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Effects of Same-day Strength Training on Bat Swing Velocity of Male Collegiate Baseball Players

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EFFECTS OF SAME-DAY STRENGTH TRAINING ON BAT SWING VELOCITY OF MALE COLLEGIATE BASEBALL PLAYERS

by

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GRADUATE COMMITTEE APPROVAL

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As chair of the candidate's graduate committee, I have read the thesis of Anthony Clah in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

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ABSTRACT

EFFECTS OF SAME-DAY STRENGTH TRAINING ON BAT SWING VELOCITY OF MALE COLLEGIATE BASEBALL PLAYERS

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The purpose of this study was to investigate the effect of same-day strength training on bat swing velocity of male collegiate baseball players. Sixteen male baseball players engaged in a preseason strength training program designed by the team's strength and conditioning coach. All subjects were tested for bat swing peak velocity immediately prior to ball impact for a non lifting day (NLD) by recording 10 swings with 30 seconds of rest in between swings. The next day, a lifting day (LD), the subjects tested four to six hours after the morning lifting session with the same amount of swings and rest as the NLD. Six Vicon MX13+ infrared cameras (Vicon-Colorado, Centennial, Colorado), running at 400 Hz, were specifically placed around the swinging area using Nexus 1.2 imaging software to download and determine bat swing peak velocity immediately prior to ball impact.

The average of the top six bat swing peak velocity test results, for each subject,

was compared to measures taken on the NLD and LD. A paired samples *t*-test revealed a significant difference in bat swing peak velocity between a NLD and a LD. A mean bat swing difference between NLD (69.18) and LD (70.86) of 1.68 was statistically different at the .05 level [p =.021]. This study suggests that male collegiate baseball players should be able to engage in a designed strength training program without negative effect, and the possibility of a positive effect, on bat swing peak velocity when a strength training session is scheduled on the same day as a baseball competition.

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ABSTRACT

The purpose of this study was to investigate the effect of same-day strength training on bat swing velocity of male collegiate baseball players. Sixteen male baseball players engaged in a preseason strength training program designed by the team's strength and conditioning coach. All subjects were tested for bat swing peak velocity immediately prior to ball impact for a non lifting day (NLD) by recording 10 swings with 30 seconds of rest in between swings. The next day, a lifting day (LD), all subjects tested on the NLD were tested four to six hours after the morning lifting session with the same amount of swings and rest. Six Vicon MX13+ infrared cameras (Vicon-Colorado, Centennial, Colorado), running at 400 Hz, were placed around the swinging area using Nexus 1.2 imaging software to download and determine bat swing peak velocity immediately prior to ball impact. The average of the top six bat swing peak velocity test results, for each subject, was compared to measures taken on the NLD and LD. A matched *t*-test revealed a significant difference in bat swing peak velocity between a NLD and a LD. A mean bat swing difference between NLD (69.18) and LD (70.86) of 1.68 was statistically different at better than the .05 level [p =.021].

This study suggests that male collegiate baseball players should be able to engage in a designed strength training program with a positive effect, and without any negative effect, on bat swing peak velocity when a strength training session is scheduled on the same day as a baseball competition.

INTRODUCTION

The physical prowess of baseball athletes has changed recently with growth of technology and research. The rules and basic strategy remain the same, however, the emergence of baseball specific strength training programs have developed baseball athletes that differ in size, strength, and speed. Success for position specific athletes require the continual development of strength, force production, stability, balance, lateral quickness, reaction time, quick first step reaction and explosiveness. Particularly, batters find success by generating power and control through a complex full body sequence.

This full body sequencing is part of a kinetic chain (Cohen & Mont, 1994; Roetert, Ellenbecker, Chu, & Buggs, 1997), requiring sequential muscle firing and transfer of forces from lower body extremities, to upper body extremities, and to the bat during swing and impact. Strength training programs can be manipulated to maximize the batting kinetic chain and the transfer of forces.

Successful strength training programs are year round involving off-season, preseason, in-season and postseason periods, as well as training for aerobic endurance, for long games and long seasons, and anaerobic endurance, for power to remain consistent over the course of the game and season (Parker, 1985). Initially, it was thought that there was no place for lifting weights in baseball. The pioneers of using weights in professional baseball are considered to be the Oakland A’s, when in 1994 they made room in their stadium for a weight room (Williams, 1997). This transformed to athletes participating in highly rigorous strength training sessions during the off-season, preferring to spend in-season improving sport specific skills. In recent years, however, in-season strength training has become the norm. Even with this shift to increased in-season strength training, players and coaches generally shun strength training on game day, believing that same-day strength training fatigues muscles and decreases mental, physical, and psychological performance.

Fatigue is known to happen after high intensity work when the carbohydrate stores and creatine phosphate (CP) are depleted in the working muscle. A complete depletion of any of these energy stores decrease the contraction for the working muscle being used (Plowman & Smith, 2003). For high intensity activities of short duration, such as baseball, the immediate source of energy for muscular contraction is adenosine triphosphate (ATP) and CP. An athlete's ability to produce force or the ability to maintain the required force can be affected by fatigue. An athlete's physical adaptation to a training program will occur over time when periods of work and rest are successfully manipulated, alternated, and training loads are progressively increased at proper levels of intensity.

The need for aerobic conditioning, even for speed-power sports like baseball, is based on the working muscle and the aerobic training status of the athlete. The availability of oxygen and the oxygen-carrying capacity, which can determine muscular fatigue, are improved with adequate aerobic training.

Athlete recovery can depend on a combination of factors. Within a few minutes of energy depletion, following a training program or game situation, the repletion of various energy stores will occur in a timed sequence. When an athlete has been properly trained and adapted to a given training stimulus, their bodies will require less time to recuperate due to faster physiological adaptation.

