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Literature Review and Critique of Shoulder Training Programs for Increasing Throwing Velocity of the Baseball Pitcher

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LITERATURE REVIEW AND CRITIQUE OF SHOULDER TRAINING PROGRAMS FOR INCREASING THROWING VELOCITY OF THE BASEBALL PITCHER

by

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To my parents Raymond and Violet Mimaki

ABSTRACT

The purpose of this independent study is a literature review of the principles of training and a critique of the shoulder strength training programs for increasing the throwing velocity of the baseball pitcher. In addition, a sport specific movement analysis, based on biomechanics, physiology and kinesiology of the baseball overhand pitch will be examined. The critique will be based on the principles of training reviewed earlier and a sport specific movement analysis. Finally, a proposal of a potential training program and possible topics for research will be discussed.

CHAPTER 1

INTRODUCTION

There have been many resistance training programs developed to improve athletic performance for different sports. These different training programs have been based on the principles of exercise physiology.

In the realm of baseball, pitching is a key factor in how well a team will do. Baseball pitching incorporates skills of accuracy, velocity, and various types of pitches to be successful. In addition, intelligence and experience are also beneficial.

Velocity is one of the components of pitching which can increase the potential success of a baseball pitcher. At the professional level, throwing velocities can reach an excess of ninety miles per hour. In this literature review, the improvement of velocity in the throwing motion of the baseball pitcher, through various training programs, will be explored.

In chapter 2, we will look at the principles of training. The chapter will review progressive overload, volume of training, specificity of training, and diversity of training.

In chapters 3 and 4, the review will discuss sport specific movement analysis and use this to analyze the overhand throwing motion. The analysis will cover the specific muscles, joint angles, type of muscular contraction, angular limb velocity, energy metabolism, and injury prevention.

Chapter 5 will critique the different types of training programs reviewed, based on the principles of training and the sport specific movement analysis. An attempt to find a possible most effective training program will be explored in chapter 6. Also, a look at possible topics for future research will be discussed.

Lastly in chapter 7, we will conclude the literature review.

CHAPTER 2

PRINCIPLES OF A TRAINING PROGRAM

Resistance training is designed to increase strength, power, and ultimately athletic performance. The principles of resistance training are derived from exercise physiology theories. There may be different classifications and terminologies which are inherently the same. This chapter will cover four principles of resistance training: 1) Progressive Overload, 2) Volume of Training, 3) Specificity, and 4) Diversity.

Progressive Overload

Resistance training programs, whether they are for strength or power, need to progressively overload the musculoskeletal system in order to increase athletic performance.[1-3] The muscle must contract against a resistance it normally does not encounter to stimulate physiological changes which cause an increase in strength. The three factors involved in progressive overload are intensity, maximal muscle contraction, and progressive resistance exercises (PRE's).[1-3]

Intensity

Intensity is the power output (rate of performing work) of an exercise. Intensity can be increased by using a heavier resistance or by moving a given load faster. If the goal of training is to increase the maximal load which the individual is able to lift, heavy resistance should be used without concern for the speed of the movement. Increasing the intensity of an exercise by increasing the speed of movement is important when the goal is to increase the acceleration output of the muscle. The heavier the load, or the closer a given load is moved to the maximal possible velocity, the greater the intensity and the training effect on the muscle.[1-3]

Maximal Muscle Contractions

Maximal muscle contractions are slightly related to intensity, in that an individual will work at maximum intensity with maximal muscle contractions. Maximal muscle contractions represent the maximal force that the muscle can produce, at any given time, whether rested or fatigued. Maximal muscle contractions will thus vary in the amount of force produced. (Maximal muscle contraction is not to be confused with the Repetition Maximum (RM), which is the maximal resistance that an individual can lift for one repetition when not fatigued).

Voluntary maximal muscle contractions appear to be the most effective way to increase muscular strength. Maximal contractions stress the muscle to the greatest extent.[1]

Progressive Resistance Exercise

The last consideration is progressive resistance exercise. As training advances the muscle will be able to exert a greater force or will be able to lift the same resistance with greater ease.[1-3] Thus, progressive resistance exercise refers to the need to continually increase the stress placed on the muscle as it becomes capable of producing greater force.

