead-up batting drill that was conducted in a series of progressive stages. There were three bi-level stages and one single level stage in the drill. Following completion of the training program, the subjects were post-tested with the Maroth Velocity bat to obtain their final bat velocity.

Data from the post test group scores were analyzed with a t-test for significance of mean scores. Analysis of the data indicated that the bat velocities from the experimental group using the "Flexibat" T.M. were

significantly higher than those obtained from the control group. Graphs were constructed depicting the grand mean of each group for scores in striking plastic golf balls from both the one-knee and the normal upright batting stance. Analysis of the scores and the resultant graphs showed that both groups dramatically improved their hand-eye coordination. In the one-knee phase, the control group held the early performance advantage in the training program. By the midway point, however, the experimental group equaled the performance level of the control group. During the final third of the training program they either equaled or surpassed the efforts of the control group. For the normal upright stance, the accuracy of the experimental group in striking golf balls exceeded that of the control group for the first two-thirds of the training program. During the final third of the training program, the performances of the control group and the experimental group were similar. Thus, while the performance of one group exceeded that of the other during the early phases of the training program, the other group eventually caught and periodically surpassed the first group during the later sessions of the training program.

Conclusions

The following conclusions are drawn from the data within the limitations of the study:

1. The "Flexibat" $_{T.M.}$ does develop the top hand movement pattern involved in swinging a bat.
2. The subsequent integration of the newly developed top hand action with the already developed bottom hand action leads to

a dramatic, significant increase in bat-head velocity. The performance of the experimental group using the "Flexibat" T.M. was superior to the group not using the training device.

3. The hand-eye coordination of both groups increased dramatically with the use of a lead-up batting drill that used both modified hitting implements and adjusted ball sizes.

Recommendations

The following suggestions are offered for future research on the problems investigated in this study:

1. Replication of this study should be undertaken in order to validate the findings.

2. Studies should be undertaken to determine the optimal length and number of training sessions necessary for the development of bat-head velocity when using the "Flexibat" T.M..

3. The subjects in the present study were chosen from a small available sample with a restricted age range. It is recommended that a larger number of subjects at various chronological ages be studied to determine the effects of training with the "Flexibat" T.M..

4. Future studies should determine if just swinging the "Flexibat" T.M. with the Power Fan attachment would result in a marked increase in bat velocity.

5. Since all the subjects in this study were male, an attempt should be made to include women in a study to determine the applicability of the training device to women athletes.

6. A study should be undertaken to determine if weight training could additionally enhance the force production phase of swinging a bat. Specifically, a training program that developed: 1) the triceps of the front arm, 2) front leg extension, 3) rear leg extension, and 4) top hand action, should be examined.

APPENDICES

APPENDIX A

GROUP VELOCITIES IN MILES PER HOUR

Table A.1 Control and experimental group bat velocities.

Group		Pre-Test Mean	Trial 1.	2.	3.	4.	5.	Post Test Mean	Gain Score
Experimental									
Subject	1.	84	96	93	96	102	92	95.8	11.8
	2.	83.6	85	87	89	89	90	88.2	4.6
	3.	94.6	114	113	113	110	114	112.8	18.2
	4.	98.4	107	109	111	104	106	107.4	9.0
	5.	97.6	110	106	102	105	104	105.4	7.8
	6.	80.0	96	101	99	102	103	100.2	20.2
								Total group	11.9
Control									
Subject	1.	88.8	86	86	89	88	86	87	-1.8
	2.	83.2	84	87	85	85	84	85	1.8
	3.	84.2	86	85	86	86	85	85.6	1.4
	4.	90.6	85	90	88	88	85	87.2	-3.4
	5.	89.4	94	100	101	99	105	99.8	10.4
	6.	97.6	110	111	109	110	110	110	12.4
								Total group	3.5

APPENDIX B

RAW DATA FOR GOLF BALL CONTACTS

DURING THE TRAINING PROGRAM

Table B.1 Raw data for experimental group scores of golf ball contacts during the training program.

