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Rehabilitation techniques for shoulder injuries from repetitive overhead motions

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**REHABILITATION TECHNIQUES FOR SHOULDER INJURIES FROM REPETITIVE
OVERHEAD MOTIONS**

A Project Report

Presented to

The Faculty of the Department of Human Performance

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Nicole K. Makris

August 2001

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APPROVED FOR THE DEPARTMENT OF HUMAN PERFORMANCE

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ABSTRACT

REHABILITATION TECHNIQUES FOR SHOULDER INJURIES FROM REPETITIVE OVERHEAD MOTIONS

by Nicole K. Makris

The purpose of the project was to develop an educational reference for student athletic trainers that presented components of a rehabilitation program for the shoulder complex consisting of: range of motion and flexibility, strength and endurance, neuromuscular control (PNF, closed-kinetic-chain, and plyometric training), aquatic therapy, functional progressive activities, and a preventive in-season program.

Three groups of individuals representing various components of sports medicine were created to establish a need for the manual, review the therapeutic exercises selected from the literature, and validate the manual. The Needs Assessment Group unanimously agreed on the need for an educational reference manual. The Therapeutic Exercise Group provided additional progressions and variations of the therapeutic exercises, and the Validation Group rated the overall manual as a good to excellent educational reference manual.

ACKNOWLEDGMENTS

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CHAPTER ONE

INTRODUCTION

As a profession, athletic training has evolved to encompass care of the physically active through the prevention, evaluation, treatment, and rehabilitation of athletic injuries (Arnheim & Anderson, 1991; Arnheim & Prentice, 2000).

Athletic training was originally oriented toward the intercollegiate athlete. Today, athletic trainers work in various settings such as clinics, hospitals, high schools, colleges, and professional leagues, where the physically active receive care for their athletic injuries (Arnheim & Anderson, 1991; Arnheim & Prentice, 2000). This diversification of employment has impacted athletic training education by placing a stronger emphasis on rehabilitation principles.

Athletic training was established in the United States during the late nineteenth century with the introduction of intercollegiate athletics (Arnheim & Anderson, 1991; Arnheim & Prentice, 2000). The first athletic trainers had no academic knowledge of medicine. Their techniques consisted of massage and home remedies (Arnheim & Anderson, 1991). The growth of athletic training as a profession was influenced by the growth in American football, and continues to expand into industrial and clinical settings (Arnheim & Anderson, 1991). Athletic training is currently one of the fastest growing subspecialties in sports medicine (Arnheim & Anderson, 1991). Primary responsibilities of athletic trainers are the prevention of athletic injuries by assessing equipment, eliminating environmental

hazards, applying bracing or taping, and returning injured athletes to their prior level of competition to prevent reinjury (Prentice, 1999). Due to the nature of athletic participation and the demands placed on the human body, injuries range from minor to life threatening. When injuries do occur, the attention of an athletic trainer shifts from prevention to evaluation, management, treatment, and rehabilitation of athletic injuries (Prentice, 1999). Athletic trainers use a wide variety of therapeutic techniques to rehabilitate injured athletes and return them to participation quickly and safely.

Athletes participating in repetitive overhead motions can be referred to as overhead athletes. Injuries occurring in overhead athletes present a challenge to the athletic trainer and sports medicine staff (Kamkar, Irrgang, & Whitney, 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Mikesky, Edwards, Wigglesworth, & Kunkel, 1995; Schmitt & Snyder-Mackler, 1999; Scriber, 1996; Warner, Micheli, Arslanian, Kennedy, & Kennedy, 1990; Wilk & Arrigo, 1993). Injuries to the shoulder complex are common in sports involving repetitive overhead activities. According to the 1989-1990 National Collegiate Athletic Association (NCAA) injury surveillance system, shoulder injuries have been the most frequently occurring baseball injury every year since 1985, accounting for 19% of the reported injuries (Mikesky et al., 1995). Shoulder pain is a common finding among tennis players at all levels of competition. Pain has been reported in up to 24% of young players ranging from 12 to 19 years-of-age, and as high

as 50% in older players (McCann & Bigliani, 1994). The competitive and recreational swimmer performs over 1 million arm cycles each year during training, setting up the shoulder complex for microtrauma and overuse injuries (Kenal & Knapp, 1996). Two common etiologies of shoulder pain and dysfunction in the overhead athlete are shoulder instability and impingement syndrome (Kamkar et al., 1993). Shoulder injuries may occur when repetitive overhead activities result in forces that exceed the passive mobility, stability, and dynamic control of the glenohumeral joint (Warner et al., 1990). In sports emphasizing overhead motions, an overlap has been observed between impingement syndrome and glenohumeral joint instability (Kamkar et al., 1993). Subacromial impingement secondary to functional scapular instability is another proposed mechanism of secondary impingement in throwing athletes (Kamkar et al., 1993).

There are two types of shoulder impingement. Primary impingement is the crowding of the subacromial arch, along with posterior capsule tightness and excessive superior migration of the humeral head due to weakness of the humeral head depressors (Kamkar et al., 1993). Secondary impingement is caused by a decrease in subacromial space due to glenohumeral joint instability. Glenohumeral joint instability may be triggered by weakness of the rotator cuff mechanism and biceps tendon (Kamkar et al., 1993). This weakness leads to overload of the static stabilizers of the glenohumeral joint during throwing

activities, resulting in glenohumeral joint laxity and later instability (Kamkar et al., 1993). Glenohumeral joint laxity or instability causes the dynamic stabilizers to become fatigued. Weakness of this mechanism results in abnormal translation of the humeral head, causing secondary impingement of the rotator cuff by the coracoacromial arch (Kamkar et al., 1993).

Historically, a "cookbook" rehabilitation program has been implemented for an injured athlete. A cookbook approach offers the same exercises to every athlete with the same injury (Wilk & Arrigo, 1993). Such an approach may not meet the needs of the injured athlete. For example, a rehabilitation program for a volleyball player should be different than for a wrestler diagnosed with the same condition. The difference is due to functional sport-specific needs (Tippett & Voight, 1995). A different approach would be to base the rehabilitation program on specific adaptations to imposed demands (SAID) principle (Tippett & Voight, 1995). This suggests that all rehabilitation programs should be geared toward the sport-specific demands that will be placed on the individual (Tippett & Voight, 1995). An effective rehabilitation program must prepare the athlete for the demands that will be placed on the injured area once the rehabilitation program has been completed (Tippett & Voight, 1995). A well-balanced rehabilitation program should consider the athlete's role in the sport, and once specific activities have been broken down into required fundamental movements,

the athlete's injured body part is stressed progressively until function is adequate for the athlete to return to sport-specific demands (Tippett & Voight, 1995).

Several protocols have been designed for rehabilitation of the injured shoulder (Kamkar et al., 1993). These protocols focus on strengthening the rotator cuff muscles in addition to restoring normal range of motion, endurance, and pain control (Kamkar et al., 1993). Additional programs suggest kinesio logic repair, which involves specific training of the rotator cuff and scapular rotators, to establish proper scapulohumeral rhythm (Kamkar et al., 1993). Proper scapulohumeral rhythm acts to lessen the risk of impingement by synchronizing scapulothoracic motion with glenohumeral joint motion (Kamkar et al., 1993). Adequate strength of the rotator cuff decreases impingement by depressing the humeral head during elevation of the arm (Kamkar et al., 1993). In addition, strengthening the rotator cuff provides dynamic stability to the glenohumeral joint by controlling excessive humeral head migration (Kamkar et al., 1993).

Purpose of the Project

The purposes of the manual, *Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions*, are the following:

1. To create a reference for student athletic trainers for the prevention and rehabilitation of surgical and nonsurgical overhead shoulder injuries, such as shoulder instability and impingement.

2. To provide a variety of therapeutic exercise examples for the scapulothoracic and glenohumeral joints to assist student athletic trainers in developing a well-balanced rehabilitation program. In addition, the manual will provide examples of exercise modification and progression in the rehabilitation of the scapulothoracic and glenohumeral joints.
3. To interrelate the scapulothoracic articulation and glenohumeral joint anatomy and biomechanics of overhead activities to the rehabilitation process.
4. To outline specific components, such as strength, endurance, range of motion, neuromuscular control, proprioception, closed-kinetic-chain, plyometrics, aquatic therapy, and functional progressive activities, used to develop rehabilitation programs.
5. To develop a format that allows student athletic trainers to be creative with therapeutic exercises and develop individualized rehabilitation programs for student athletes, as well as develop a personal style in rehabilitation.
6. To develop a format that allows student athletic trainers to develop well-balanced rehabilitation programs in a systematic and organized fashion.
7. To develop a format that introduces a wide variety of rehabilitation techniques to student athletic trainers.
8. To develop a format that allows student athletic trainers to add to the manual as they develop a broader knowledge base in advanced therapeutic exercise.

9. To present information to enable an entry-level student athletic trainer to better understand how the anatomy and biomechanics of the shoulder complex affect the rehabilitation process.

Significance of the Project

The project included developing a reference guide that isolates the scapulothoracic articulation and glenohumeral joint for entry-level student athletic trainers to institute proper rehabilitation techniques and develop well-balanced rehabilitation programs for athletic injuries. There is an abundance of literature for lower extremity rehabilitation. However, there are limited resources available that emphasize overhead motions in the rehabilitation of the scapulothoracic articulation and glenohumeral joint. Not only is there limited information, but the information available does not integrate sports biomechanics with anatomy, and scapulothoracic articulation and the glenohumeral joint. This integration, along with an adaptable format, will provide a reference for student athletic trainers as they care for athletes who participate in sports emphasizing overhead motions. The rehabilitation of athletes participating in overhead activities, such as baseball, softball, volleyball, tennis, swimming, and various throwing events in track and field, is dramatically different from that of a running back in football. The baseball pitcher's exercise prescription, for example, should reflect functional activities and positioning involved in throwing, such as 90° of shoulder abduction and external rotation, and should emphasize eccentrics,

concentrics, and plyometrics (Wolin & Tarbet, 1997). A football player can be placed on an exercise program emphasizing strengthening below 90° of abduction (Wolin & Tarbet, 1997).

Rehabilitation classes in the educational setting are normally one to two semesters. This does not allow enough time to go into depth on specific muscular or articular injuries, surgical and nonsurgical considerations, and preventive rehabilitation techniques. Isolating the shoulder complex and addressing it as an individual entity will better prepare student athletic trainers to provide care for overhead athletes.