During strength training, a highly intensive intermittent exercise, the recovery of ATP and CP must be recovered in order to complete the lifts (sets and reps) of an entire strength training session (Viru, 1994). A proper strength training program includes the necessary recovery period for ATP and CP energy stores. Existing research, although limited, indicates there is no significant negative or significant positive effect on athletic performance, when completing a strength training session on the day of measured skill tests (Kerbs, 2000; Murakami, 2002; Reynolds, 2005; Woolstenhulme, Bailey, & Allsen, 2004). No published research was found evaluating the positive, negative, or no effect of same-day strength training in male collegiate baseball players. Specifically, no published research could be found evaluating the effects of same-day strength training on bat swing velocity. Russell (2003) determined in his research the importance of bat swing velocity to ball speed after impact. He concluded an increased bat swing velocity will cause a baseball to travel further and with increased speed. Part of his conclusion explains how increased bat swing velocity increases ball speed after impact, making the time defensive players need to field the baseball shorter. His results showed increased batting average of professional and college-level baseball teams because of an increase in bat swing velocity.

Statement of Problem

The purpose of this study was to investigate the effect of same-day strength training on bat swing velocity.

METHODS

Subjects

Sixteen members of the men's varsity baseball team at Brigham Young University were asked to volunteer for this study. Subjects included seniors, juniors, sophomores, redshirt freshman, and true freshman. The subjects, at the time of the study, had been involved in a periodized strength training program designed by their head strength and conditioning coach. This included their fall off-season and winter preseason lifting routine. Before subjects were allowed to participate in the study, they completed and signed an informed consent. This study was approved by the Institutional Review Board (IRB) at Brigham Young University.

Strength Training Program

Periodization is the founding concept behind designing a strength training program for any sport. One year is divided into seasons (preseason, in-season, postseason, and off-season) called macrocycles. Mesocycles are monthly/weekly cycles and microcycles represent the daily structure of a strength training program (Baechle & Earle, 2000). During these cycles, load, intensity, and volume can be varied to avoid overtraining and to maintain peak strength and physical performance during a competitive season. The subject's strength training program was adjusted throughout the year according to these stated principles of periodization.

Maximum lift tests were performed at specific weeks during the strength training program. This information combined with periodization was used to help develop an individualized strength training program. Each strength training session included a warm-up routine. Major muscle and full body lifts included warm-up sets to prepare the working muscle for a strenuous workout. These conditions facilitated an increased rate of blood flow helping to prevent muscle pulls, strains, and tears (Bompa, 1999).

Each lift varied between 3 and 8 sets of 4 to 12 repetitions at a training intensity of 60% to 80% of their 1RM. Recovery time between sets was established at 60 to 90 seconds. The phosphogen energy systems should have been completely replenished within ten minutes of ending their strength training session (Viru, 1994). The glycogen energy system should have been completely restored four to six hours after the lifting session (Viru, 1994). These systems should have recovered quicker because the subjects have been participating in a strength and conditioning program starting six months prior to testing (Baechle & Earle, 2000). The following lifts were incorporated in Brigham Young University's baseball strength training program: power clean, back squat, bench press, shoulder circuit, lat pull-down, hammer curl, dumbbell complex, leg press, dumbbell incline, reverse curl, seated row, triceps extension, hang clean, pause squat, dumbbell bench, dumbbell military, reverse hyper, dumbbell triceps extension, and varied forearm routines.

The preseason schedule, during the time the data were gathered, included strength training on Monday, Wednesday, and Friday, utilizing the full body routine. Preseason team practice sessions were scheduled to take place Monday through Friday. Subjects were instructed from the head baseball strength and conditioning coach on proper technique and form prior to starting every strength training session. Furthermore, the strength and conditioning coach was constantly screening and correcting athlete technique and form during every strength training session.

Design

A matched *t* test guided this study. The independent variables were lifting day (LD) and non-lifting day (NLD). The dependant variable was bat swing peak velocity immediately prior to contact.

Procedures

Testing occurred over two consecutive days. On Friday there was no lifting and all subjects were tested. The following day, Saturday, all subjects lifted followed by testing four to six hours later. This transpired during baseball's preseason to prevent interference with the regular season. All subjects participated in the designed three-days-a-week strength training program. Testing procedures remained the same during both testing sessions.

Subjects arrived at the biomechanics lab at a specific time, dressed in their issued practice clothes and shoes. Before each test, the athletes were allowed a self-chosen warm-up which should have been consistent with how they warmed-up prior to real games and remained consistent during testing on NLD and LD. Six Vicon MX13+ infrared cameras (Vicon-Colorado, Centennial, Colorado), running at 400 Hz, were specifically placed around the swinging area and were used to determine bat swing peak velocity immediately prior to ball impact. One reflective spherical marker was placed at 15 cm distal from the "sweet spot" on the aluminum bat and another reflective spherical marker was placed 15 cm proximal from the "sweet spot." There is no single definition of the "sweet spot." Each bat may have differing locations of the "sweet spot." We know it is the region between nodes of least vibration that produces maximum energy transfer to the ball. The "sweet spot" of our aluminum bat was determined by loosely holding the bat between two fingers at the grip. A rounded hammer was then tapped along the fat end of the bat going towards the handle. When the vibrations stopped, the distance from the end of the bat was measured. Continuing to tap toward the handle, the vibrations would start up again. This point was also measured and the result was a region determined the "sweet spot." The exact middle of these two points was used in the formula for determining bat swing peak velocity. A stabilized tee was used so every athlete would have consistent and stable hitting conditions. Subjects were allowed to adjust the height of the tee for maximum swing force and velocity through their ideal swinging pattern. Certified NCAA baseballs and a certified NCAA aluminum bat was used. During testing, subjects were instructed to swing with maximum force and velocity when making contact with the baseball and to contact the ball between the two spherical markers. Each subject was allowed ten hits with the top six velocities being chosen for the statistical analysis. Each subject was allowed a minimum of thirty seconds between swings to simulate the amount of time taken between pitches during game play. The raw data were downloaded to the Nexus 1.2 imaging software where it was transferred to an excel document that was prepared with the proper velocity conversion formulas. Bat swing velocity was determined as the peak velocity of the "sweet spot" of the bat (average of the two markers) before impact. Once the bat swing peak velocity was determined for all ten swings, the top six velocities were transferred to a data collection sheet in preparation for statistical analysis using SPSS.