There are several methods for progressively increasing the stress placed on the muscle. The resistance used to perform a certain number of repetitions can be increased. The use of the one RM is another way which assures progressive resistance. In addition, increasing the volume of exercise performed by increasing the number of sets also progressively stresses the muscle.

Volume of Training

The volume of training is estimated by summing the total number of repetitions performed during a specific time period. In general, a higher volume of training appears to benefit the goal of muscular hypertrophy or increasing lean muscle mass.[1] The frequency and duration of training have a direct bearing on the volume of training. The rest period is also an important factor in volume of training.[1-3] In this section we shall explore frequency, duration and rest periods.

Frequency

Frequency is the number of training sessions per week, month, or year. There is much controversy over the ideal frequency of training session for the different types of resistance training, for example, isometrics and isokinetics.[1-3] In general, frequency is determined by the individual, in that, individuals react differently to training. An individual who has trained extensively will be able to have a greater frequency than one who is just beginning. Frequency is a function of an individual's experience and physical condition.[3]

Duration

Duration is the time or length of time necessary to perform a certain training program.[1-3] Duration is also very controversial, and also determined by the individual. As an individual's experience and physical condition increases duration can also be increased.[3]

Rest Periods

Lastly, rest periods are needed for recuperation of the muscle. Rest periods between sets are determined by the goal of the training program.[1-3] If the goal is to increase the maximal force which the body can exert, a long rest period of several minutes should be taken. If the goal is to increase the individual's performance of high intensity skills, then short rest periods of less than one minute should be taken.

The rest periods between training sessions have traditionally been set at one day of recuperation for the muscle groups exercised.[1] However, if acute muscle soreness persists after one day of recuperation, one day of rest was possibly not sufficient.[1-3] Again, as with frequency and duration, rest periods should be determined by the individual.

Specificity of Training

Specificity refers to the specific metabolic and physiologic adaptations which are dependent on a specific type of overload.[1-3] For example, the development of strength in an overhead throwing motion is most effectively achieved if the specific muscles used in the skill are strength trained. Specific exercise elicits specific adaptations creating specific training effects.[1-3] In this section, the literature review will look at the components of training specificity: muscle groups, speed, contraction, and energy source

Muscle Group

Specificity of muscle group states that to strengthen a certain muscle group, that particular muscle group must be stressed. A training program which targets the desired muscles must be utilized.

Speed

Specificity of speed states that the greatest strength gains occur at the velocity at which the training is performed.[1-3] There is evidence that an intermediate training velocity can be used if the goal of the program is to increase strength in all velocities of movement.[1]

Muscular Contraction

There are three types of muscular contraction; isometric, concentric, and eccentric. An isometric contraction involves no change in the muscle length. A concentric contraction involves the shortening of the muscle. Lastly, an eccentric contraction involves the lengthening of the muscle. In all types of contraction there is tension throughout the muscle. Specificity of muscular contraction states that increases in strength are specific to the type of training.[1] Therefore, if an individual trains with isometric muscular contractions, gains in strength will be predominantly isometric in nature. A training program should be specific to muscular contraction found in the sport.[1-3]

Energy Source

There are two metabolic pathways used for energy by the body, anaerobic and aerobic. If an individual wants to increase their aerobic capacity, the training program should be longer in duration and lower in intensity. If an individual wants to increase their anaerobic capacity, the training program should consist of short duration and high intensity activity.[2,3] Specificity of energy source states the training program should focus on the metabolic pathway used in the sport.[1]

Diversity of Training

The diversity of training can have various meanings. For this literature review, it will be defined as the different types of resistance training specifically; isometric, dynamic constant resistance, isokinetic, or plyometric training.[1-3]

Isometric Training

Isometric training involves the contraction of the muscle with no change in the length of the muscle.[1-3] The muscle does not produce enough force to move the resistance. Due to the nature of isometric training (contracting muscle force at a specific joint angle), gains in strength are specific to the angle of training.[1-3]