Assumptions

Assumptions in the manual, Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions, are the following:

- 1. Student athletic trainers have access to rehabilitation equipment that is mentioned in the manual such as dumbbells, therapeutic tubing, therapeutic balls, T-bar, putty, fitter, wobble boards, tilt boards, stools, plyoballs, trampolines, and an aquatic center.**
- 2. All rehabilitation programs developed for student athletes by student athletic trainers are cleared and supervised by a certified athletic trainer.**
- 3. Protocols mentioned in the manual are in accordance with the policies and procedures of the athletic training program, and the National Athletic Training Association undergraduate competencies in athletic training.**

4. The manual does not create new protocols or therapeutic exercises, but is an accumulation of information from the current literature.

Limitations

Limitations of the manual, *Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions*, are the following:

1. Specific stages of rehabilitation, such as tissue healing and time frames to return to full participation, are not provided for specific injuries.
2. The manual does not address all components of rehabilitation.
3. Specific therapeutic exercises included for the scapulothoracic articulation and glenohumeral joint are representative of exercises in the current literature and expert recommendations.
4. The manual is an educational reference that should be used in conjunction with academic preparation, under the direct supervision of a certified athletic trainer, and within the philosophy of the athletic training room.
5. The therapeutic exercise manual is limited to the shoulder complex, specifically the scapulothoracic articulation and glenohumeral joint.
6. The manual is written for the entry-level student athletic trainer.
7. The manual does not include therapeutic modalities, psychological considerations, social considerations, isokinetics, pharmacological agents, cardiorespiratory fitness, injury evaluation, or documentation requirements of rehabilitation programs.

8. Information gathered for the development of the manual was primarily collected from literature emphasizing sports with overhead motions such as baseball, softball, swimming, volleyball, tennis, and various throwing events in track and field.

Delimitations

The manual, *Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions*, was developed for the following population:

1. Entry-level student athletic trainers who are not certified, or recently certified, with academic preparation in anatomy, biomechanics, and rehabilitation principles of the shoulder complex.
2. Student athletic trainers developing rehabilitation programs for student athletes in overhead sports such as baseball, softball, volleyball, tennis, swimming, and various throwing events in track and field.
3. Student athletic trainers with an interest in developing creative, challenging, rehabilitation programs for athletes participating in overhead sports.

Definition of Terms

Active range of motion (AROM) – “joint motion that occurs because of muscle contraction” (Arnheim & Prentice, 2000, p. G-1).

Agonist muscles – “muscles directly engaged in contraction as related to muscles that relax at the same time to allow joint motion” (Arnheim & Prentice, 2000, p. G-1).

Antagonist muscles – “muscles that counteract the action of the agonist muscle” (Arnheim & Prentice, 2000, p. G-1).

Atrophy – “wasting away of tissue or of an organ; diminution of the size of a body part” (Arnheim & Prentice, 2000, p. G-1).

Autogenic inhibition – “relaxation of the agonist muscle after a contraction” (Arnheim & Prentice, 2000, p. G-1).

Biomechanics – “branch of study that applies the laws of mechanics to living organisms and biological tissue” (Arnheim & Prentice, 2000, p. G-1).

Chronic injury – “injury with a long onset and duration” (Arnheim & Prentice, 2000, p. G-1).

Circumduction – “act of moving a limb, such as the arm or hip, in a circular manner” (Arnheim & Prentice, 2000, p. G-1).

Collision sport – “sport in which athletes use their bodies to deter or punish Opponents” (Arnheim & Prentice, 2000, p. G-2).

Concentric (positive) contraction – “the muscle shortens while contracting against Resistance” (Arnheim & Prentice, 2000, p. G-2).

Eccentric (negative) contraction – “the muscle lengthens while contracting against resistance” (Arnheim & Prentice, 2000, p. G-2).

Force couple – “equal and parallel forces acting in opposite directions, resulting in rotational movement. Force couples have also been described as divergent pulls of forces, creating a pure rotation” (Dillman, Fleisig, & Andrews, 1993; Kamkar et al., 1993).

Functional progression – “a series of sport-specific movement patterns progressed according to the physical and psychological tolerance of an individual in preparation for return to preinjury sport functions” (Tippett & Voight, 1995, p. 102).

Golgi tendon organ – “a deep, muscle-tendon mechanoreceptor responsible for monitoring tension within the muscle-tendon unit” (Tippett & Voight, 1995, p. 102).

Isometric exercise – “the muscle contracts statically without changing length” (Arnheim & Prentice, 2000, p. G-3).

- Isotonic exercise** – “the muscle shortens and lengthens through a complete range of motion” (Arnheim & Prentice, 2000, p. G-3).
- Joint capsule** – “saclike structure that encloses the ends of bones in a diarthrodial Joint” (Arnheim & Prentice, 2000, p. G-3).
- Kinesthesia** – “sensation or feeling of movement; the awareness one has of the spatial relationships of one’s body and its parts” (Arnheim & Prentice, 2000, p. G-3).
- Mechanoreceptors** – “specialized groups of cells that function to convert mechanical distortion of tissue into electrical activity that is subsequently transmitted to the central nervous system” (Tippett & Voight, 1995, p. 102).
- Microtrauma** – “injury produced by submaximal loading of a body part that occurs in a repetitive, cyclic fashion” (Tippett & Voight, 1995, p. 102).
- Muscular endurance** – “the ability to perform repetitive muscular contractions against resistance” (Arnheim & Prentice, 2000, p. G-3).
- Muscular strength** – “the maximal force that can be applied by a muscle during a single, maximal contraction” (Arnheim & Prentice, 2000, p. G-3).
- Muscle spindle** – “a complex receptor located within intrafusal muscle fibers that is responsible for monitoring the tension within the muscle-tendon unit” (Tippett & Voight, 1995, p. 102).
- Overhead athletes** – athletes competing in sports that emphasize repetitive overhead motions such as baseball, softball, volleyball, tennis, swimming, and various throwing events in track and field.
- Pacinian corpuscles** – “a rapidly adapting articular mechanoreceptor responsible for sensing the initiation and/or cessation of joint movement” (Tippett & Voight, 1995, p. 102).
- Passive range of motion (PROM)** – “movements that are performed completely by the examiner without assistance or muscle contraction by the athlete” (Arnheim & Prentice, 2000, p. G-4).

Plyometrics – “a mode of training developed in eastern Europe that emphasizes a quick, eccentric muscle contraction to produce a greater subsequent concentric muscle contraction” (Tippett & Voight, 1995, p. 102).

Proprioception – “the ability to determine the position of a joint in space” (Arnheim & Prentice, 2000, p. G-4).

Proprioceptive neuromuscular facilitation (PNF) – “stretching and strengthening techniques that involve combinations of alternating contractions and muscle relaxation” (Arnheim & Prentice, 2000, p. G-4).

Ruffini endings – “a slowly adapting articular mechanoreceptor responsible for sensing stretch within the joint capsule” (Tippett & Voight, 1995, p. 103).

CHAPTER TWO

REVIEW OF LITERATURE

The following section is a literature review of the functional anatomy, biomechanics, and rehabilitation techniques for the shoulder complex in overhead athletes. The rehabilitation section will contain concepts involving strength and endurance training, range of motion, flexibility, proprioceptive neuromuscular facilitation, closed-kinetic-chain exercise, plyometric techniques, aquatic therapy, and functional throwing progression for the scapulothoracic articulation and glenohumeral joint.

Functional Anatomy

The shoulder complex is made up of three bones: the scapula, the clavicle, and the humerus (Zachazewski, Magee, & Quillen, 1996). The scapula is characterized as a flat, triangular bone. The clavicle is an "S" shaped bone commonly called the collarbone, and the humerus is the long bone of the upper arm (Donnelly, 1990). These bones make up three joints and one articulation: the glenohumeral, acromioclavicular, and sternoclavicular joints, and the scapulothoracic articulation (Zachazewski et al., 1996). The shoulder complex is the most freely moving joint in the body, allowing excessive range of motion without enormous stability. This sacrificing of stability for mobility leads to potential injury, particularly in overhead sports (Donnelly, 1990; Kendall, McCreary, & Provance, 1993; Magee, 1992; Zachazewski et al., 1996).

The glenohumeral joint refers to the articulation of the head of the humerus and the glenoid fossa of the scapula (Donnelly, 1990; Kendall et al., 1993). The glenohumeral joint is a shallow, multiaxial, ball-and-socket, synovial joint that depends on muscles rather than bones or ligaments for stability (Magee, 1992). Primary stabilizers of the glenohumeral joint can be classified as passive or active (Zachazewski et al., 1996). These primary stabilizers work independently and cooperatively to provide stability while allowing incredible range of motion within the shoulder joint. Passive (static) stabilizers include the labrum and joint ligaments. The labrum is a fibrocartilage ring attached tightly to the bottom half of the glenoid, and loosely to the top half. The labrum increases the glenoid depth, adding to glenohumeral joint stability (Magee, 1992; Zachazewski et al., 1996). The superior, middle, and inferior glenohumeral joint ligaments are thickenings of the synovial capsule, which add additional passive stabilization to the glenohumeral joint (Zachazewski et al., 1996). Active (dynamic) stabilizers of the glenohumeral joint include the supraspinatus, infraspinatus, subscapularis, and teres minor, which are collectively referred to as the rotator cuff (Zachazewski et al., 1996). The rotator cuff acts as a stabilizer by compressing the humeral head into the glenoid fossa, decreasing the amount of superior translation occurring between the glenoid fossa and humeral head with arm abduction (Zachazewski et al., 1996). There are eight basic glenohumeral joint movements: flexion and extension in the coronal axis,

abduction and adduction in the sagittal axis, horizontal abduction and adduction in the longitudinal axis, and medial (internal) and lateral (external) rotation in the longitudinal axis (Kendall et al., 1993). In addition, there is circumduction, which is a combination of movements of flexion, abduction, extension, and adduction (Kendall et al., 1993).

In addition to the rotator cuff, primary movers of the glenohumeral joint are the pectoralis major and minor, latissimus dorsi, biceps brachii (long head), triceps brachii, deltoid, and teres major (Zachazewski et al., 1996). Branches of the posterior cord and the suprascapular, axillary, and lateral pectoral nerves innervate the muscles of the glenohumeral joint (Kendall et al., 1993).