Statistical Analysis

A matched *t* test was used to compare the results between the LD and NLD following two days of testing.

RESULTS

Sixteen male collegiate varsity baseball members completed this study. An analysis of the bat swing peak velocity performance scores are contained in Table 1. A matched *t* test revealed there was a significant difference in bat swing velocity between NLD and LD (p = 0.021). The average bat swing peak velocity on NLD was 69.18 ± 3.33 mph and 70.86 ± 4.09 mph on LD.

DISCUSSION

The results of this study suggest that same-day strength training followed by a recovery period has a beneficial effect on bat swing peak velocity following a preseason strength training program.

Russell (2003) reported that an increase in bat swing velocity increases the distance the baseball travels and the speed the baseball travels. These results determined that ball speed increased from an average of 100.0 mph (NLD) to 102.00 mph (LD). This translates into an increased travel distance average of 352.8 feet (NLD) to 361.4 feet (LD) using a reference for obtaining distances (Adair, 2002). Russell (2003) concluded that an increased bat swing velocity gives the batter additional time to read the type of pitch, increasing batting averages and decreasing strikeouts. An increased bat swing velocity increases ball speed after impact thus reducing the amount of time a defender has to react to ball placement. In many instances it could mean the difference between getting on base or being out, getting an extra base or two, or even the difference between a fly out and a homerun.

The reason for performing a study of this nature is because a high majority of coaches and athletes will not lift on the same day as a game (Kerbs, 2000). This idea is founded with the perception that a strength training session will create additional muscle fatigue, soreness, and possibly alter motor performance during a game. According to Plowman and Smith (2003) fatigue will result in reduced force and velocity of a contracting muscle. When an athlete begins a strength training cycle, or has to take some time off, there can be soreness. There can be immediate muscle soreness, which is the pain felt immediately after finishing a set, or there can be delayed-onset muscle soreness, where the pain gradually increases over twenty-four hours and maintains for up to forty-eight hours (Plowman & Smith, 2003). However, as the muscle adapts to the given workload the workout can be completed quicker, with less exertion, and with a faster energy recovery (Plowman & Smith, 2003). It has also been established that immediately following a one-hour strength training session muscle fatigue does not affect speed of movement, reaction time, choice reaction time, speed of movement, tapping speed, or motor performance (Kaurenen, Siira, & Vanharanta, 1999).

It is reasoned the strength training program followed during this study did not have a negative effect on bat swing velocity because of different circumstances. Bat swing peak velocity not being affected by same-day strength training suggests that fatigue was not severe enough to alter performance. The intent of the strength training program used in this study was not necessarily to induce fatigue or soreness but to represent an in-season strength training session that a collegiate male baseball athlete would typically perform. Additionally, the subject's muscles have become adapted from six months of strength training prior to testing.

The data analysis did not show the strength training program to be a negative factor, which is comparative with previous studies that used a strength training routine while researching the effects of same-day strength training on performance among female collegiate soccer, female collegiate tennis, and female collegiate basketball players (Kerbs, 2000; Murakami, 2002; Reynolds, 2005; Woolstenhulme et al, 2004).

Bompa (1999) illustrates that there are several factors that can affect how quick of a recovery an athlete will experience. Some of the factors include gender, age, and altitude. However, the main factors of recovery are largely associated with fitness level. Skeletal muscle recovery will come quicker the higher the fitness level of an athlete. This infers the four to six hour rest period between strength training and bat swing velocity testing in this study was sufficient for subjects to recover and provided some sort of supercompensation of power production.

Although it remains uncertain what exactly caused a significant increase in bat swing peak velocity four to six hours following a strength training session, there are some recommendations. Viro (1994), when talking about supercompensation, found that skeletal muscle can have a peculiar synthesizing state that is related to the overproduction of ATP and other energy stores. Sale (2004) discussed in his article the possibility postactivation potentiation (PAP) has on fast ballistic performances like jumping and throwing. He concluded there is not enough research to determine PAP's effect on these movements, but that it could possibly increase the rate of force production. He did not speculate on the circumstances for which this would be possible.

There were possible limitations with this study. Subjects only included Brigham Young University baseball team members and were not randomly sampled among all collegiate baseball athletes. Testing was completed after two days. Even though the subjects were asked to swing with their maximum force and velocity, there was no gauge as to whether each subject gave maximum force and velocity on every swing on both days. Another limitation of this study might be a learning curve effect. Since the subjects were tested as a group on consecutive days they may have become familiar with the testing environment from day one to day two. This might have contributed to a possible positive outcome. This study only determined the effects of strength training on bat swing velocity. It did not include peak sprinting speed, reaction time, vertical jump, pitching speed, or any other skill needed to be successful in baseball. This study did not include possible psychological impact strength training on the same day as a game would have on the subjects. A positive or negative attitude toward lifting on game day could affect testing performance.

Even though there was an effect between the LD and NLD, coaches and athletes who predispose their minds as to how same-day strength training affects performance, may not be willing to accept the results.

Future studies can set up a similar study with repeated measures over the course of a few weeks to determine the validity of the positive effect strength training has on bat swing peak velocity four to six hours later. Once confirmed, additional research will also need to determine physiologically how strength training increases bat swing peak velocity four to six hours after a strength training session. Future studies can also evaluate any of the psychological changes that might result from a similar same-day strength training study, as well as testing other skills, on the same day as a strength training session, needed to be successful in baseball.