Subject	Session 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Gain scores between the middle third, final third and total program
	Experimental Group, One-Knee Position																					
1.	22	21	19	21	22	20	20	20	18	20	20	22	19	20	21	17	23	16	20	18	22	-15 +10 = -5
2.	13	15	11	16	17	17	16	21	21	21	19	19	16	23	23	19	20	18	20	21	21	20 + 1 = 21
3.	12	12	15	16	18	17	15	19	18	16	17	20	20	18	17	19	22	22	20	24	22	13 +10 = 23
4.	21	20	15	16	17	20	20	17	16	18	22	22	20	22	22	20	21	22	23	20	24	10 + 3 = 13
5.	19	21	23	20	21	19	15	19	19	23	23	24	20	19	21	24	21	19	24	23	23	5 + 5 = 10
6.	12	12	15	22	16	20	18	19	21	17	17	24	18	21	22	23	22	22	22	23	23	12 +12 = 24
Group Mean	16.5	17	16	18.5	18.5	19	17	19	19	19	20	22	19	20.5	21	20	21.5	20	21.5	21.5	22.5	9 + 6 = 15

Subject	Session 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Gain scores between the middle third, final third and total program
	Experimental Group, Upright Position																					
1.	21	23	21	19	22	20	19	19	18	19	20	20	18	20	21	15	21	19	18	19	22	-6 + 0 = -6
2.	12	12	10	16	19	5	17	23	19	20	18	19	22	18	20	22	21	18	22	24	22	38 + 5 = 43
3.	13	14	14	10	15	16	16	20	21	20	21	17	20	22	23	22	22	22	22	20	21	25 + 6 = 31
4.	20	22	15	16	20	21	20	17	21	18	22	24	19	24	23	23	23	24	24	24	22	7 +10 = 17
5.	19	22	22	20	21	23	18	17	20	18	22	23	23	24	21	21	22	22	20	18	25	1 + 1 = 2
6.	18	17	15	21	16	18	17	15	23	21	20	24	22	22	20	23	22	22	21	20	24	14 + 3 = 17
Group Mean	17	18	16	17	19	17	18	18.5	20	19	20.5	21	21	22	21	21	22	21	21	21	22	11 + 4 = 15

Table B.2 Raw data for the control group scores of golf ball contacts during the training program.

Subject	Session 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Gain scores between the middle third, final third and total program
Control Group, One-Knee Position																						
1.	16	17	19	17	17	19	20	19	20	18	20	20	20	22	23	23	22	23	22	21	22	8 + 10 = 18
2.	17	20	19	18	17	17	21	22	20	17	18	21	20	19	22	22	21	21	22	23	20	4 + 7 = 11
3.	14	13	11	17	16	18	18	20	21	21	18	18	22	23	18	20	20	19	21	18	21	21 + -4 = 17
4.	18	20	19	20	17	17	15	16	20	18	20	18	19	20	18	19	22	21	21	19	19	3 + 4 = 7
5.	22	20	19	15	17	21	19	22	20	21	21	20	21	22	22	19	22	22	23	22	22	8 + 2 = 10
6.	15	16	16	15	20	20	22	21	21	15	18	19	17	19	20	18	18	16	20	21	20	3 + 2 = 5
Group Mean	17	18	17	17	17	19	19	20	20	18	19	19	20	21	20.5	20	21	20	21.5	21	21	7 + 5 = 12
Control Group, Upright Position																						
1.	13	16	15	20	20	19	23	24	23	17	22	20	22	22	20	23	22	19	21	23	21	11 + 2 = 13
2.	16	17	21	16	17	17	22	20	24	20	20	21	21	20	21	22	21	23	23	20	21	11 + 3 = 14
3.	11	13	17	16	17	15	17	19	20	16	20	18	23	18	18	19	20	23	19	18	19	17 + 1 = 18
4.	16	17	19	22	17	19	17	19	19	21	19	17	19	24	20	20	17	21	18	25	23	6 + 3 = 9
5.	19	12	15	17	18	20	20	19	19	20	22	20	20	19	22	23	20	22	20	21	22	10 + 7 = 17
6.	14	20	17	17	20	17	16	13	14	14	17	18	18	19	21	22	18	22	19	20	22	-4 + 17 = 13
Group Mean	15	17	15	18	18	15	19	19	20	18	20	19	20.5	20	20	21.5	20	22	20	21	21	6 + 5 = 11

APPENDIX C

INTERGROUP RANKINGS BY PERCENTAGE OF GOLF BALL CONTACT

Table C.1 Ranking by percentage of golf ball contacts for both groups from the one-knee position.