The shoulder girdle refers to the articulation of the acromioclavicular and sternoclavicular joints, and scapulothoracic articulation (Kendall et al., 1993). The sternoclavicular joint provides the only bony connection for the shoulder girdle with the axial skeleton (Kendall et al., 1993). The acromioclavicular joint is a plain synovial joint with a fibrous capsule and an articular disc (Magee, 1992). Joint stability within the acromioclavicular joint depends primarily on the acromioclavicular and coracoclavicular ligaments (Magee, 1992). The sternoclavicular joint is a saddle-shaped synovial joint, stabilized by a thick capsule and disc between the clavicle and the manubrium sternum (Magee, 1992). Movements of the acromioclavicular and sternoclavicular joints are elevation, depression, protrusion, retraction, and rotation (Magee, 1992).

The scapulothoracic articulation is not considered a true joint because it does not have a capsular pattern, or a close-packed position (Kamkar et al., 1993; Magee, 1992). The scapula articulates approximately between the second and seventh ribs, and at rest, the medial borders are parallel and approximately 4 inches apart (Kendall et al., 1993). Primary movers and stabilizers of the scapulothoracic articulation are muscles that attach the scapula and thorax to the vertebral column. They include the serratus anterior, latissimus dorsi, trapezius, rhomboids, levator scapulae, and pectoralis minor (Kendall et al., 1993; Zachazewski et al., 1996). These muscles are obliquely oriented, providing for rotational and linear motions of the scapula (Kendall et al., 1993). There are seven basic movements of the scapulothoracic articulation: adduction, abduction, lateral (upward) rotation, medial (downward) rotation, anterior tilt, elevation, and depression (Kendall et al., 1993).

Biomechanics of the Shoulder Complex

The movements of the glenohumeral joint and scapulothoracic articulation are not performed in isolation, but are associated with movements at the sternoclavicular and acromioclavicular joints (Kamkar et al., 1993). These three joints and one articulation participate in shoulder motion in an inseparable, coordinated, synchronized, and smooth pattern called scapulohumeral rhythm (Kamkar et al., 1993; Schmitt & Snyder-Mackler, 1999). Scapulohumeral rhythm has two functions; the first function is to maintain the glenoid fossa in an optimal

position to receive the articular surface of the humeral head, and the second function is to maintain the scapula in the optimal length-tension relationship of the muscles acting on the humerus (Kamkar et al., 1993). Scapulohumeral rhythm can be divided into glenohumeral-scapulothoracic and acromioclavicular-scapulothoracic contributions (Kamkar et al., 1993). Normal maximal shoulder elevation is 180° (Warner et al., 1990). The glenohumeral joint contribution is 120° , and the scapulothoracic articulation contributes 60° (Kamkar et al., 1993). Overall, there is a 2:1 motion ratio in shoulder elevation involving the glenohumeral joint and scapulothoracic articulation: for every 2° of glenohumeral elevation, there is 1° of scapulothoracic rotation (Kamkar et al., 1993). The first 30° of scapular rotation during shoulder elevation is the result of the clavicle elevating at the sternoclavicular joint, and the last 30° of scapular rotation during shoulder elevation is the result of the acromioclavicular joint rotating and elevating (Kamkar et al., 1993). There is a specific timing of events in the performance of shoulder elevation. Disruption in this motion at any of the involved joints may affect the total motion produced (Kamkar et al., 1993). In addition, an imbalance, weakness, or dysfunction of force couples may disrupt scapulohumeral rhythm (Kamkar et al., 1993).

The definition of a force couple is equal and parallel forces acting in opposite directions, resulting in rotational movement (Dillman et al., 1993; Kamkar et al., 1993). Force couples have also been described as divergent pulls

of forces, creating a pure rotation (Dillman et al., 1993; Kamkar et al., 1993). The force couples of the glenohumeral joint and scapulothoracic articulation are extremely important in preventing abnormal positioning of these joints in overhead activities, and reducing pathologies of shoulder impingement and instability. The first force couple of the glenohumeral joint occurs in the transverse plane, where the subscapularis is counterbalanced by the infraspinatus and teres minor (Dillman et al., 1993; Kamkar et al., 1993). This prevents superior impaction of the humeral head into the acromion process, and compression of the soft tissue (Kamkar et al., 1993). The second force couple of the glenohumeral joint occurs in the coronal plane between the anterior fibers of the deltoid and the inferior rotator cuff muscles (Dillman et al., 1993; Wilk & Arrigo, 1993). The cocontraction of this force couple compresses the humeral head within the glenoid fossa, maintaining joint congruency, and limiting humeral head displacement during shoulder movements (Wilk & Arrigo, 1993). The supraspinatus assists the deltoid in abduction, and helps to stabilize the glenohumeral joint with the force of gravity by depressing the humeral head during shoulder elevation. This also prevents impingement of soft tissues under the subacromial arch (Kamkar et al., 1993).

A force couple of the scapulothoracic muscles functions similarly to force couples at the glenohumeral joint by acting as synergist and antagonist, stabilizing the scapula against the thorax during shoulder motions. The force

couple produced concentrically by the lower fibers of the serratus anterior and the upper fibers of the trapezius achieves upward rotation of the scapula, which is pertinent to scapulohumeral rhythm during shoulder elevation (Kamkar et al., 1993; Wilk & Arrigo, 1993). During adduction of the shoulder, this force couple acts eccentrically to control downward rotation of the scapula (Kamkar et al., 1993; Wilk & Arrigo, 1993). The integrity of this force couple is important not only in proper scapulohumeral rhythm, but also in the dynamics of the shoulder complex by anchoring the scapula to the thorax (Dillman et al., 1993; Kamkar et al., 1993). The serratus anterior shows high levels of activity during the late cocking, acceleration, and follow through phases of pitching (Kamkar et al., 1993). Activation of the serratus anterior during the late cocking phase is needed to eccentrically decelerate the retracting scapula (Dillman et al., 1993; Kamkar et al., 1993). During acceleration, the serratus anterior concentrically protracts the scapula, along with adduction and internal rotation of the shoulder (Dillman et al., 1993; Kamkar et al., 1993).

Weakness or fatigue of the serratus anterior prevents the scapula from stabilizing against the thorax, causing excessive winging of the vertebral border and the inferior angle of the scapula (Dillman et al., 1993; Kamkar et al., 1993). This excessive winging and tipping of the scapula will lead to abnormal gliding of the scapula and a significant decrease in the subacromial space, thus causing impingement of soft tissue (Dillman et al., 1993; Kamkar et al., 1993). If

humeral elevation is not synchronized with upward scapular rotation, or if lowering of the arm is not synchronized with downward scapular rotation, scapulothoracic rhythm will be disrupted (Dillman et al., 1993; Kamkar et al., 1993; Kenal & Knapp, 1996; Wilk & Arrigo, 1993). Disruption of the scapulothoracic rhythm leads to dysfunction of the scapulohumeral joint. This results in impingement of the rotator cuff due to insufficient elevation of the acromion, compressing the rotator cuff as it passes underneath the coracoacromial arch (Dillman et al., 1993; Kamkar et al., 1993).

Overall, when these force couples are not properly balanced or equalized, abnormal glenohumeral joint mechanics occur (Dillman et al., 1993; Wilk & Arrigo, 1993). The overhead athlete may exhibit posterior shoulder pain and weakness, causing shoulder dysfunction secondary to force couple imbalances (Wilk & Arrigo, 1993).

In addition, the overhead athlete performs repetitive overhead movements at high velocities with explosive forces, placing stress on the shoulder complex (Dillman et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Mikesky et al., 1995). Weakness or fatigue of the scapular muscles after repeated use may lead to impingement due to failure to achieve the required scapular rotation with humeral elevation (Dillman et al., 1993). This may cause pain leading to inhibition of the scapular muscles, resulting in further impingement (Kamkar et al., 1993).

Overhead athletes present a challenge to the athletic trainer and sports medicine staff (Dillman et al., 1993; Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Mikesky et al., 1995; Schmitt & Snyder-Mackler, 1999; Scriber, 1996; Warner et al., 1990; Wilk & Arrigo, 1993). These athletes usually exhibit glenohumeral joint hypermobility resulting from significant laxity of the shoulder capsule, particularly the anterior portion of the shoulder capsule (Dillman et al., 1993; Scriber, 1996; Warner et al., 1990; Wolin & Tarbet, 1997). This increased laxity of the anterior capsule is necessary to allow the athlete the excessive anterior translation of the humeral head required in the cocking phase of throwing and other overhead motions (Dillman et al., 1993; Scriber, 1996; Warner et al., 1990; Wilk & Arrigo, 1993; Wolin & Tarbet, 1997). Due to this acquired capsular laxity, the rotator cuff is stressed trying to maintain glenohumeral joint congruency (Scriber, 1996; Warner et al., 1990; Wolin & Tarbet, 1997).

Therefore, there is a delicate balance where the glenohumeral joint capsule is loose enough to allow the extreme range of motion required for successful completion of various sporting activities, but at the same time, is able to dynamically stabilize the humeral head (Scriber, 1996; Warner et al., 1990; Wolin & Tarbet, 1997). Due to the laxity of the anterior capsule, the overhead athlete usually exhibits excessive external rotation of the shoulder of approximately 145°, and a decrease in internal rotation of approximately 75° or

less (Warner et al., 1990). This adaptive change in external and internal rotation of the shoulder is due to the repetitive stresses placed on the capsule (Mikesky et al., 1995; Scriber, 1996; Warner et al., 1990; Wilk & Arrigo, 1993; Wolin & Tarbet, 1997).

With the excessive anterior capsule laxity, there is a loss of flexibility in the posterior musculature and joint capsule, causing the humeral head to migrate anterosuperiorly during shoulder range of motion. This may contribute to secondary functional impingement (Mikesky et al., 1995; Scriber, 1996; Warner et al., 1990; Wilk & Arrigo, 1993; Wolin & Tarbet, 1997). The loss of flexibility of the posterior shoulder structures in the overhead athlete, combined with tight anterior chest structures, causes a large amount of stress to be applied to specific tissues during the deceleration phase of overhead activities, and may contribute to tensile tissue failure (Scriber, 1996; Warner et al., 1990; Wilk & Arrigo, 1993; Wolin & Tarbet, 1997).