The results of this study suggest that when routine strength-training sessions and baseball games fall on the same day, athletes do not need to forego their regularly scheduled strength-training session if adequate recovery time is permitted. It also suggests strength training purposely on game days may increase bat swing peak velocity, improving time available to read pitches, increasing ball speed after impact (reducing defensive reaction time), and distance the ball travels.

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Table 1. Comparison of bat swing peak velocity for LD and NLD (n=16).

Variable	Mean	SD	SE_M	SE_D	*r*	t
Non-Lifting Day	69.18	3.34	.83	1.32	.77	-2.57
Lifting Day	70.86	4.09	1.02			

*Significance at $p<0.021$

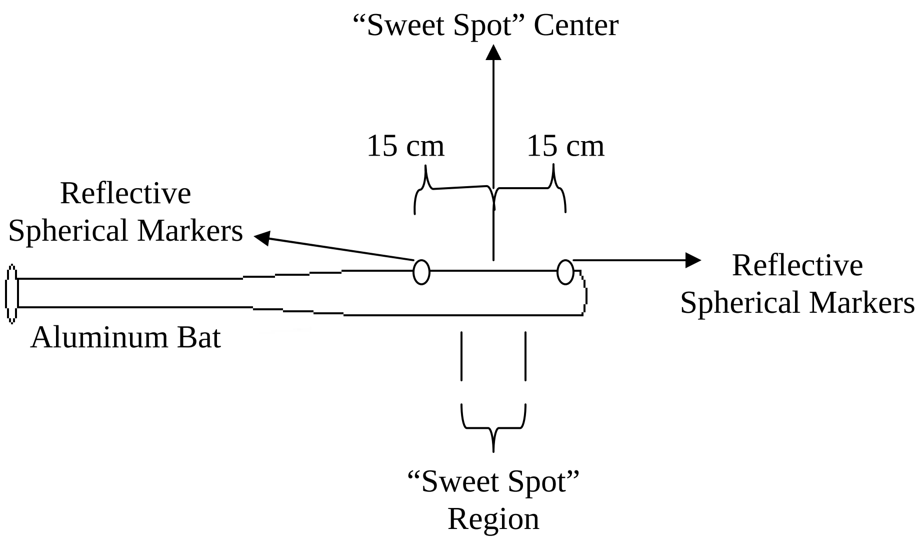

Figure 1. Placement of reflective spherical markers according to "sweet spot"

APPENDIX A

Prospectus

Chapter 1

Introduction

Baseball has changed over the course of time. Even though the rules and basic strategies remain the same, the emergence of sport specific strength training programs have developed baseball athletes that differ in size, strength, and speed. Individual success for pitchers, infielders, outfielders, and batters require the continual development of strength, force production, stability, balance, lateral quickness, reaction time, quick first step reaction and explosiveness. Particularly, batters find success by generating power and control through a complex full body sequence.

This full body sequencing is part of a kinetic chain (Cohen and Mont, 1994; Roetert, Ellenbecker, Chu, and Buggs, 1997), requiring sequential muscle firing to transfer forces from the lower body extremities, to upper body extremities, and to the bat during swing and impact. Strength training programs can be manipulated to maximize the batting kinetic chain and the transfer of forces.

Successful strength training programs are year round involving off-season, preseason, in-season and postseason periods, as well as training for aerobic and anaerobic endurance (Parker, 1985). Initially, it was thought that there was no place for lifting weights in baseball (Williams, 1997). The pioneers of using weights in professional baseball is considered to be the Oakland A’s, when in 1994 they made room in their stadium for a weight room (Williams, 1997). This transformed to athletes participating in highly rigorous strength training sessions during the off-season, preferring to spend in-season improving sport specific skills. In recent years, however, in-season strength training has become the norm. Even with this shift to increased in-season strength training, players and coaches generally shun strength training on game day, believing that same-day strength training fatigue muscles and decreases performance.

The time sequence of the repletion of various energy stores can occur within a few minutes. During strength training, a highly intensive intermittent exercise, the recovery of ATP and phosphocreatine must be recovered in order to complete the lifts of an entire strength training session (Viru, 1994). A proper strength training program includes the necessary recovery period for the ATP and phosphocreatine energy stores. Existing published research, although limited, indicates there is no significant negative or significant positive effect on athletic performance, when completing a strength training session on the day of measured skill tests (Kerbs, 2000; Reynolds, 2005; Murakami, 2002; Woolstenhulme, 2000). No published research can be found evaluating the positive, negative, or no effect of same-day strength training in male collegiate baseball players. Specifically, no published research exists evaluating the effects of same-day strength training on bat swing velocity. Russell (2003) determined in his research the importance of bat swing velocity to ball speed after impact. He concluded an increased bat swing velocity will cause a baseball to travel further and with increased speed. Part of his conclusion explains how increased bat swing velocity increases ball speed after impact, making it harder for defensive players to field the baseball. His results showed increased batting average of professional and college-level baseball teams.

This study will help determine the effect of same-day strength training on bat swing velocity of male collegiate baseball players over four weeks of training.

Statement of Problem

The purpose of this study is to investigate the effect of same-day strength training on bat swing velocity.

Research Hypothesis

Same-day strength training will have an effect on bat swing velocity of male collegiate baseball players.

Null Hypothesis

Same-day strength training will have no significant effect on the bat swing velocity of male collegiate baseball players.

Definitions

One repetition maximum (1RM) – the maximum weight that can be lifted during one repetition.

Mesocycle – cycle that details the weekly or monthly plan of a strength training program.

Microcycle – a daily structure detailing a strength training program.

Moderate strength training – 60-80% of 1 RM resistance weight training program.

Velocity – velocity of the "sweet spot" of the bat, immediately prior to contact with the baseball.

Impact force – the amount of force being acted upon by another object.