An isometric training program would consist of maximal muscular contractions for optimal gains in strength.[1-3] To achieve strength throughout a movement it would be necessary to train the individual at various joint angles. The frequency and duration vary from author to author. However, it appears that daily training sessions with high volume produce the greatest gains.[1-3]

Dynamic Constant Resistance Training

Dynamic constant resistance training involves the contraction of the muscle against an unchanging resistance.[1] This form of training uses an external resistance or weight which is constant through out the motion. However, force exerted by a muscle is not constant throughout the motion; biomechanical advantages at differing joint angles allow the tension in the muscle to vary. Again, there has been much research on the optimal volume and progressive overload needed to achieve strength gains. A high repetition, low resistance training program will achieve increased endurance or aerobic capacity of the muscle. Conversely, a low repetition, high resistance training program will increase strength.[1-3]

Eccentric training is another component of dynamic constant resistance training. Eccentric training refers to a muscular contraction where the muscle is elongating. (An example of this type of training is lowering your body to the floor after performing a push up.) In eccentric training, high resistance is used to place a significant overload on the musculoskeletal system. This produces higher muscle tension than either concentric or isometric muscular contractions. Thus, eccentric training is greater associated with acute muscle soreness.[1-3] The use of the high resistance means that low repetitions are used.

Variable resistance training is in essence, another type of dynamic constant resistance. In this type of training, specialized equipment is used to vary the external resistance through means of levers or cams, in order to match the strength curve of the muscle trained. (The weight itself is unchanged.) If the applied resistance can vary to match the natural strength curve, maximal resistance can theoretically be applied through out the motion. In actuality, it is very difficult to match the strength curves of each individual. However, as with other training methods, variable resistance produces increases in strength as well. Repetitions and resistance used follows the same effects as dynamic constant resistance

Isokinetic Training

Isokinetic training involves muscular contraction performed at a constant angular limb velocity.[1-3] Usually these muscular contractions are performed at maximal voluntary contraction. The velocity is controlled by the machine and there is no set resistance, the machine only mirrors the amount of force which the muscle can exert. Isokinetic theory states isokinetic training produces maximal force and maximal overload of the muscle through a full range of motion.[1-3] Strength gains are optimal. This method also allows for muscular contractions which simulate the velocities used in sports. In general, optimal volume and overload will vary from study to study, as various authors find different protocols.[1] Improvements in velocity are best at the speeds the individual has been specifically trained in.[1-3] This follows the specificity of training rule.

Plyometric Training

Plyometric training involves an explosive countermovement of the body.[1-4] This requires a muscular contraction following a prestretch of the muscles used. The activation of the stretch reflex and the elastic components of the muscle produce a more powerful muscular contraction.[1,4] Plyometric training attempts to increase the reactive ability of the neuromuscular system, thus increasing strength. Plyometric training may utilize the body weight itself or it may include the use of external weights to increase the resistance or overload placed on the body.

The benefits of plyometric training are controversial due to the conflicting results found in different studies.[1-4] It is the author's opinion that plyometric training offers neuromuscular coordination of the sport movement and that it appears to be a widely used training protocol. No generalizations will be made regarding plyometric training because of these conflicting reports.

Summary

In this chapter, the literature review has gone over the principles of a training program. Progressive overload factors of intensity, maximal muscle contraction, and PRE's are necessary to increase the strength of the musculoskeletal system. The volume of training components are the frequency, the regularity, and the rest period. Specificity of training determines the muscle group to be trained, the angular velocity of the limb, the type of muscular contraction, and the energy source used in the type of training. Diversity of training identifies isometric, dynamic constant resistance, isokinetic, and plyometric training methods. These various types of training methods will be looked into further in the critique of the training programs.

CHAPTER 3

SPORT SPECIFIC MOVEMENT ANALYSIS

In this chapter, the literature review will discuss the beginning stage of developing a training program, called the sport specific movement analysis. The sport specific movement analysis is basically a biomechanical and physiological assessment of a skill. The specific movement is evaluated. The metabolic needs of the movement are determined. Injury risk is noted. The sport specific movement analysis may lead to an exercise prescription. The training program is designed specifically for the individual to maximize his or her training potential.