A study performed by Mikesky et al. (1995) assessing bilateral isokinetic eccentric and concentric muscular strength of shoulder external and internal rotator muscles in a group of collegiate baseball pitchers indicated that there is a strength and endurance imbalance. Results indicated that the internal rotator muscles were consistently stronger than the external rotator muscles, and that the concentric and eccentric external to internal rotator strength ratio ranged from 62% to 81%. The eccentric strength of shoulder rotator muscles averaged

114% of concentric strength. Imbalance of the rotator cuff musculature causes excessive anterior capsular laxity and loss of posterior capsular flexibility which have been implicated as etiologic factors in both glenohumeral joint instability and impingement (Warner et al., 1990).

In swimming, Kenal and Knapp (1996) believe the external and internal strength imbalance develops from the forward propulsion in swimming, which is accomplished by repetitive motions of adduction and internal rotation of the glenohumeral joint during the power phase, and abduction and external rotation during recovery. This power phase selectively trains the anterior chest wall and internal rotator cuff muscles, creating an imbalance in the dynamic stabilizers of the glenohumeral joint (Kenal & Knapp, 1996).

Athletic trainers, sport medicine physicians, physical therapists, and coaches believe that many of the overhead injuries occur during the follow-through phase, such as when the muscles of the shoulder and elbow are contracting eccentrically to decelerate the limb after the ball has been released. Concentric strength is important during the acceleration phase of overhead activities, but it is the eccentric strength required during the follow-through phase which is the most critical in decreasing shoulder injuries (Mikesky et al., 1995). Eccentric strength and endurance are more important than concentric strength and absolute strength in overhead athletes (Mikesky et al., 1995).

Repetitive overhead motions performed at high velocities and with explosive forces stress the shoulder complex and may lead to inflammation of the shoulder joint capsule and the rotator cuff muscles (Kamkar et al., 1993; Mikesky et al., 1995; Scriber, 1996; Warner et al., 1990; Wilk & Arrigo, 1993). This type of prolonged microtrauma will decrease muscular efficiency, resulting in poor dynamic stability, increased humeral head displacement, and eventually functional instability that leads to progressive tissue failure (Mikesky et al., 1995; Warner et al., 1990; Wilk & Arrigo, 1993).

Rehabilitation

Shoulder injuries in sports are primarily due to trauma resulting from collision or noncollision, and overuse (Zackazewski et al., 1996). Noncollision injuries include torsional injuries and instability, often seen in overhead activities such as throwing, swimming, and swinging. The repetitive nature of these activities causes muscular fatigue, weakness, and imbalances of synergistic and primary movers often acting as a force couple, therefore causing abnormal shear forces that lead to instability, impingement, and rotator cuff tears (Zachazewski et al., 1996). Common injuries consist of dislocations, subluxation, tendinitis, impingement, rotator cuff injuries, fractures, thoracic outlet syndrome, sprains, strains, and contusion (Booher & Thibodeau, 1994; Magee, 1992; Prentice, 1999; Zachazewski et al., 1996).

In the past, rehabilitation of the shoulder complex after an injury or

repair was frequently delayed for several weeks to allow the natural healing process to start (Wilk & Arrigo, 1993). After several weeks of immobilization, only passive range of motion was initiated for the next several weeks (Wilk & Arrigo, 1993). This type of rehabilitative treatment approach in the younger athletic population may result in significant atrophy of the shoulder complex musculature, causing range of motion compensation and prolonged complaints of pain and dysfunction (Kamkar et al., 1993; Kenal & Knapp, 1996; Wilk & Arrigo, 1993). It is believed that strict immobilization increases the occurrence of functional instability. This functional instability is due to a decrease dynamic stability through rotator cuff inhibition or shutdown, muscular atrophy, and poor neuromuscular control (Kenal & Knapp, 1996; Wilk & Arrigo, 1993). Current trends in the rehabilitation process have shifted toward earlier, protected active, and passive range of motion, strengthening, and stabilizing exercises for the rotator cuff musculature to reestablish voluntary stability of the humeral head within the glenoid fossa (Wilk & Arrigo, 1993). It is believed that rehabilitation programs emphasizing early range of motion and strengthening exercises have a lower incidence of recurring subluxations and dislocations by decreasing rotator cuff inhibition and muscular atrophy, and maintaining neuromuscular control (Warner et al., 1990).

This trend toward earlier aggressive, more progressive, rehabilitation programs is possible by improved surgical procedures, such as advances in

arthroscopic procedures, and improved soft tissue fixation techniques and devices (Kamkar et al., 1993; Wilk & Arrigo, 1993). With the advancement in surgical procedures, there is less tissue morbidity of the shoulder musculature. Arthroscopic advancements, in particular, decrease the amount of disrupted tissue by eliminating the need to resect the anterior deltoid during surgery (Wilk & Arrigo, 1993). In addition to better surgical techniques, there is a conservative trend of nonoperative treatment in shoulder dysfunction caused by shoulder instability and impingement (Kamkar et al., 1993; Kenal & Knapp, 1996). The nonoperative management of shoulder instability and impingement consists of rest, anti-inflammatory medications, and extensive therapeutic exercises emphasizing the function of the rotator cuff and scapulothoracic muscles (Kamkar et al., 1993).

There is no "cookbook" approach in the rehabilitation of the shoulder complex for overhead athletes. An extremely important concept in rehabilitation of overhead athletes is individualization. This concept acknowledges that every injured athlete is different and unique, and the rehabilitation program should reflect this. The athlete's specific injury, sport activity, tissue status, muscular strength and endurance status, static stability, body type, age, and desired goals should be carefully considered (Wilk & Arrigo, 1993). In addition, the time of season that the injury occurs affects the speed of the rehabilitation program. If the injury occurs in the beginning of the season, and the athlete has a prognosis

of returning to participation, the rehabilitation process may be aggressive. If the injury occurs toward the end of the season, there is no need to rush the rehabilitation progression.

The athlete's specific sport is extremely important in developing a rehabilitation program. For example, the rehabilitation program for a baseball pitcher is dramatically different from that of a running back in football. The baseball pitcher's exercise prescription should reflect functional activities and positioning involved in throwing. Examples might include 90° of shoulder abduction, and external rotation emphasizing eccentrics, concentrics, and plyometrics (Wilk & Arrigo, 1993). In contrast, a football player can be placed on an exercise program emphasizing strengthening below 90° of abduction (Wilk & Arrigo, 1993). The patient's desired functional goals should be considered, and the rehabilitation program should have progressive steps to accomplish these functional desires (Wilk & Arrigo, 1993).

Several protocols have been developed for the rehabilitation of the injured shoulder. Most of these protocols focus on strengthening the rotator cuff and the scapulothoracic muscles, in addition to restoring normal range of motion, endurance, and pain control (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Wilk & Arrigo, 1993). Physical modalities, such as ultrasound, heat, and cold, have been suggested to control pain and inflammation (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Wilk & Arrigo,

1993). The following sections will discuss current information on restoring or maintaining scapulothoracic and glenohumeral range of motion, strength and endurance, and neuromuscular control. In addition, the use of aquatic therapy, functional progressive activities, and a preventive in-season program will be discussed.

Range of Motion and Flexibility

Due to limited flexibility of the posterior capsule and imbalances in internal rotation, flexibility training must be initiated to increase or maintain normal range of motion. Examples of stretching the posterior capsule and soft tissue without manipulating the scapulothoracic articulation or glenohumeral joint are limited in the literature. One example is to stabilize the scapula manually on the lateral border, then apply traction to the shoulder joint, horizontally adduct the arm, and apply pressure. To increase scapular range of motion, an athletic trainer can perform scapular mobilizations, pectoralis major and minor stretches, and various flexibility exercises.

Strength and Endurance Training

Wilk and Arrigo (1993) suggest that rehabilitation progression in the shoulder complex should emphasize proximal stability and progress to distal mobility. Since the scapula provides proximal stability by acting as an anchor to the thorax, allowing distal segment mobility, the scapulothoracic articulation must first be corrected before moving on to the glenohumeral joint (Wilk &

Arrigo, 1993). Stability of the scapulothoracic articulation cannot be achieved by one muscle alone. Proper functioning of all the scapulothoracic muscles is necessary to achieve dynamic stability of the scapula (Kamkar et al., 1993). Isolated strengthening of just one of the scapulothoracic muscles will create a muscular imbalance (Kamkar et al., 1993; Kenal & Knapp, 1996).

Examples of exercises used to strengthen the scapulothoracic muscles are: (a) wall push-ups with emphasis on protracting the scapula, (b) end range shoulder flexion in the prone position, (c) serratus anterior punches, (d) rowing, (e) scapular retraction with the shoulder in horizontal abduction and external rotation in a prone position, (f) shoulder elevation and external rotation with the arm positioned diagonally between flexion and abduction, (g) scapular retraction with shoulder horizontal abduction and internal rotation in a prone position, (h) press ups, and (i) movement awareness drills (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Wilk & Arrigo, 1993).

Movements progress from straight planes, to circular movements, then diagonal patterns, emphasizing the quality, not quantity, of movement (Kamkar et al., 1993). A functional, stable scapulothoracic articulation is critical for the overhead athlete and enhances sport performance by dynamically maintaining a consistent length-tension relationship for the shoulder girdle musculature (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Wilk & Arrigo, 1993). The muscles involved in the scapulothoracic articulation are not

required to contract powerfully in short periods of time, nor are they required to produce large amounts of force. Therefore, muscular endurance is the goal (Kamkar et al., 1993). Since muscular endurance is the goal, it is recommended that exercises should be quantified by time and repetition, and not based on the number of sets and repetitions (Scriber, 1996).

The shoulder joint muscles can be classified into prime movers and stabilizers (Wilk & Arrigo, 1993). The prime movers are known as the accelerators of the shoulder and are characterized as double-joint muscles that internally rotate the shoulder (Wilk & Arrigo, 1993). The prime movers consist of the pectoralis major, latissimus dorsi, teres major, and triceps brachii muscles (Wilk & Arrigo, 1993). The accelerators can be effectively exercised with manual resistance, isokinetic exercise, and plyometric exercise training (Wilk & Arrigo, 1993).