Kinetic chain- the link of legs, hips, trunk, and upper limbs that generates force for certain motions, such as swinging a bat to ball impact.

Strength training program- a type of training program used to bring about strength gains.

Strength training session- The time it takes to complete a microcycle in a training program.

Assumptions

There are several fundamental assumptions in this study:

1. The subjects will be physically and emotionally healthy to participate in this study.
2. The subjects will give maximal effort throughout this study.
3. The instruments which will be used for this study will be valid, objective, accurate and reliable for measuring bat swing velocity.
4. The selected variables of bat swing velocity can be used as measures of athletic performance in a baseball game.

Delimitations

The delimitations of this study are as follows:

1. The subjects will be collegiate male baseball players at Brigham Young University.
2. The testing variables will only include bat swing velocity.

3. This study will only investigate the effect of same-day strength training on bat swing velocity of male collegiate baseball players.
4. The intensity during a strength session will be controlled and performed at 60-80% of their 1 repetition maximum.

Limitations

Attempts to quantify overall baseball game performance are very subjective, and no measurements can fully take into account what ensues during an actual game. This study will not evaluate overall athlete performance during a game. There are several variables, such as the crowd, coaching, refereeing, and opponents' play that will affect overall performance outcome. None of these factors are simulated during the testing of this study. Although an athlete may show a decrease in selected performance variables during testing, individual motivation and desire to win may overcome this deficit in an actual game situation. This study will examine the aspects of bat swing velocity of baseball batting that may influence athlete performance. Any such measures can only be considered estimations of what might happen during actual game play. Subject numbers are limited to the number of batters on the team.

Significance

This study will investigate the potential influence that strength training may have on game day bat swing velocity performance. Theoretically, at the end of the season a team that implements strength training on game day will have more lifting days and would therefore be further along, in a strength training program than a team that shuns lifting on game day. If, however, there is a negative effect, strength training should be avoided on game day. In contrast, if there is a positive or no effect, strength training may be beneficial to game day bat swing velocity performance and peaking strategies toward the end of season championship tournaments. Traditional beliefs concerning same-day strength training may be overturned.

Chapter 2

Review of Literature

Baseball is a major part of American history. Through early stages, the game relied heavily on strategy. Homeruns were rare, because teams needed players who could hit with high accuracy. Most of the offensive scores came through bunting and base stealing (Lahman, N.D.) Baseball dynamics, like many other sports, has progressed along with participating athletes.

To be successful, many future athletes develop complex skills younger to gain an edge against competition and to advance their career (Allsen, 2003). As a result, athletes are bigger, stronger, faster, and more athletic. Increased knowledge of strength training has been at the core of this transition. However, even with advanced strength training knowledge, many coaches have steered away from strength training on game day. Kerb (2000) found this practice valid when they called 50 male and female high school and college coaches in Utah. Out of 50 coaches, 48 prevent their athletes from lifting on the day of an athletic competition, because they believe it could be detrimental to player agility, quickness, and overall quality of performance. A handful of researchers have focused their research on quelling these preconceived notions.

Kerbs (2000) researched the effects of a same-day strength training session on shooting skills of collegiate female basketball players. Kerbs stated, “same-day strength training does not have an effect on basketball shooting skills.” Woolstenhulme (2000) conducted a basketball study with college female players using different independent variables: vertical jump, anaerobic power, and VO2 max. Woolstenhulme concluded that athletes can participate in a strength training session on the same day as an athletic competition without experiencing negative physiological effects in performance. Shoenfelt (1991) conducted a basketball shooting accuracy study with two groups: strength training and aerobic exercise. Research was recorded within one hour of their assigned activity. Results showed no difference in shooting accuracy between strength training and aerobic exercise groups. Lastly, Ford and Puckett (1983) researched basketball skill test scores (front shot, speed pass, jump and reach or dribble) after ninth grade boys participated in a strength training session. The study involved those who participated in a basketball program, those who participated in a strength training session, and a control group. Researchers concluded there was no difference in performance of basketball skills between groups.

Validating the research hypothesis requires understanding how to manipulate the strength training program for the skill being tested. The research design is focusing on the effects of same-day strength training in a batter's swing velocity, which requires a functional knowledge of its biomechanical breakdown. A base understanding is needed to understand the mechanics of hitting a baseball. Much like any sport that requires swinging an object, baseball uses large base segments transitioning momentum to smaller segments. Basically, in the instance of baseball hitting, the larger segments decelerate with the remaining velocity transitioning to increase the velocity of the smaller segments carrying momentum. Segments carry momentum when they are moving at a certain velocity. Enhancing the mechanical and physiological components create motivation for the mechanics integrated during the hitting motion (Welch, Banks, Cook and Draovitch, 1995). As a result, a hitter's mechanical performance comes from maximizing the kinetic chain, a complex full body movement necessary to control ball placement and distance (Cohen and Mont, 1994; Roetert, Ellenbecker, Chu, and Buggs, 1997). It requires the transfer of forces from the lower extremities, through the upper extremities, and finally to the bat for control during swing and impact (Kibler, 1995).

For a right handed batter, swing loading or coiling starts with the arm, shoulder, and hip segments rotating clockwise (top view) while weight shifts toward the rear foot. Segments are moved in opposite intended directions rotationally and linearly before being accelerated toward baseball contact, establishing the rotational and linear components of motion.

The movement of segments around the axis of the trunk involves the rotational component. The hip segment starts counterclockwise rotation before the shoulder and arm segment. This proper sequencing allows the kinetic chain to engage the trunk musculature and upper extremity through preload.

Forward movement of the body is defined as the linear component. When the batter shifts weight to the rear foot, the center of pressure has been positioned behind the center of mass. This creates an out of balance equilibrium. With the center of pressure and center of mass aligned, the body is motivated toward the direction of the center of mass. In combination with the rear foot shear force, the batter is driven in a linear direction toward the ball.