Sport Specific Movement

Analysis of the sport specific movement answers the following questions. 1) what are the specific muscles used in the activity? 2) what are the joint angles used in the activity? 3) what type of muscle contraction is used in the activity? 4) what angular limb velocities are encountered in the activity?[1-3] In the first, second, and third questions, high speed film or video, electromyography (EMG), and computers may be used in the quantitative analysis of the muscles, angles, velocities and forces used in the activity. In essence, this is a biomechanical analysis of the activity.

Energy Metabolism Analysis

The second consideration is concerned with the metabolism used in the activity. There are three sources of energy available to the muscle; 1) ATP-PC, 2) Anaerobic Glycolysis, and 3) Aerobic Glycolysis.[1-3] One and two are anaerobic sources of energy. The third is an aerobic source of energy. Most sports generally use all three of the energy sources. However, ATP-PC and anaerobic glycolysis are considered the energy sources for explosive and high intensity, short duration activities. Low intensity, long duration activities use aerobic glycolysis as the source of energy.[1-3]

Injury Prevention

The third consideration of the sport specific movement analysis involves injury prevention. The most common sites of injury for the particular sport should be identified. These areas should be evaluated carefully in the development and implementation of a training program.[1] In addition, any of the muscles, joints, ligaments, bones and other soft tissues stressed under the training program must be monitored.[1-3] While precise monitoring may prevent injuries, no training program is totally safe.

Summary

The sport specific movement analysis is the groundwork for developing an individualized training program. Important factors in the biomechanical assessment of the sport skill are specific muscles involved, specific joint angles, type of muscle contractions encountered, angular velocities of the limb, and load demands on the musculoskeletal system. The energy source used for the activity is a physiological factor in assessing the skill and in determining the need for anaerobic or aerobic training. The last component of the analysis is the concern for injury prevention. Identifying common sites and mechanisms of injury allows for safe training and the prevention of performance injuries.

CHAPTER 4

SPORT SPECIFIC MOVEMENT ANALYSIS OF THE SHOULDER IN OVERHAND THROWING MOTIONS

In the following chapter, an analysis of the shoulder involved in the overhand baseball pitch will be examined under the criteria listed in chapter 3. The purpose of this will be to develop a manner to critique the training protocols researched in the next chapter.

The Baseball Overhand Throwing Motion

The overhand baseball pitch is a complex physical skill. It involves the lower extremities, continuing up to the trunk, shoulder, elbow, wrist, and fingers.[5-14] This skill is a finely coordinated process which is perfected through training. The positioning of the shoulder and upper extremity in space is important in determining how much energy can be imparted to the baseball and thus, the velocity of the pitch.[5-9] The skill of pitching, in regard to the shoulder, can be separated into four phases: preparation, cocking, acceleration, and follow through.[5-14]

Preparation Phase

The preparation phase is also called the "wind-up" in baseball. The preparation phase occurs from the start of the pitching motion and ends with the hand-ball (the arm used in throwing the ball) positioned farthest away from the body.[5-14] This phase is highly diverse between individuals due to idiosyncrasies of the particular pitcher.

Cocking Phase

The cocking phase represents the movement occurring from the hand-ball position to the point of maximum lateral rotation at 90 degrees of shoulder abduction. In the beginning of the movement, the scapula is retracted and the shoulder is laterally rotated, abducted, and horizontally abducted. The elbow may be extended or flexed. During the cocking phase, the scapula starts to protract providing a propulsive platform for the shoulder. At the end of the cocking phase, the shoulder reaches maximal lateral rotation and is now entering into the acceleration phase.[5-14]

External rotation is limited by the passive restraints of the glenohumeral capsule and ligaments. The most significant restraint is the inferior glenohumeral ligament.[6] These passive restraints are assisted by the activity of the horizontal abductor, the pectoralis major, and the internal rotator muscles which are the latissimus dorsi and the subscapularis.[9,12] In addition, the reciprocal inhibition of the external rotators of the shoulder, the supraspinatus, infraspinatus, and teres minor, allows for preparation of explosive shoulder internal rotation.[9,12]

Acceleration Phase

The acceleration phase starts at the point of maximum lateral rotation and maximum abduction of the shoulder.[5-14] Acceleration continues until the point when the ball is released. In the acceleration phase, the movement of the shoulder consists of horizontal adduction and internal rotation. At the same time the scapula is protracted. This phase is exhibits a brief and explosive movement.