The stabilizers are known as the decelerators, which are characterized as single-joint muscles that abduct and externally rotate the shoulder, producing slow, controlled movement (Wilk & Arrigo, 1993). The stabilizers consist of the infraspinatus, teres minor, and posterior deltoid muscles (Wilk & Arrigo, 1993). The decelerators can be trained effectively using exercise tubing which applies consistent load to the musculotendinous unit by stimulating an eccentric or decelerated type of contraction (Wilk & Arrigo, 1993). The dynamic stabilizers must exert force over a long period of time, thus requiring strength, power, and

endurance (Borsa, Lephart, Kocher, & Lephart, 1994). Endurance training is vital in preventing fatigue. Once the muscles fatigue, there is a higher risk of subluxation and impingement due to the loss of dynamic stabilization (Borsa et al., 1994). The scapular stabilizers must function along with the rotator cuff to stabilize and rotate the scapula during activity (Borsa et al., 1994). The stable base of the scapula permits smooth, controlled motion of the humerus by the rotator cuff, while also providing joint stability (Borsa et al., 1994). Strengthening the rotator cuff muscles provides dynamic stability to the joint and decreases hypermobility (Kenal & Knapp, 1996; Prentice, 1999). The rotator cuff muscles can be strengthened by using a pulley while standing or sitting, using a theraband or surgical tubing connected to a wall, holding a hand-held weight in a side-lying position, lying prone with the arm in horizontal abduction, and using the empty can exercises (Prentice, 1999; Scriber, 1996).

Strengthening the dynamic stabilizers of the shoulder complex should initially consist of exercises in the inner range of motion, progress to the outer ranges, and slowly to functional activities. Exercises should progress from slower, controlled velocities to faster velocities that simulate game situations as the joint can tolerate (Kenal & Knapp, 1996). Scapular plane exercises are often recommended for strengthening the internal and external rotators of the shoulder (Wilk & Arrigo, 1993). The scapular plane is defined as elevation of the shoulder joint in a range between 30° and 40° anterior to the frontal plane (Wilk

& Arrigo, 1993). This position is often used because it places minimal stress on the shoulder capsule, and it places the glenohumeral joint in a functional plane of movement (Wilk & Arrigo, 1993). Shoulder abduction combined with external and internal rotation is progressed from 0° to 30-40°, and then 90° (Wilk & Arrigo, 1993). This progression maximally challenges the dynamic stabilizers of the shoulder complex, and progresses from a position of maximal joint stability to a minimal stability position (Wilk & Arrigo, 1993).

The body blade is another piece of equipment that promotes dynamic stability and muscular synchronization to ensure that the head of the humerus stays centered in the glenoid fossa (Scriber, 1996). The body blade is oscillated in 30- to 60-second work bouts in several positions (Scriber, 1996). Examples of movements performed with the body blade are oscillating side to side, up and down, and forward and backward with the arm flexed to 90° and the elbow straight (Scriber, 1996). Another example is the body blade oscillating in an anterior and posterior direction in the cocking phase of throwing, which is 90° abducted and externally rotated (Scriber, 1996). The final example is the arm oscillating in the approximate position where a ball is released during a throwing motion (Scriber, 1996). These movements ensure that the head of the humerus stays centered in the glenoid fossa, and also enhance the functional joint stability that is important to the throwing athlete (Scriber, 1996).

During the initial rehabilitation phase, extrinsic support techniques can be utilized in a hypermobile shoulder. While strengthening and stability problems are addressed, McConnell glenohumeral and scapulothoracic taping may decrease pain during humeral elevation by facilitating normal scapular positioning and stability (Kenal & Knapp, 1996).

Neuromuscular Control

As mentioned, there is a delicate balance between mobility and stability in the shoulder complex. Therefore, dynamic stability from capsuloligamentous structures is even more crucial for maintaining functional stability (Borsa et al., 1994; Prentice, 1999). Static and dynamic stabilizers interact to provide stability for the glenohumeral joint, which involves an intricate balance of muscular strength, endurance, flexibility, and neuromuscular control (Borsa et al., 1994). Historically, rehabilitation programs have been directed toward restoring muscular strength, muscular endurance, and joint flexibility following an injury, without considering the role of the neuromuscular mechanism (Borsa et al., 1994). The neuromuscular mechanism contributes to joint stability, provided by articular mechanoreceptors which provide the athlete with sensations of kinesthesia and joint position (Borsa et al., 1994). Injury to the articular and muscular structures results in a mechanical disturbance, and a loss of joint sensation due to damage to the articular and peripheral mechanoreceptors (Prentice, 1999). This disruption to the sensory feedback decreases reflexive

joint stabilization, and neuromuscular coordination and stabilization, contributing to repetitive, chronic injuries and a progressive decline in the joint (Borsa et al., 1994; Prentice, 1999).

Joint proprioception refers to conscious and unconscious awareness of joint positioning, while kinesthesia is the sensation of joint motion or acceleration (Borsa et al., 1994; Prentice, 1999). Proprioceptive and kinesthetic signals are transmitted to the spinal cord through afferent sensory pathways (Prentice, 1999). The efferent motor response to sensory information is referred to as neuromuscular control (Prentice, 1999). This neuromuscular response provides neurological feedback that controls muscular action to protect against excessive strain on static stabilizers of the joint (Borsa et al., 1994). Articular ligaments play an important role in normal joint kinematics by providing mechanical restraints, but they also provide important neurological feedback that directly mediates muscular reflex stabilization of a joint (Borsa et al., 1994).

Proprioception is mediated by peripheral receptors in articular, muscular, and cutaneous structures (Borsa et al., 1994). Articular structures include free-nerve endings and proprioceptive mechanoreceptors consisting of Pacinian corpuscles, Ruffini endings, and Golgi tendon organ-like endings (Borsa et al., 1994). Mechanoreceptors are specialized neurons that transduce mechanical deformation into electrical stimuli, indicating joint motion and positioning (Borsa et al., 1994). Muscle spindles, which are sensitive to changes in length, and

Golgi tendon organ-like endings, which are sensitive to changes in muscle tension, are slow adapting, and are important in signaling actual joint positioning or change (Borsa et al., 1994). Pacinian corpuscles are rapid adapting, and are sensitive to sudden motions of acceleration or deceleration (Borsa et al., 1994). These articular mechanoreceptors have been identified in the glenoid labrum and glenohumeral joint ligaments (Borsa et al., 1994). Stimulation of these receptors enhances the proprioceptive mechanism, and results in proprioceptive sensibility and reflex musculature stabilization of the joint (Borsa et al., 1994). There is a link between proprioceptive deficits and joint pathology in athletes, individuals presenting with acute traumatic joint pathology, and people with degenerative joint disease (Borsa et al., 1994).

Overhead-throwing athletes must possess a delicate neuromuscular balance between flexibility and stability to permit the mobility necessary for their sport. Loss of normal, coordinated, neuromuscular firing occurs as a result of capsuloligamentous trauma and proprioceptive deficits (Borsa et al., 1994). This unstable condition places increased physiologic demands on the dynamic stabilizers to compensate for the loss of static stability (Borsa et al., 1994).

A rehabilitation program must restore normal joint stability and proprioception of both mechanical restraints, and strengthen the muscles which coordinate the neuromuscular-controlling mechanism required for joint stability, especially during the sudden changes in joint position common in overhead

activities. A lag in the neuromuscular reaction time can result in joint instability and impingement (Borsa et al., 1994). The objective of proprioceptive rehabilitation is to enhance cognitive joint position and motion, enhance muscular stabilization of the joint in the absence of static structural restraints, and facilitate synergy and synchrony of muscular firing patterns necessary for functional activities (Borsa et al., 1994). To obtain rehabilitation objectives, the activities must maximally recruit the muscles responsible for humeral and scapular rotation and stabilization (Borsa et al., 1994). Three techniques that help reestablish proprioception, kinesthesia, and joint position sense are proprioceptive neuromuscular facilitation (PNF), closed-kinetic-chain exercises, and plyometric training.

Proprioceptive Neuromuscular Facilitation

Proprioceptive neuromuscular facilitation is a therapeutic technique based on the principles of functional human anatomy and neurophysiology (Prentice & Kooima, 1989). Proprioceptive neuromuscular facilitation was first used in the treatment of patients with paralysis and various neuromuscular disorders (Prentice & Kooima, 1989). Proprioceptive neuromuscular facilitation utilizes proprioceptive, cutaneous, and auditory input to increase strength, flexibility, and range of motion (Prentice & Kooima, 1989; Surburg & Schrader, 1997). Proprioceptive neuromuscular facilitation has been utilized as a component of the

rehabilitation process of many sport-related injuries (Prentice & Kooima, 1989; Surburg & Schrader, 1997).

The principles and techniques of PNF are based primarily on the neurophysiologic mechanism involved in the stretch reflex (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). The stretch reflex involves two types of receptors: muscle spindles, which are sensitive to a change in length and rate of change, and Golgi tendon organs, which detect changes in tension (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). Stretching of a given muscle causes an increase in the frequency of impulses transmitted to the spinal cord from the muscle spindle, which in turn produces an increase in the frequency of motor nerve impulses returning to that same muscle. This causes a reflex contraction that resists the stretch (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997).

Autogenic inhibition and reciprocal inhibition are two neurophysiologic phenomena used during PNF patterns to facilitate and/or inhibit the neuromuscular system (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). Autogenic inhibition is defined as inhibition mediated by afferent fibers from a stretched muscle acting on the alpha motor neurons supplying that muscle, thus causing the muscle to relax (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). This inhibition protects the muscle against injury from reflex contractions resulting from excessive stretch (Prentice,

1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). Reciprocal inhibition deals with the agonist-antagonist relationship. The agonist muscle is the muscle or muscle group contracting to produce motion. The antagonist muscle is the muscle or muscle group that stretches to allow motion in the agonist pattern (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). When the agonist muscle contracts, it sends an impulse causing a reflex relaxation of the antagonist, thus allowing a greater stretch to occur in the agonist pattern (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997).

Basic considerations of PNF include: (a) teaching the PNF patterns; (b) establishing visual cues to help facilitate proper patterns; (c) establishing firm, simple verbal cues to coordinate maximal voluntary effort with reflex responses; (d) determining appropriate hand placement on the moving surface, with enough pressure to influence the direction of motion and facilitate maximal reflex responses induced by the pressure receptors; (e) acquiring proper mechanics and body positioning for the athletic trainer; and (f) determining the amount of resistance required to facilitate a maximal response to allow smooth, coordinated motion (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997).