Group	Initial Third		Middle Third		Final Third	
Combined	1.	ES1-83	2.	ES4-84	1.	ES6-90
	2.	ES5-79	2.	ES5-84	2.	ES5-89
	3.	CS5-76	2.	CS5-84	3.	CS1-89
	4.5	ES4-74	4.	CS3-82	4.	ES4-87
	4.5	CS2-74	5.	ES2-80	5.	CS5-86
	6.	CS4-72	6.	CS1-79	6.	CS2-85
	7.5	CS1-71	7.5	ES6-78	7.	ES3-83
	7.5	CS6-71	7.5	CS2-78	8.	ES2-81
	9.	ES6-66	9.	CS5-75	9.	CS4-79
	10.	CS3-61	10.	CS6-74	10.5	ES1-78
	11.5	ES2-60	11.	ES3-73	10.5	CS3-78
	11.5	ES3-60	12.	ES1-68	12.	CS6-76

Table C.2 Ranking by percentage of golf ball contacts for both groups from the upright position.

Group	Initial Third		Middle Third		Final Third	
Combined	1.5	ES1-83	1.5	ES5-84	1.	ES4-90
	1.5	ES5-83	1.5	ES6-84	2.5	ES3-87
	3.	ES4-76	4.	CS1-83	2.5	ES6-87
	4.	CS4-73	4.	CS2-83	4.5	CS2-86
	5.5	CS1-72	4.	ES4-83	4.5	CS5-86
	5.5	CS2-72	6.	ES3-81	6.5	ES5-85
	7.	ES6-70	8.	ES2-79	6.5	CS1-85
	8.5	CS5-69	8.	CS4-79	8.	ES2-84
	8.5	CS6-69	8.	CS5-79	9.5	CS6-82
	10.	CS3-60	10.5	CS3-77	9.5	CS4-82
	11.	ES3-56	10.5	ES1-77	11.	CS3-78
	12.	ES2-41	12.	CS6-65	12.	ES1-77

REFERENCES

REFERENCES CITED

1. Adams, Gary L., Effect of eye dominance on baseball batting. Research Quarterly, 36: 3-9, 1965.

2. Adams, Gene M., The relationship of leg strength to baseball bat velocity. Unpublished Master's Thesis, UCLA, 1965.

3. Adams, Jack A., Response feedback and learning. Psychology Bulletin, 70: 486-504, 1968.

4. Akers, William F., A study to determine the total offensive performance of the major league player. Doctoral Dissertation, Springfield College, Springfield, Mass., 1963.

5. Alston, Walter; Don Weiskopf, The Complete Baseball Book. Boston, Mass., Allyn and Bacon, 475, 1972.

6. Bagg, Ewart J., Effect of mental and physical practice on baseball batting. Unpublished Master's Thesis, UCLA, 1966.

7. Bannister, H.; J. Blackburn, An eye factor affecting proficiency at ball games. British Journal of Psychology, 21: 382, 1931.

8. Bates, Frank H., Relationship of hand and eye coordination to accuracy in baseball hitting. Unpublished Master's Thesis, University of Iowa, 1948.

9. Bartow, Jerome J., The strength of the wrist joint flexors and extensors as they relate to the velocity of the bat. Unpublished Master's Thesis, Washington State University, 1959.

10. Bethel, Dell, A total concept of the hitting action. Scholastic Coach, 37: 11, 1968.

11. ____________, Charley Lau on Hitting, Coach, 47: 9, April, 1978.

12. Breen, James L., What makes a good hitter. Journal of Health Physical Education and Recreation, 38: 36-39, April, 1967.

13. Brown, Paul T., Effects of three intensity levels of warm-up on the reaction time and speed of movement in the baseball swing. Doctoral Dissertation, University of Indiana, 1971.

14. Bunn, John W., Scientific Principles of Coaching. Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1955.

15. Carroll, Richard D., The relationship of prehension to bat swing velocity. Journal of American Association of Health, Physical Education and Recreation, Vol. 1, 1959.

16. Conard, Ruth, A cinematographical analysis of the major sequential movement patterns of skilled, semi-skilled, and non-skilled baseball batters. Doctoral Dissertation, Temple University, 1965.

17. Cook, Earnshaw, Percentage Baseball. Boston, Mass., M.I.T. Press, 1964.

18. Coombs, Jack; Danny Litwhiler, Baseball. Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 4th Edition, 1967.

19. Creger, Larry, A study of movement time from two stances in hitting a baseball. Master's Thesis, Colorado State College, 1960.

20. Deese, Paul W., The effect of weight training on batting movement time. Unpublished Master's Thesis, University of Illinois, 1962.

21. Dulchinos, D. G., A study to determine the relationship of wrist strength to the velocity of swinging a baseball bat. Unpublished Master's Thesis, University of Illinois, 1962.