Follow Through Phase

Lastly, the follow through phase is characterized by the point after release of the ball to the point of maximum medial rotation of the shoulder.[5-14] Concurrently, the shoulder is also horizontally adducted. It is separated into two parts, early and late, distinguished by arm being parallel to the ground. The early phase lasts for only one-tenth of a second. In the late phase, there is a slight recoil of the shoulder into external rotation. This is followed by adduction of the shoulder in a diagonal pattern across the body. In the follow through phase, the external rotators of the shoulder are slightly active in decelerating the shoulder.[9,12] However, as in the preparation phase, this technique may vary due to individual difference.

Sport Specific Movement Analysis of the Acceleration Phase

The purpose of this literature review is to critique the training programs used to increase the velocity of the pitch. Therefore, the pitching phase which will be analyzed is the acceleration phase.

The muscles used by the shoulder in the acceleration phase are the pectoralis major, the latissimus dorsi, and the subscapularis.[6,9,12-14] However, it is also necessary to include the serratus anterior.[9,12] This muscle provides a stable base for the shoulder and helps to accelerate the shoulder by providing a forward thrust.

The joint angles in the shoulder encountered during the acceleration phase are as follows. At the beginning of the acceleration phase shoulder external rotation is approximately 60 to 90 degrees, shoulder abduction is approximately 100 to 120 degrees, and shoulder horizontal abduction is approximately 0 degrees. At the end of the acceleration phase, the shoulder is in approximately 0 degrees of external/internal rotation, shoulder abduction is approximately 90 to 110 degrees, and shoulder horizontal adduction is approximately 10 degrees.[7,8]

Only one type of muscular contraction is used in the shoulder during the acceleration phase of the overhand throwing motion. The pectoralis major, subscapularis, and latissimus dorsi develop force through the limb to the baseball.[9,12-14] These muscles contract concentrically to propel the baseball forward.

The angular velocities of the shoulder in the acceleration phase are reported for three movements. The angular velocity of internal rotation is approximately 5000 degrees per second (major league baseball pitchers can generate velocities of 6000 degrees per second), horizontal adduction is approximately 500 to 1000 degrees per second, and adduction is approximately 250 to 500 degrees per second.[7,8,15,16]

Energy Metabolism Analysis of the Acceleration Phase

The acceleration phase of the overhand throwing motion is a short duration, high intensity movement. Thus, the muscles used to produce the pitching velocity utilize primarily anaerobic metabolism. However, a pitcher, utilizes aerobic metabolism as well, because of the long duration of the game and the number of pitches that he or she may throw.[1-3]

Injury Prevention

There are numerous types of injuries associated with the overhand throwing motion. The most are overuse syndromes, such as impingement, bursitis, tendinitis, and rotator cuff tears.[10,16-22] Other problems related to the throwing motion come from muscle imbalances, decreased flexibility, and glenohumeral instability.[10,16,18,19,21,22,27] Most authors which advocate overall preventative measures, suggest a conditioning program for the entire body because the throwing motion involves the entire body.[22-26] Those who focus on the shoulder and scapular muscles suggest a conditioning program for the musculature involved in every phase of the throwing motion. The muscles must be strengthened through a full range of motion.[16,22,27] Some authors place large emphasis on the strengthening of the rotator cuff musculature.[13,23,24,26] A final key point in injury prevention is the need to maintain muscle and soft tissue flexibility.