There are five basic principles of PNF consisting of: (a) patterns utilizing rotational movements which are critical components in producing a maximal

contraction; (b) distal segments moving first, and should be complete halfway through the pattern; (c) maximizing resistance at specific angles throughout the range of motion allows overflow, or irradiation to the weaker component, and enables the stronger components to facilitate the weaker component of a movement pattern; (d) specific joints may be facilitated by using traction or approximation which stimulate joint proprioceptors; and (e) a quick stretch to the muscle prior to the muscle contraction facilitates the stretch reflex mechanism, thus producing a greater force (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997).

Each of the principles should be applied to the specific technique of PNF for the purpose of strengthening, by facilitating a particular agonistic muscle group, or for stretching, by inhibition of the antagonistic group (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). Proprioceptive neuromuscular facilitation strengthening techniques are used to develop muscle strength, endurance, and coordination. These techniques include repeated contraction, slow-reversal, slow-reversal-hold, and rhythmic stabilization (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). Proprioceptive neuromuscular facilitation stretching techniques used for the purpose of increasing range of motion consist of rhythmic initiation, contract-relax, hold-relax, and slow reversal-hold-relax (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997).

Human movement rarely involves straight plane motions, but consists of diagonal and spiral patterns in all planes and axes (Prentice & Kooima, 1989; Surburg & Schrader, 1997). Therefore, PNF techniques utilize many muscle groups within a pattern, as opposed to isolated muscle actions (Prentice & Kooima, 1989; Surburg & Schrader, 1997). These gross movements are composed of rotational and diagonal exercise patterns which are similar to the motions required in overhead activities (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). The exercise patterns consist of three components which include flexion and extension, abduction and adduction, and internal and external rotation (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). There are two separate patterns of diagonal movements referred to as D1 and D2 patterns (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997).

When used appropriately, PNF can be an effective tool for rehabilitation of sport-related injuries. PNF techniques strengthen weak muscles or muscle groups and improve range of motion about an injured joint (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997). Specific techniques depend on the individual athlete's needs, and may be modified accordingly (Prentice, 1999; Prentice & Kooima, 1989; Surburg & Schrader, 1997).

Scapulothoracic neuromuscular control exercises are drills designed to maximally challenge the scapular force couples, which are the upper and middle

trapezius, the rhomboids counterbalanced by the lower fibers of the serratus anterior, and the lower trapezius and upper serratus anterior fibers (Wilk & Arrigo, 1993). The athlete is in a side-lying position on the uninjured arm, and the affected arm is abducted to 90° and internally rotated. The athlete's hand is placed on the table to stabilize the distal segment and assist in isolating the scapulothoracic musculature. The athlete is asked to slowly elevate and depress the scapula against the athletic trainer's manual resistance. Scapular protraction and retraction are also performed in the same manner (Wilk & Arrigo, 1993). The athletic trainer can utilize a variety of manual therapy techniques, such as slow reversal holds, rhythmic stabilization, and timing for emphasis, to intensify the dynamic control and kinesthesia of the scapulothoracic articulation (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Wilk & Arrigo, 1993).

Closed-Kinetic-Chain Exercise

Closed-kinetic-chain exercise has been popular for the lower extremity, but similar concepts can be used for the upper extremity. Closed-kinetic-chain exercise is defined as exercise performed with the distal segment fixed to an immovable object (Prentice, 1999; Wilk & Arrigo, 1993). Examples of upper extremity, closed-kinetic-chain exercises include push-ups, press-ups, and hand-supported weight shifts (Prentice, 1999; Wilk & Arrigo, 1993). These exercises can be useful in providing joint approximation forces, which promote co-

contraction about the joint, enhancing the dynamic joint stabilizers, and maintaining neuromuscular control (Prentice, 1999; Wilk & Arrigo, 1993). Hand-supported weight shifting exercises can be employed early in the rehabilitation program to enhance dynamic stability of the shoulder, and may progress in later stages by having the athletic trainer apply random directional pressure, to which the athlete must respond to maintain a static position (Prentice, 1999). Hand-supported weight shifts start in a four-point kneeling push-up position, shifting one's weight side-to-side and front-to-back (Prentice, 1999). The athlete then progresses to a three- or two-point position, and finally advances to an unstable surface, such as a wobble board or plyoball (Prentice, 1999). Progressing from a stable surface to an unstable surface while balancing will further challenge the dynamic stabilizers (Prentice, 1999; Wilk & Arrigo, 1993). In addition, the shoulder is only one part of the kinetic chain during overhead activities. The athlete's trunk and legs play a significant role in producing power in these sporting activities (Kenal & Knapp, 1996; Wilk & Arrigo, 1993). Therefore, the rehabilitative exercise program for the overhead athlete must include extensive leg, hip, abdominal, and back conditioning exercises, in addition to the shoulder complex (Kenal & Knapp, 1996; Wilk & Arrigo, 1993).

Plyometric Training

Movements of the shoulder in overhead sports involve a cocking phase. This cocking phase places a prestretch on the adductor and internal rotator

musculature of the shoulder to facilitate the explosive, concentric, muscular contraction that accelerates the arm (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Scriber, 1996; Wilk & Arrigo, 1993). Plyometric exercise, or more appropriately stretch-shortening exercise, causes a prestretch prior to the contraction, which facilitates the muscle spindles that assist in enhancing explosive, concentric muscular contractions (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Scriber, 1996; Wilk & Arrigo, 1993).

There are three phases in the stretch-shortening drills. The first phase is the setting or eccentric phase, where there is a rapid prestretch applied to the musculotendinous unit that stimulates the muscle spindles. The second phase is the amortization phase, representing the time between the eccentric and concentric phase. This phase should be as short as possible. The third phase is the concentric muscular contraction from the prestretch stimulus (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Scriber, 1996; Wilk & Arrigo, 1993). There is an increase in muscular performance in the overhead athlete when stretch-shortening rehabilitative exercises are utilized. The performance enhancement observed appears to occur from neural adaptation, increased speed of the myotatic reflex, desensitization of the Golgi tendon organ, or enhanced neuromuscular control, and not from morphological changes of the muscle (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994;

Scriber, 1996; Wilk & Arrigo, 1993). Examples of plyometric exercises are:

(a) two-hand overhead soccer throw, (b) two-hand chest pass, (c) two-hand side-to-side throw, (d) one-hand step and pass, (e) one-hand overhead baseball throw, (f) exercise tubing plyometrics with internal and external rotation, (g) exercise tubing plyometric biceps curl, (h) plyoball push-ups, and (i) plyoball wall throws (Kamkar et al., 1993; Kenal & Knapp, 1996; McCann & Bigliani, 1994; Scriber, 1996; Wilk & Arrigo, 1993).

Aquatic Therapy

The use of water as a treatment dates back to the Greeks and Romans (Korel, 1996; Speer, Cavanaugh, Warren, Day, & Wickiewicz, 1993). Early aquatic therapy programs were based on the traditional swimming strokes, but physical therapists and athletic trainers realized that the properties of water allowed people to do things that they could not do on land (Korel, 1996; Speer et al., 1993). Today, aquatic therapy is used either in the form of a traditional whirlpool treatment or as an exercise medium (Korel, 1996; Speer et al., 1993).

The benefits vary depending on the intensity and duration of exercise (Korel, 1996; Speer et al., 1993). Effects and benefits of aquatic therapy include: (a) increased circulation to muscles; (b) increased heart rate, respiratory rate, and general muscle metabolism; (c) decreased blood pressure, sensitivity of sensory nerve endings, pain, and joint effusion; (d) general muscle relaxation; and (e) improved range of motion and flexibility, strength, coordination,

ambulation, mood, and feelings of well-being (Korel, 1996; Speer et al., 1993).

The effects of exercise and the warmth of water, approximately 27° to 33°C, work together to produce a variety of physiological and psychological effects (Korel, 1996; Speer et al., 1993).

Exercise can be adapted to water by taking into account the force principles that apply to water such as density, buoyancy, movement of force, hydrostatic pressure, viscosity, and cohesion medium (Korel, 1996; Speer et al., 1993). With an understanding of these principles, an athletic trainer can easily develop an appropriate exercise program in water to help the athlete progress through all stages of rehabilitation (Korel, 1996; Speer et al., 1993). The basic principles of strength and functional gains are the same as for a land-based exercise program. The only difference is that in the water, the exercise can be assisted or resisted by buoyancy (Korel, 1996; Speer et al., 1993). Buoyancy-assisted motions can be used to help increase range of motion, or when an athlete is unable to perform the motion against resistance (Korel, 1996; Speer et al., 1993). Buoyancy-assisted motions occur in a vertical plane, while buoyancy-resisted motions occur in a horizontal plane (Korel, 1996; Speer et al., 1993). Resistance can be added to motions by increasing the speed of movement, or by adding a floating device (Korel, 1996; Speer et al., 1993). Using aquatic therapy in the rehabilitation of shoulder injuries has shown that the hydrostatic pressure may provide biofeedback in the form of proprioceptive information (Korel, 1996;

Speer et al., 1993). Floating devices can be used for buoyancy-assisted or resistive motions in all arcs of motion, as hand-held weights are used on land at any stage of therapy (Speer et al., 1993). Using the principles of water pressure and resistance, athletic trainers can adapt a water exercise program to meet the goals of almost any athlete (Speer et al., 1993). However, aquatic exercise is most effective when used with traditional land therapy (Korel, 1996).

Functional Progressive Activities

The last phase of the rehabilitation program is functional progressive activities. This phase stresses the glenohumeral joint and scapulothoracic articulation in sport-specific activities. Once the athlete has been cleared to return to participation, a program of short-distance tossing is progressed to longer throws while increasing velocity (Tippett & Voight, 1995). A gradual interval-throwing program is designed to minimize risk for reinjury and emphasize proper throwing mechanics (Tippett & Voight, 1995). Due to the differences between individuals and different pathologies, there is no set timetable for return-to-sport functional exercise progressions (Tippett & Voight, 1995). To reduce risk of reinjury, each program must be tailored to the needs of the individual athlete. Each stage of the interval program must be completed without complications or pain. Therefore, pain should be an athletic trainer's guide to rate of progression (Tippett & Voight, 1995). It is not unusual for an

athlete to experience postexercise soreness, but sharp pain is an indicator to stop progression and reevaluate before continuing (Tippett & Voight, 1995).