The linear and rotational components begin to interact with each other when the stride foot makes contact with the ground. When the stride foot makes contact with the ground, the center of pressure has moved to the other side, toward the pitcher, of the center of mass. This application of shear forces between the right and left foot produce a force couple at the hip segment, assisting counterclockwise acceleration around the trunk axis. The batter can mechanically emphasize the rotational or linear component of the swing at this point. Regardless of which component is emphasized, the segment of the hip is accelerated around the trunk axis to maximum velocity. When this happens the entire system is moving in the intended direction with increased velocity. When the hip segment decelerates, the shoulder segment accelerates, employing the kinetic chain principle. Proper timing through efficient segment acceleration produces higher rotational velocities producing bat speed and power (Welch, Banks, Cook and Draovitch, 1995). Maximizing efficiency, power, and force of this kinetic chain, requires strength training to fuse the entire coordinated transfer of forces.

Over the course of a strength training program, there will be neuromuscular and musculoskeletal adaptations. These changes can allow for a previously maximal lift, during early training, being lifted with less muscle. One of the main purposes of strength training is to increase force-generating capability, skeletal muscle mass and metabolic capacity (Baechle and Earle, 2000). Metabolic capacity will contribute to increased recovery of ATP, phosphocreatine, and glycogen energy systems in trained athletes (Foss and Keteyian, 1998).

Strength training for baseball is a year round program aimed at gaining and maintaining core strength, overall force production, stability, balance, lateral quickness, reaction time, first-step reaction and explosiveness. Historically, baseball athletes have participated in serious strength training programs during the off-season, preferring to spend in-season time improving individual skill. Scheduled days for strength training should not be missed at any time during the year, if an athlete desires to attain maximum gains. Hedrick's (1993) research showed weight lifting once a week will slow the rate of muscle atrophy. Unfortunately, strength training once a week will not sustain gains. Strength training twice a week is necessary to maintain strength gains and training three times a week is necessary to increase overall strength (Hedrick).

The research design is focusing on the effects of strength training on bat swing velocity. Russell (2003) determined the importance of bat swing velocity in his research. An increased bat swing velocity increases the distance and the speed the baseball travels. Part of his conclusion showed improved hitting averages for championship college baseball teams. If the research design shows strength training on game days for collegiate male baseball players is positive or has no effect on bat swing velocity, canceling strength training sessions because of a game would need further reconsideration. This would be beneficial to college teams who can end up playing several days in a row. If a team applied the results, theoretically, they would have more overall strength training days, which could mean increased physical peaking for conference and national tournaments. Conversely, if the results show a negative effect on bat swing performance, athletes should avoid strength training sessions on competition day.

Chapter 3

Methods

Subjects

Up to thirty-five members of the men's varsity baseball team at Brigham Young University will be asked to volunteer for this study. Subjects may include seniors, juniors, sophomores, redshirt freshman, and true freshman. Test subjects can also include scholarship athletes, walk-on athletes, and athletes who are trying out for the team. Once selected, subjects will participate in the preseason strength training program for the fall semester. Before subjects can participate in the study, completion of an informed consent form is mandatory. A sample informed consent form can be found in Appendix A.

Strength Training Program

Periodization is the founding concept behind designing a strength training program for any sport. One year is divided into seasons (preseason, in-season, postseason, and off-season) called macrocycles. Mesocycles are monthly/weekly cycles and microcycles represent the daily structure of a strength training program (Baechle and Earle, 2000). During these cycles, load, intensity, and volume are varied to avoid overtraining and to maintain peak strength and physical performance during a competitive season. The subject's strength training program will be adjusted throughout the year according to these stated principles of periodization.

Maximum lift tests will be performed at specific weeks during a strength training program. This information combined with periodization will help to develop an individualized strength training program. Each strength training session will include a warm-up routine. Major muscle and full body lifts can include warm-up sets to prepare the working muscle for a strenuous workout. These conditions facilitate an increased rate of blood flow helping to prevent muscle pulls, strains, and tears (Allsen, 2003).

Each lift will vary between 3 and 8 sets of 4 to 12 repetitions at a training intensity of 60% to 80% of their 1RM. Recovery time between sets is established at 60 to 90 seconds. The phosphogen energy systems will be completey replenished within ten minutes of ending their strength training session (Viru, 1994). The glycogen energy system will be completely restored four to six hours after the lifting session (Viru, 1994). These systems will recover quicker because the subjects will have been participating in a strength and conditioning program since the beginning of September 2007 (Baechle and Earle, 2000). The following lifts are incorporated in Brigham Young University's baseball strength training program: power clean, back squat, bench press, shoulder circuit, lat pull-down, hammer curl, dumbbell complex, leg press, dumbbell incline, reverse curl, seated row, triceps extension, hang clean, pause squat, dumbbell bench, dumbbell military, reverse hyper, dumbbell triceps extension, and varied forearm routines.

The preseason schedule during the time the data will be gathered includes strength training on Monday, Wednesday, and Friday, utilizing the full body routine. Team practice sessions are scheduled to take place Monday through Friday. Subjects will be instructed from the head baseball strength and conditioning coach on proper technique and form prior to starting the strength training session. Furthermore, the strength and conditioning coach will be constantly screening and correcting athlete technique and form during each strength training session.

Design

A paired/matched *t* test will guide this study. The independent variables are lifting day (LD) and non-lifting day (NLD). The dependant variable will be bat swing peak velocity immediately prior to contact.

Procedures

Testing will occur over two consecutive days. On Friday there will be no lifting and subjects will be tested. The following day, Saturday, everyone will lift followed by testing four to six hours later. This will transpire during baseball's preseason to prevent interference with the regular season. All subjects will participate in the designed three days a week strength training program. Every subject will not lift on Friday when there is no scheduled lifting session, but they will be tested in the biomechanics lab. Every subject will lift on Saturday followed by being tested in the biomechanics lab. Testing procedures will remain during both testing sessions (Appendix B).