Summary

This chapter has illustrated the four phases of the overhand throwing motion: preparation, cocking, acceleration, and follow through. Of these four, the acceleration phase is responsible for imparting the velocity onto the baseball. The shoulder movements in the acceleration phase consist of internal rotation, horizontal adduction, and slight adduction. The primary muscles used to perform this task are the pectoralis major, latissimus dorsi, and subscapularis with assistance from the serratus anterior. The joint angles, angular limb velocities, type of muscular contraction and metabolic energy used were given. In addition, injury prevention was considered and the various problems related to the throwing shoulder were examined. Once the need analysis has been established, a training program can then be developed accordingly.

CHAPTER 5

CRITIQUE OF OVERHAND THROWING TRAINING PROGRAMS FOR INCREASING PITCHING VELOCITY

In this chapter, the literature review will critique the training programs designed to increase pitching velocity based on principles of training, discussed in chapter one. As a review, the principles of training are progressive overload and the volume, specificity, and diversity of training. At this time it would be beneficial to state that all the training programs are able to progressively overload the targeted musculature. Secondly, all of the training programs, in general, will follow the same volume of training. Specificity and diversity will be addressed in greater detail below.

In the principles of training, specificity is an essential component. "Specific exercise elicits specific adaptations creating specific training effects." When training and testing are performed using the same type of resistive equipment, a large increase in strength is demonstrated. However, if testing is performed on different equipment the increases in strength may be small or even none.[1]

Thus, it appears paramount that training programs be specific to the skill which the individual is trying to improve. The program must target specific muscles involved, replicate angular limb velocities, allow the same type of muscular contraction, and utilize the same energy source. Also, concerns about joint angles and injury prevention, which were brought up in chapter 3 will be examined.

The training programs reviewed will be compared by the types of different training protocols; dynamic constant resistance, isometric, isokinetic, and plyometric.

Targeting Specific Muscles Involved

In all of the training programs which were reviewed there were no difficulties in targeting specific musculature involved in the overhand throwing motion.[4,13,23-26,28-33] However, the three motions involved in the acceleration phase (horizontal adduction, internal rotation and slight adduction) were difficult to train at once with isokinetic, isometric, and some dynamic constant resistance programs. Dynamic constant resistance programs have tried to eliminate this problem by using manual or other types of resistance (weighted baseballs, for example) which allow the three movements to occur at once.[29] Plyometrics have been able target the three motions simultaneously.[4] The benefit of training three movements at once may be an increase in the coordination of the muscles involved in the movement.

Replicating Angular Limb Velocities

At this time, there is no training equipment (machinery) which allows angular velocities close to those found in the acceleration phase of the overhand throwing motion (5000 to 6000 degrees per second).[1,16,19,20]

Although unable to reproduce the angular limb velocities encountered in the acceleration phase, isokinetic training has produced significant increases in throwing velocities.[1,32] This may be due to the nature of isokinetic training which allows the maximal contraction of the muscle through out the range of movement.

Isometric training has been used to strengthen weak areas in specific musculature, however this static form of training may decrease the angular velocity of the limb due to training at only a few joint angles.[1-3]

Plyometric training may use many different weighted balls. The weight of the ball used in the program will determine the possible angular velocity of the limb.[4,13]

Dynamic constant resistance using weighted baseballs closely replicates angular limb velocities.[29] Training with balls that are slightly "underweight" produces greater improvement in pitching velocity. This may be due to the pitchers ability to closer replicate actual angular limb velocities.

Allowing the Same Type of Muscular Contraction

All training programs demonstrate a concentric contraction of the musculature involved in the acceleration phase of the overhand throwing motion.[4,13,23-26,28-32]

Utilize the Same Metabolic Energy Source

All the training programs utilized the same metabolic energy source as that used in the acceleration phase of the overhand throwing motion (anaerobic). However, some training programs were general conditioning programs, which utilized both anaerobic and aerobic metabolic energy sources.[13,23-25] Training anaerobically and aerobically would appear beneficial as pitching performance requires both.

Joint Angles Trained

There appeared to be no problems involved in the ability to train the specific musculature at the joint angles encountered in the acceleration phase.