22. Eccles, John C., The physiology of imagination. Scientific American, 199: 3, 135-145, September, 1958.

23. Ellis, Robert, Hit your pitch, not the pitchers'. Coach, 46: 7, February, 1977.

24. Falkenstine, J. W., A study on the relationship between ocular dominance and performance in certain selected motor activities. Doctoral Dissertation, Michigan State University, 1959.

25. Fitts, Paul M., Perceptual motor learning. In Arthur W. Melton (ed) Categories of human learning. New York: Academic Press, Inc., 1964.

26. _____________; Michael Posner, Human Performance. Belmont, California, Brooks/Cole Publishing Company, 1967.

27. Flaherty, B. C., The effect of weight training on selected baseball skills. Master's Thesis, San Diego State College, 1962.

28. Fleishman, Edwin A., A comparative study of aptitude patterns in skilled and unskilled psychomotor performances. Journal of Applied Psychology, 41: 263-272, 1957.

29. Fulton, Ruth E., Speed and accuracy in learning a balistic movement. Research Quarterly, 13: 30-36, 1942.

30. Hartsell, L. D., Contrasting approaches to the analysis of skilled sports movements. Journal of General Psychology, 20: 263-293, 1939.

31. Hay, James G., The Biomechanics of Sports Techniques. Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 211-212, 1973.

32. Hooks, G. E., Prediction of baseball ability through an analysis of measures of strength and structure. Research Quarterly, 30: 38, March, 1959.

33. Hubbard, Alfred W.; C. N. Seng, Visual movements of batters. Research Quarterly, 25: 42-57, 1954.

34. Jacobson Edmund, The course of relaxation in muscles of athletes. American Journal of Psychology, 48: 98-108, January, 1936.

35. _______________, Electromyography of mental activities. American Journal of Psychology, 44: 677-694, 1932.

36. Johnson, Thomas F., Locating the critical hitting zone in the bat. Athletic Journal, 37: 38, April, 1957.

37. Kachline, Clifford; Chris Roewe, The Official Baseball Guide. St. Louis, Missouri, C. C. Spinks and Sons, 1965.

38. Kay H., Information theory on the understanding of skills. Occupational Psychology, 31: 218-224, 1957.

39. Keele, Steven W., Movement control in skilled motor performance. Psychological Bulletin, 70: 387-403, 1968.

40. Kitzman, E. W., Baseball: electromyographical study of the batting swing. Research Quarterly, 35: 116, May, 1964.

41. Knapp, Barbara, Skill in Sport: the Attainment of Proficiency. London, England, Routledge and Kegan Paul Ltd., 1963.

42. Koppett, Leonard, A Thinking Man's Guide to Baseball. New York, E. P. Delton and Co., 1967.

43. Kuklenski, Wm. George, A comparative study of the exercise programs on the development of bat swinging velocity, throwing distance and running speed of college freshman baseball players. Master's Thesis, University of Washington, 1969.

44. Lande, Leon, What causes hitting errors. Athletic Journal, 58: 68-86, 1958.

45. Litwhiler, Daniel, Overload: for the quick bat. Athletic Journal, January, 38-42, 1967.

46. MacFarlane, Paul; Chris Roewe; Larry Wiggle, The Official Baseball Guide. St. Louis, Missouri, The Sporting News, 1970.

47. Maltz, Maxwell, Psychocybernetics. Englewood Cliffs, New Jersey, Prentice-Hall Inc., 1960.

48. Marcin, Joe; Chris Roewe; Larry Wiggle; Larry Vichrey, The Official Baseball Guide. St. Louis, Missouri, The Sporting News, 1973.

49. ________; ________; ________; ________, The Official Baseball Guide. St. Louis, Missouri, The Sporting News, 1977.

50. Moses, Wally, Personal communications with, during the 1973 baseball season. Rocky Mt., North Carolina, 1973.

51. Neft, David; L. Allen; R. Markel; J. C. Tattersall; J. A. Deutsch, The Sports Encyclopedia: Baseball. Grossett and Dunlap, 1973.

52. Oxendine, Joseph B., Emotional arousal and motor performance. Quest Monograph XIII. Psychology of Sport, January, 1970.

53. Posner, Michael I., Components of skilled performance. Science, 152: 1712-1718, 1966.

54. Race, D. E., A cinematographic and mechanical analysis of the external movements involved in hitting a baseball effectively. Research Quarterly, 32: 394, 1961.

55. Reiff, Guy G., What research tells the coach about baseball. American Association of Health, Physical Education and Recreation, Washington, D. C., 1-10, 1971.