Preventive In-Season Program

Overhead athletes are predisposed to excessive anterior joint capsule laxity, posterior joint capsule tightness, limited posterior and anterior shoulder musculature flexibility, imbalances of strength and endurance of the dynamic stabilizers, mechanical stresses disrupting normal biomechanics, poor sport-specific mechanics, and abnormal postural alignment. The key is prevention during the off-season, preseason, in-season, and postseason.

Scriber (1996) suggests the following for overhead athletes in-season:

(a) strengthen the proximal shoulder stabilizers first; (b) stretch and strengthen the external rotators; (c) warm up properly; (d) emphasize progressive, distance-based, interval throwing programs; (e) use proper form, technique, and mechanics; and (f) vary the exercise programs. In addition, athletes should work hard in the off-season, as well as during the season. Being in better shape before the season will decrease any possible complications during the season.

CHAPTER THREE

METHODS

This chapter presents the format for developing the manual, *Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions*. Sections will include subjects, establishing a need for the manual, development and selection of the therapeutic exercises, chapter set-up, illustrations and page set-up, and validation.

Subjects

There were three separate and distinct subject groups who completed specific questionnaires imperative to the development of the manual. Exemption from human subjects review was granted by the San Jose State University Human Subjects Institutional Review Board (Appendix A). All three groups consisted of different individuals representing various components of sports medicine. A sports medicine team consists of a variety of individuals who work together to provide the best care for an injured athlete. A team may include coaches, certified athletic trainers, team physicians, team orthopedists, physical therapists, strength and conditioning coaches, nurses, dentists, podiatrists, dietitians, and equipment personnel (Arnheim & Prentice, 2000).

The three subject groups were a Needs Assessment Group, Therapeutic Exercise Expert Group, and Manual Validation Group. Each participating subject signed a consent form (Appendix B), indicating willingness to participate in the

development of the manual, *Rehabilitation Techniques of Shoulder Injuries from Repetitive Overhead Motions*. All completed consent forms and questionnaires were confidential and stored in a locked filing cabinet. All three subject groups consisted of entirely different evaluators. There was no overlapping of individuals within the three subject groups.

Establishing a Need for the Manual

To establish a need for an educational reference manual for student athletic trainers, a questionnaire was developed and given to a Needs Assessment Group (Appendix C). The Needs Assessment Group consisted of four student athletic trainers, four certified athletic trainers, and one team physician.

Development and Selection of the Therapeutic Exercises

Exercises from the literature review were collected and divided into specific sections related to the rehabilitation process. These specific sections were range of motion and flexibility, muscular strength and endurance, neuromuscular control, aquatic therapy, functional progressive activities, and preventive programs. These sections were further categorized into subsections. For example, range of motion was broken down into passive and active exercise, muscular strength and endurance training into isometric and isotonic exercise, and neuromuscular control into closed-kinetic-chain exercises and plyometric training. From the literature review, 5 to 20 individual exercises were collected and placed in the appropriate section or subsection.

The exercises gathered from the literature review were given to the Therapeutic Exercise Expert Group which consisted of two team physicians, four certified athletic trainers, one strength and conditioning coach, and one physical therapist. Each expert had a minimum of 2 years experience with athletes participating in repetitive, high velocity, explosive overhead motions such as baseball, softball, volleyball, tennis, swimming, water polo, and various throwing events in track and field.

The purpose of using a panel of experts to review the therapeutic exercises was to combine professional experiences with current literature to establish a well-rounded selection of therapeutic exercises. As mentioned in the literature review, there is no "cookbook" approach for the rehabilitation of overhead athletic injuries. Sport therapists modify therapeutic exercises for sport-specific reasons. Creative changes can prevent athletes from becoming bored during long rehabilitation programs and allow modification for surgical limitations. This knowledge is gained through years of professional experience in rehabilitation.

Each individual in the Therapeutic Exercise Expert Group received a letter explaining the purpose of the manual (Appendix D1), a questionnaire indicating number of years experience working with overhead athletes (Appendix D2), a questionnaire for suggestions and additional exercises (Appendix D3), and the therapeutic exercises gathered from the literature (Appendix D4).

Chapter Set-Up

Information collected from the literature review, such as functional anatomy, biomechanics, and rehabilitation, provided one or two pages of background information for each section and subsection. This information was presented at a level that an entry-level student athletic trainer could understand.

The information was divided into the following chapters:

1. Chapter One briefly introduced the significance, purpose, assumptions, limitations, and delimitations of the manual. In addition, specific directions on how to use the manual in developing rehabilitation programs for upper extremity injuries were provided.
2. Chapter Two explained the functional anatomy and biomechanics of the shoulder complex.
3. Chapter Three explained biomechanical complications with overhead athletes.
4. Chapter Four explained specific rehabilitation considerations.
5. Chapter Five explained other considerations when rehabilitating an overhead athlete, such as the effects of lumbar, thoracic, and cervical range of motion in overhead motions.
6. Chapter Six explained the importance of restoring and maintaining range of motion and flexibility. In addition, this chapter defined passive and active range of motion, explained procedures for applying range of motion

techniques, provided guidelines and precautions for stretching, and outlined normal shoulder range of motion in all planes. Chapter six contained illustrated examples of passive, assisted, and active range of motion therapeutic exercises, along with an explanation of the athlete's position, procedures, muscles involved, and progressions for each exercise.

7. Chapter Seven explained how to regain muscular strength and endurance. In addition, this chapter defined muscle strength and endurance, explained the overload principle, outlined rehabilitation progressions, and identified prime movers and dynamic stabilizers. Exercises were broken down into isometric training, isotonic training of the shoulder joint and shoulder girdle, and body blade dynamic stabilizing exercises. Each exercise was illustrated along with an explanation of the athlete's position, procedures, muscles involved, and progressions.
8. Chapter Eight explained basic principles for reestablishing neuromuscular control during overhead activities. In addition, this chapter explained the neuromuscular mechanism, joint proprioception, joint kinesthesia, and mechanoreceptors. Each exercise was illustrated along with an explanation of the athlete's position, procedures, muscles involved, and progressions.
9. Chapter Nine explained basic principles of closed-kinetic-chain exercise.

Each exercise was illustrated along with an explanation of the athlete's position, procedures, muscles involved, and progressions.

10. Chapter Ten explained basic principles of plyometric training. Each exercise was illustrated along with an explanation of the athlete's position, procedures, muscles involved, and progressions.
11. Chapter Eleven explained basic principles of aquatic therapy. Each exercise was illustrated along with an explanation of the athlete's position, procedures, muscles involved, and progressions.
12. Chapter Twelve explained basic principles of functional throwing and tennis progressions for return to participation, and preventive programs performed during preseason and in-season.

Illustrations and Page Set-Up

To create clear, concise, and professional illustrations for the manual, a certified athletic trainer at Washington State University sketched approximately 3x3 inch illustrations of the individual therapeutic exercises. These illustrations were scanned, and two to four illustrated exercises were placed on the right side of each page. Detailed procedures for each exercise, such as the athlete's body position, external devices used (i.e., dumbbells, theraband, etc.), alternative external devices, involved muscles, progressions, creative modifications, and suggested sets and repetitions were described on the left side of the page.

Validation

To establish validity and clarity of the manual, the Validation Group was given a copy of the manual, Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions (Appendix E1), a letter explaining the project (Appendix E2), and a questionnaire (Appendix E3). The Validation Group consisted of two team physicians, four certified athletic trainers, one biomechanist with a Ph.D, and one physical therapist or physical therapy. The Validation Group rated the clarity and quality of the background information, exercises selected, illustrations, descriptions of exercise alterations and progressions, and provided an overall rating of the manual.

CHAPTER FOUR

RESULTS

The purpose of the manual, *Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions*, was to create a reference for student athletic trainers for the prevention and rehabilitation of overhead shoulder injuries, such as shoulder instability and impingement. The manual (a) provides a variety of therapeutic exercise examples for the scapulothoracic and glenohumeral joints to assist student trainers in developing a well-balanced rehabilitation program; (b) interrelates the scapulothoracic articulation and glenohumeral joint anatomy and biomechanics of overhead activities to the rehabilitation process; and (c) outlines specific components, such as strength, endurance, range of motion, neuromuscular control, proprioception, closed-kinetic-chain, plyometrics, aquatic therapy, and functional progressive activities, used to develop rehabilitation programs.

Needs Assessment Group

To establish a need for an educational reference manual for student athletic trainers, a questionnaire (Appendix C) was developed and given to four student athletic trainers, four certified athletic trainers, and one team physician. Each question was analyzed by tallying the responses and reporting the percentages (Table 1).

Table 1

Responses to Questionnaire Establishing a Need for the Manual

YES %	NO %	QUESTION
100	0	Do you feel there is a need to create a reference for student athletic trainers for the prevention and rehabilitation of overhead shoulder injuries, such as shoulder instability and impingement?
100	0	Do you feel there is a need for a manual that provides a variety of therapeutic exercise examples for the scapulothoracic and glenohumeral joints to assist student trainers in developing a well-balanced rehabilitation program?
100	0	Do you feel there is a need for a manual that interrelates the scapulothoracic articulation and glenohumeral joint anatomy and biomechanics of overhead activities to the rehabilitation?
100	0	Do you feel there is a need for a manual to outline specific components, such as strength, endurance, range of motion, neuromuscular control, proprioception, closed-kinetic-chain, plyometrics, aquatic therapy, and functional progressive activities, in developing rehabilitation programs for the shoulder complex?

(table continues)

YES %	NO %	QUESTION
100	0	Do you feel there is a need to develop a manual that allows student athletic trainers to be creative with therapeutic exercises and develop individualized rehabilitation programs for student athletes, as well as developing a personal style in rehabilitation?
100	0	Do you feel there is a need to develop a manual that allows student athletic trainers to develop well-balanced rehabilitation programs in a systematic and organized fashion?
100	0	Do you feel there is a need to develop a manual that introduces a wide variety of rehabilitation techniques of the shoulder complex to student athletic trainers?
100	0	Do you feel there is a need for a manual to present information so that an entry-level student athletic trainer can better understand how the anatomy and biomechanics of the shoulder complex affect the rehabilitation process?