Subjects will sign up to arrive at the biomechanics lab at a specific time, dressed in their issued practice clothes, shoes, and equipment. Before each test, the athletes will be allowed a self chosen warm-up which will remain consistent with how they warm-up prior to real games and will remain consistent from test to test. Six Vicon MX13+ infrared cameras (Vicon-Colorado, Centennial, Colorado), running at 400 Hz, will be specifically placed around the swinging area and will be used to determine bat swing velocity. Two reflective spherical markers will be placed at 30 cm from the "sweet spot" on the aluminum bat. They will help determine the velocity of the "sweet spot" of the bat immediately prior to contacting the baseball. A stabilized tee will be used so every athlete will have consistent and stable hitting conditions. Subjects will be allowed to adjust the height of the tee for maximum swing force and velocity. Certified NCAA baseballs and bats will be used. During testing, subjects will be instructed to swing with maximum force and velocity when making contact with the baseball. Each subject will be allowed ten hits and the top six velocities will be chosen for the study. Each subject will be allowed a minimum of thirty seconds between swings to simulate the amount of time taken between pitches during game play. Information will be recorded on a data collection sheet (Appendix C). Nexus 1.2 imaging software will be used to download and determine bat swing peak velocity. Bat swing velocity will be determined by dividing the average displacement of the two reflective spherical markers during the three frames prior to impact by 3/400 s.

Statistical Analysis

A paired/matched t-test will be used to compare the results between the lifting day and non-lifting day.

Findings

Testing and statistical analysis will result in a list of findings being compiled.

Conclusion and Recommendations

A list of findings will result in conclusions and recommendations being made.

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APPENDIX B

Informed Consent Form

INFORMED CONSENT TO BE A RESEARCH SUBJECT

Explanation of the Skill Test

The purpose of this study is to determine the effect of same-day strength training on bat swing velocity in male collegiate baseball players. The research is conducted by Anthony Clah, a graduate student in the Exercise Science Department at Brigham Young University, and full-time Assistant Strength and Conditioning Coach for BYU Athletics. The testing period will be a four week period before the season begins in February.

You will be asked to swing a bat at maximal velocity and power. Every subject will be tested on a day without lifting, Friday, February 8th and every subject will be tested on a day 4 to 6 hours after lifting. Below is a complete schedule:

- Testing Day 1- Friday, February 8th, 2008-All subjects bat swing velocity tested between 8 to 12:30 PM
- Testing Day 2- Saturday, February 9th, 2008-Morning Lifting Session, All subjects bat swing velocity Tested between 1 to 5 PM.

You will dress in your regular practice uniforms. After the warm-up is completed, you will line up and adjust the tee according to your height. Each batter will have a total of 10 swings. Your results will be recorded with Vicon Infrared Camera Software to be processed and analyzed later.

You will dress in your regular practice uniforms. After the warm-up is completed, you will line up and adjust the tee according to your height. Each batter will have a total of 6 swings. Your results will be recorded with Vicon Infrared Camera Software to be processed and analyzed later.

Risks and Discomforts

The risks associated with this study are minimal. The risks will be less than during practice or games.

Responsibility of the Participant

It is your responsibility to report any discomfort or problems that you may have while participating in this study. You agree to give your maximal effort during this study.

Expected Benefits from Testing

All results obtained from this study will be kept confidential. However, results will be used for statistical purposes. Upon your request, you will have your results and explanation. You have the right to exit this study at any point without penalty. Participation in this study is voluntary.

Inquiries

If you have any questions regarding this study, you may contact Anthony Clah, 109C SAB, 147 SFH Intercollegiate Weight Room, 422-1916, ants_clah@byu.edu, and/or cell (801) 360-7040. If you have any questions regarding your rights as a participant in this study, you may contact Dr. Christopher Dromey, the Chair of the Institutional Review Board, Brigham Young University, Provo, UT 84601.

I have read this form and I understand the test procedures I will participate in. I agree to participate in this study.

______________________________ ______________________________

Signature of Research Subject Date

______________________________ ______________________________

Signature of the Witness Date

APPENDIX C

Two –Day Test Chart

Winter Lifting Cycle	3 day/week lifting routine	Day 1
		Non-Lifting Day
		Every subject tested between 8:00 AM and 12:30 PM
		Day 2
		Lifting Day
		Every subject lifts from 8:00 AM to 9:00 AM and is tested a minimum of 4 hours later between 1:00 PM and 5:00 PM

APPENDIX D

Data Collection Sheet

Men's Baseball Bat Swing Velocity Study

Data Collection Sheet

L=Lifting day

		Bat Swing Peak Velocity Immediately Prior to Ball Contact									
Subject Name	Position	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10

Men's Baseball Bat Swing Velocity Study

Data Collection Sheet

NL=Non Lifting day

		Bat Swing Peak Velocity Immediately Prior to Ball Contact									
Subject Name	Position	NL1	NL	NL3	NL4	NL5	NL6	NL7	NL8	NL9	NL10