56. Rickey, Branch, Goodbye to some old baseball ideas. Life, 37: 78-86, August 2, 1954.

57. Sain, John, Lecture notes from Medalist baseball clinic. Hyatt Regency, Chicago, Illinois, 1976.

58. Scott, M. G., Analysis of Human Motion. New York: Crofts, 1945.

59. Siebert, Dick, Lecture notes from Medalist baseball clinic. Chicago, Illinois, 1976.

60. Sievers, Roy, On the art of hitting. Sports Illustrated. 19: 43-44, 1958.

61. Simegoff, James, Integrating baseball's new formula. Athletic Journal, 35: 40, April, 1955.

62. Singer, Robert N., Motor Learning and Human Performance: An Application to Physical Education Skills. 2nd Edition, Mac-Millan Publishing Company, 1975.

63. ________________, Coaching, Athletics, and Psychology. McGraw-Hill Book Company, 1972.

64. Siwoff, Seymour, The Book of Baseball Records. Seymour Siwoff Editor and Publisher, New York, 1977.

65. Slater-Hammell, A. T.; R. L. Stumpner, Batting reaction time. Research Quarterly, 21: 351-356, 1950.

66. ____________________, A neglected batting factor. Scholastic Coach, 20: 14, April, 1951.

67. ____________________, Initial body position and total reaction time. Research Quarterly, 24: 91, 1953.

68. Solley, W. H., The effects of verbal instructions of speed and accuracy upon the learning of a motor skill. Research Quarterly, 23: 231-240, 1952.

69. Spink, C. C. Johnson; Paul Richart; Clifford Kachline, Official Baseball Guide. St. Louis, Missouri, The Sporting News, 1968.

70. Steinhaus, Arthur H.; Jeanne E. Norris, Teaching Neuromuscular Relaxation. Cooperative Research project no. OE 1529, George Williams College, 1964.

71. Stimpson, W. G., The art of golf. Cited by Mrs. Stewart Hanley in the "sense and feel of golf". Journal of Health, Physical Education and Recreation, 8: 366, 1937.

72. Stout, G. F., Manual of Psychology. London, University Correspondence College, 1899.

73. Suinn, Richard M., Body thinking: psychology for olympic champs. Psychology Today, July, 1976.

74. Swangard, Trevor M., Effect of isometric and isotonic weight training programs on development of bat swing, throwing and running in college baseball players. Master's Thesis, University of Oregon, 1965.

75. Swimley, Phillip S., A cinematographical analysis of two selected baseball swings. Master's Thesis, Sacramento State College, 1964.

76. Thorpe, W. H., Learning and Instinct in Animals. Cambridge: Harvard University Press, 1956.

77. Van Huss, W. D.; J. Friedrich; R. Mayberry; R. Neimeyer; H. Olson, Physical Activity in Modern Living. Englewood Cliffs, New Jersey, Prentice-Hall Inc., 2nd Edition, 1969.

78. Vaughn, Ross E., The relationship of certain variables to success in batting. Master's Thesis, Washington State University, 1969.

79. Wathens, David L., Motion pictures as an instructional aid in correcting baseball hitting faults. Research Quarterly, 34: 228-233, 1963.

80. Watson, Louise, A study in the relationship between the ability to relax and athletic ability among college women. Doctoral Dissertation, University of Oregon, 1952.

81. Weems, Fred, An investigation of the comparative effects of various training programs on the velocity of a baseball bat. Master's Thesis, University of Southern Mississippi, 1971.

82. __________, The batting hitch: help or hindrance. Coach, 46: 7, February, 1976.

83. Weiskopf, Don, Batting with Wally Moses. Athletic Journal, February, 38-42, 1969.

84. ____________, Batting styles of the world champions. Athletic Journal, 40: 8-13, 1960.

85. Wells, Katherine, Kinesiology. Philadelphia, W. B. Saunders Company, 1940.

86. Werling, W. E., The relationship of forearm muscle strength to the bat swing velocity. Master's Thesis, University of Maryland, 1962.

87. Wertich, Harold G., Jr., The velocity of the baseball batting swing as affected by the addition of a select resistance exercise to a traditional pre-swing weight training program. Unpublished Master's Thesis, South Dakota State University, 1967.

88. Whiting, H. T. A., Acquiring Ball Skill. Philadelphia, Lea and Febiger, 1975.

89. Williams, Ted; John Underwood, The Science of Hitting. New York, Pocket Books, 1972.

90. Winograd, Samuel, The relationship of timing and vision to baseball performance. Research Quarterly, 13: 481-493, 1942.