In isokinetic training, there have been numerous training angles tested in an attempt to find an optimal formula for success.[19,27,33,34] However, no angles have been proven more beneficial than others.

The real problem which exists is the ability to train the musculature in three dimensions. During the throwing motion, the joint angles are constantly changing; the shoulder moves approximately 10 degrees in horizontal adduction while concurrently internally rotating.

Only dynamic constant resistance and plyometric training are able to allow for natural movements of the shoulder through three dimensions. Isokinetic training attempts to remedy this by training in a diagonal plane.[20,32] However, this is still a linear plane and not a natural movement in the throwing motion.

Injury Prevention

In the critique of training programs is injury prevention. All training programs utilize maximal musculature contraction for optimal strength gains. In any training program there exhibits risk. It is difficult to assess the potential for injury involved in the different types of training.

In general, before any training program to increase pitching velocity is implemented, the individual should be physically conditioned.[16,17,23,25,26] The strength, endurance, and flexibility of all musculature surrounding the shoulder be addressed.[16] As throwing motion is not limited to the shoulder, conditioning of the trunk, hip, and leg musculature is also necessary in the prevention of injury. All of these components must also be monitored closely as training progresses.[16]

Summary

All training programs are able to target specific muscle groups involved in the throwing motion, demonstrate the same type of muscular contraction, and utilize the same metabolic energy source. There exists a difference concerning the angular limb velocities between training programs. Only dynamic constant resistance and plyometric training are able to replicate performance velocities. Only dynamic constant resistance and plyometric training allow for natural joint angles encountered in the throwing motion. Finally, injury prevention centers around the conditioning and monitoring of strength, endurance, and flexibility throughout the individual.

CHAPTER 6

EXPLORATION OF A POSSIBLE MOST EFFECTIVE TRAINING PROGRAM AND AREA OF RESEARCH

There are many training protocols, each stating increases in performance and benefits to using a certain protocol than another. This makes it difficult to assess a superior training program.

Possible Most Effective Training Program

Based on the critique in chapter 5, a program which employs dynamic constant resistance and plyometric training better replicates the sports specific movements of the acceleration phase of the overhand throwing motion. In addition, dynamic constant resistance and plyometric training are the only training programs which will allow for high angular limb velocities.

In Fargo, North Dakota, an exercise physiologist, John Frapier, has developed a training program utilizing "sprint cords".[35] This would be considered a type of dynamic constant resistance training program. The "sprint cord" alone is basically surgical tubing. However, Frapier has a patent pending on a device which directs the cords to load specific muscle groups. The individual can train at specific joint angles and three dimensions of movement using the "sprint cords". In addition, specific angular limb velocities can be approximated by altering the tension applied through the cord. It appears that this form of training would be successful in strengthening the shoulder for increasing pitching velocity. However, research on this subject is needed.

Areas of Possible Research

In areas of research, more needs to be done on the comparison of different types of training programs using functional tests such as throwing velocities, instead of internal and external rotator muscle strength. Research in comparing different joint angles used in strengthening to determine the possible benefits of training in specific joint angles is needed. Also, research on specificity of angular limb velocity in isokinetic training could be developed more. There is room for research involving resistance training for the overhand throwing motion in many areas; those named above are just a few of the potential studies.

CHAPTER 7

CONCLUSION

In this independent study, an attempt to explore the most effective resistance training program for increasing the throwing velocity of the baseball pitcher was examined. The principles of training, the movement analysis of the baseball pitch, and different training programs were analyzed. Based on this information, a critique of the different training programs was performed in the effort to find the most effective training program possible.

The attempt to find an effective training program was difficult. Trying to determine if progressive overload is equal for the different types of training programs is challenging due to individual differences in intensity and maximal muscle contraction.

However, from the critique, it appeared that the most effective training program would utilize factors of specific joint angles, angular limb velocity, and type of muscular contraction. Dynamic constant resistance and plyometric training seem to target these three factors with the greatest ability.

Further research is needed on training programs designed to improve throwing velocities. Specifically, comparison and pilot studies of different and new training programs are needed. Lastly, these research studies should determine improvements on a functional performance basis.

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