APPENDIX E

Raw Data

		Miles Per Hour Top 6 Velocity Marks					
		Day 1	Day 2	Day 1	Day 1	Day 2	Day 2
		Nonlift Ave	Lift Ave	Nonlift high	Nonlift low	Lift high	Lift low
Subject 1	Pitcher	69.0	67.7	70.2	67.9	68.5	67.3
Subject 2	1B	76.2	78.6	77.0	75.5	78.9	78.4
Subject 3	SS	69.4	68.2	70.3	68.4	69.5	67.4
Subject 4	OF	68.6	67.2	68.9	68.2	70.4	64.9
Subject 5	2B	63.5	65.3	64.7	62.1	65.6	64.8
Subject 6	Catcher	67.1	68.8	68.2	66.1	70.0	67.7
Subject 7	OF	71.6	75.7	73.5	70.3	76.6	74.5
Subject 8	SS/2B	71.5	75.4	73.6	69.5	76.8	74.3
Subject 9	Pitcher	65.5	68.1	68.0	63.1	70.7	66.6
Subject 10	OF	72.2	69.7	72.8	71.5	71.5	68.9
Subject 11	3B	71.5	69.0	72.6	70.6	70.6	68.4
Subject 12	Catcher	68.1	73.0	69.9	67.5	76.4	70.3
Subject 13	SS	73.0	78.2	75.5	71.4	79.1	77.1
Subject 14	2B	64.9	68.2	65.8	64.5	70.6	66.3
Subject 15	Pitcher	67.5	71.1	68.6	66.5	72.8	68.8
Subject 16	Pitcher	67.0	69.5	68.7	65.9	71.8	68.3

		Miles Per Hour All Velocity Marks					
		Day 1	Day 2	Day 1	Day 1	Day 2	Day 2
		Nonlift Ave	Lift Ave	Nonlift high	Nonlift low	Lift high	Lift low
Subject 1	Pitcher	68.5	67.4	70.2	67.4	68.5	66.3
Subject 2	1B	75.3	78.3	77.0	70.4	78.9	77.1
Subject 3	SS	68.8	67.7	70.3	67.4	69.5	66.2
Subject 4	OF	67.6	66.2	68.9	63.1	70.4	63.8
Subject 5	2B	62.3	64.4	64.7	58.6	65.6	60.0
Subject 6	Catcher	66.6	67.8	68.2	65.0	70.0	65.4
Subject 7	OF	70.6	74.9	73.5	65.9	76.6	71.8
Subject 8	SS/2B	70.5	74.8	73.6	68.3	76.8	72.9
Subject 9	Pitcher	62.6	67.2	68.0	51.8	70.7	64.1
Subject 10	OF	71.4	68.4	72.8	69.5	71.5	65.1
Subject 11	3B	70.7	68.2	72.6	68.3	70.6	65.1
Subject 12	Catcher	67.6	71.8	69.9	66.4	76.4	69.0
Subject 13	SS	72.3	77.6	75.5	70.3	79.1	76.4
Subject 14	2B	64.3	66.8	65.8	61.5	70.6	63.5
Subject 15	Pitcher	66.6	69.7	68.6	63.1	72.8	67.3
Subject 16	Pitcher	66.3	68.6	68.7	63.9	71.8	66.1

Ball Speed (mph) after impact

		Day 1	Day 2	Day 1	Day 1	Day 2	Day 2
		Nonlift Ave	Lift Ave	Nonlift high	Nonlift low	Lift high	Lift low
Subject 1	Pitcher	99.7	98.3	101.2	98.5	99.2	97.7
Subject 2	1B	108.4	111.4	109.4	107.5	111.7	111.1
Subject 3	SS	100.3	98.9	101.3	99.1	100.4	97.9
Subject 4	OF	99.4	97.7	99.7	98.8	101.5	94.9
Subject 5	2B	93.2	95.3	94.6	91.5	95.8	94.8
Subject 6	Catcher	97.6	99.6	98.9	96.3	101.0	98.2
Subject 7	OF	103.0	107.8	105.2	101.4	108.9	106.5
Subject 8	SS/2B	102.8	107.5	105.3	100.4	109.2	106.2
Subject 9	Pitcher	95.6	98.7	98.7	92.7	101.9	96.9
Subject 10	OF	103.7	100.6	104.3	102.8	102.8	99.7
Subject 11	3B	102.8	99.8	104.1	101.8	101.8	99.1
Subject 12	Catcher	98.7	104.5	100.8	98.0	108.7	101.3
Subject 13	SS	104.6	110.9	107.6	102.7	111.9	109.5
Subject 14	2B	94.9	98.9	95.9	94.3	101.8	96.6
Subject 15	Pitcher	98.0	102.3	99.3	96.8	104.4	99.5
Subject 16	Pitcher	97.4	100.4	99.4	96.0	103.2	98.9
	Average	100.0	102.0	101.6	98.7	104.0	100.6

Horizontal Displacement (ft) with pitch velocity of 85 mph

		Day 1	Day 2	Day 1	Day 1	Day 2	Day 2
		Nonlift Ave	Lift Ave	Nonlift high	Nonlift low	Lift high	Lift low
Subject 1	Pitcher	351.7	345.4	357.8	346.4	349.4	343.0
Subject 2	1B	388.6	401.1	392.6	384.8	402.5	399.8
Subject 3	SS	353.9	348.0	358.3	348.8	354.6	343.8
Subject 4	OF	350.1	342.8	351.4	347.8	359.3	331.2
Subject 5	2B	323.8	332.8	330.0	316.5	334.7	330.7
Subject 6	Catcher	342.5	351.0	348.0	337.0	357.1	345.2
Subject 7	OF	365.3	386.0	374.8	358.5	390.7	380.2
Subject 8	SS/2B	364.6	384.7	375.3	354.7	391.7	379.0
Subject 9	Pitcher	334.1	347.3	347.0	321.9	360.7	339.7
Subject 10	OF	368.5	355.4	371.1	364.6	364.6	351.5
Subject 11	3B	364.8	352.0	370.0	360.3	360.2	348.8
Subject 12	Catcher	347.4	372.1	356.3	344.1	389.8	358.4
Subject 13	SS	372.5	399.1	385.1	364.0	403.4	393.2
Subject 14	2B	331.2	348.0	335.4	328.7	360.3	338.3
Subject 15	Pitcher	344.4	362.5	349.7	339.3	371.4	350.7
Subject 16	Pitcher	341.7	354.2	350.3	336.0	366.2	348.2
	Average	352.8	361.4	359.6	347.1	369.8	355.1