Note. Nine individuals responded to the questionnaire (four student athletic trainers, four certified athletic trainers, and one team physician).

Additional comments consisted of the following:

1. "If there were such a manual, I would definitely get it because the shoulder is such a complex area."
2. "New sources are always needed, and if a person has this information, the best thing they can do is to share it."
3. "A manual with these components will be extremely helpful for any student athletic trainer."
4. "Such a manual would be a great resource for rehabilitation for the injured shoulder."
5. "This manual will be great for all levels of athletic trainers."
6. "I think that this type of manual would greatly help not only a student athletic trainer, but certified athletic trainers as well."
7. "I believe a manual as described above would be a great benefit for student athletic trainers, and allow them to better serve the active population."

Therapeutic Exercise Expert Group

The purpose of the Therapeutic Exercise Expert Group was to combine professional experiences with current literature. The Therapeutic Exercise Expert Group completed a questionnaire (Appendix D2) to indicate years of experience with overhead athletes. The expert group consisted of two team physicians with an average of 8.5 years of experience working with overhead athletes, four

certified athletic trainers with an average of 8.4 years of experience, one strength and conditioning coach with 17 years of experience, and one physical therapist with 10 years of experience. All the experts indicated experience working with athletes who participated in baseball, softball, volleyball, tennis, swimming, water polo, and various throwing events in track and field. A list of exercises was sent to the Therapeutic Exercise Expert Group for review (Appendix D4). They provided suggestions for additional exercises (Appendix D3) which can be found in Table 2.

Validation Group

To establish the validity and clarity of the manual, the Validation Group rated the clarity and quality of the background information, exercises, illustrations, descriptions of possible alterations or progressions of exercise, and provided an overall rating of the manual (Appendix E3). A summary of the ratings is provided in Table 3.

Additional comments consisted of the following:

1. "Need more citations."
2. "Using AMA style would save space and make the manuscript more readable."
3. "The manual is very appropriate for student athletic trainers, as well as certified athletic trainers. The Neuromuscular Control segment and drawings are excellent. I think you should look into presenting the

manual to Human Kinetics."

4. "I think this is a wonderful effort! It is practical, user friendly, and succinct."
5. "Look into Hawkins core shoulder exercises."
6. "An excellent manual which I would purchase, were it available. Excellent teaching tool. Overall, very, very well done."
7. "The manual was very easy to read and understand, and was very complete."
8. "Expand more on Aquatic Therapy."
9. "Points of interest were excellent, but need to clarify exercises' primary, secondary, and synergists [muscle groups]."
10. "Why limit manual to student athletic trainers?"
11. "Biomechanical and core stability involvement in overhead motions are easily forgotten; the Biomechanical Complication chapter was excellent."

Table 2

Suggestions for Additional Exercises to be Included in the Manual

Subsections	Suggested Exercises
Range of Motion and Flexibility	T-bar or L-bar active assisted flexion, extension, and external rotation exercises; Dowel overhead pectoralis stretch; and posterior deltoid stretch
Strength and Endurance	No additional exercises were suggested
Neuromuscular Control	Scapular PNF, upper body theraband plyometrics, and physioball exercises
Aquatic Therapy	Straight arm pullover, lateral raises, shoulder rear flexion, and arm circles
Functional Progressive Activities	Jobe and Schwab throwing program, Wilk and Andrews throwing program, golf and tennis interval programs
Preventive In-Season Program	No program or exercises were indicated
Additional Comments	Concern for including PNF techniques in the manual due to the complexity of this technique. Experts indicated that the

(table continues)

Subsections	Suggested Exercises
Additional Comments continued	manual contained a solid collection of therapeutic exercises for the rehabilitation of the shoulder complex.

Note. Eight individuals responded to the questionnaire (two team physicians, four certified athletic trainers, one strength and conditioning coach, and one physical therapist).

Table 3

Responses to Questionnaire Validating the Manual

QUESTION	E %	VG %	G %	F %	U %
Chapter One					
1. Rate the clarity of the introduction.	50	38	12	0	0
2. Rate the directions.	50	38	12	0	0
Chapter Two					
1. Rate the clarity and quality of the literature review of the functional anatomy of the shoulder complex.	50	38	12	0	0
2. Rate the clarity and quality of the literature review of the biomechanics of the shoulder complex.	50	38	12	0	0
Chapter Three					
1. Rate the clarity and quality of the biomechanical complications with overhead athletes.	62	38	0	0	0
Chapter Four					
1. Rate the clarity and quality of the specific rehabilitation considerations.	50	50	0	0	0
Chapter Five					
1. Rate the clarity and quality of the other considerations.	50	38	12	0	0

(table continues)

QUESTION	E %	VG %	G %	F %	U %
Chapter Six					
1. Rate the clarity and quality of the range of motion and flexibility background information.	38	62	0	0	0
2. Rate the clarity and quality of the therapeutic exercises selected.	38	62	0	0	0
3. Rate the clarity and quality of the illustrations.	25	62	13	0	0
4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.	50	50	0	0	0
Chapter Seven					
1. Rate the clarity and quality of the muscular strength and endurance background information.	50	38	12	0	0
2. Rate the clarity and quality of the therapeutic exercises selected.	75	25	0	0	0
3. Rate the clarity and quality of the illustrations.	38	50	12	0	0
4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.	62	38	0	0	0

(table continues)

QUESTION	E %	VG %	G %	F %	U %
Chapter Eight					
1. Rate the clarity and quality of the background information on reestablishing neuromuscular control.	50	50	0	0	0
2. Rate the clarity and quality of the therapeutic exercises selected.	62	38	0	0	0
3. Rate the clarity and quality of the illustrations.	50	38	12	0	0
4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.	50	38	12	0	0
Chapter Nine					
1. Rate the clarity and quality of the closed-kinetic-chain background information.	38	50	12	0	0
2. Rate the clarity and quality of the therapeutic exercises selected.	62	38	0	0	0
3. Rate the clarity and quality of the illustrations.	50	50	0	0	0
4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.	62	38	0	0	0

(table continues)

QUESTION	E %	VG %	G %	F %	U %
Chapter Ten					
1. Rate the clarity and quality of the plyometric background information.	62	25	13	0	0
2. Rate the clarity and quality of the therapeutic exercises selected.	50	50	0	0	0
3. Rate the clarity and quality of the illustrations.	50	38	12	0	0
4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.	50	38	12	0	0
Chapter Eleven					
1. Rate the clarity and quality of the aquatic therapy background information.	50	38	12	0	0
2. Rate the clarity and quality of the therapeutic exercises selected.	38	50	12	0	0
3. Rate the clarity and quality of the illustrations.	38	62	0	0	0
4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.	62	25	13	0	0

(table continues)

QUESTION	E %	VG %	G %	F %	U %
Chapter Twelve					
1. Rate the clarity and quality of the background information for functional throwing progression.	38	38	24	0	0
2. Rate the clarity and quality of the therapeutic exercises selected.	38	38	12	12	0
3. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.	38	38	12	12	0
Overall Rating					
1. Rate the overall accuracy of the manual.	38	62	0	0	0
2. Rate the overall quality of the manual.	38	62	0	0	0
3. Rate the potential for use as an educational reference for student athletic trainers working with overhead athletes.	62	38	0	0	0

Note. Abbreviations consist of: E – Excellent, VG – Very Good, G – Good, F – Fair, and U – Unsatisfactory. Eight individuals responded to the questionnaire (two team physicians, four certified athletic trainers, one biomechanist with a Ph.D., and one team physician).

CHAPTER FIVE

CONCLUSIONS

Athletes participating in sports emphasizing high velocity, explosive, repetitive overhead motions, such as baseball, softball, volleyball, swimming, water polo, tennis, and various throwing events in track and field, present a challenge to the athletic trainer and sports medicine staff. Areas of concern include excessive anterior joint capsule laxity, posterior joint capsule tightness, limited posterior and anterior shoulder musculature flexibility, imbalances of strength and endurance of the dynamic stabilizers, mechanical stresses which disrupt normal biomechanics, poor sport-specific mechanics, inadequate force production, poor force distribution, abnormal transfer of kinetic energy, lack of ground reactive forces, improper muscular compensation, poor muscle recruitment, and abnormal postural alignment, which lead to shoulder instability or impingement.

Summary of the Important Findings

Establishing a Need for the Manual

Results from the needs assessment questionnaire strongly indicated a need for a rehabilitation manual for student athletic trainers that provides a wide variety of therapeutic exercises including range of motion and flexibility, muscular strength and endurance, neuromuscular control, proprioception, closed-kinetic-chain, plyometric training, aquatic therapy, and functional progressive

activities for the scapulothoracic articulation and glenohumeral joint. In addition, the respondents indicated a need for a manual that interrelates the anatomy and biomechanics of the scapulothoracic articulation and glenohumeral joint. Needs Assessment Group indicated that the therapeutic manual would be beneficial to certified athletic trainers. More importantly, the purpose of the manual is to provide a resource for student athletic trainers when developing systematic, creative, and well-balanced rehabilitation programs for injuries resulting from repetitive overhead motions.

Development and Selection of the Therapeutic Exercises

For the most part, additional exercises suggested by the Therapeutic Exercise Expert Group were already included in the manual, but were named differently. Some suggestions helped to provide progressions and variations to the therapeutic exercises. Due to the response of several experts, PNF techniques were eliminated from the manual due to the complexity of the techniques.

Validation

Overall, the Validation Group rated the manual very good to excellent. The introductory chapters, including functional anatomy and biomechanics, biomechanical complications, rehabilitation considerations, and other considerations, were rated good to excellent. The chapters on range of motion, muscular strength and endurance, reestablishing neuromuscular control, closed-

kinetic-chain, and plyometric training were rated good to excellent in clarity and quality of background information, therapeutic exercises selected, instructions, variations, and modifications. The clarity and quality of the therapeutic exercise illustrations were rated good to excellent. An area for improvement, indicated by a lower rating, was Chapter Twelve, Functional Progressive Activities. One validator indicated that Chapter Eleven, Aquatic Therapy, was not as developed as Chapters One through Ten.

Additional comments indicated that the manual was well written, easy to read and understand, and would be an excellent teaching tool. In addition, the Validation Group indicated that the manual should not be limited to student athletic trainers, but that certified athletic trainers would benefit as well. The chapters on Biomechanical Complications, Rehabilitation Considerations, and Reestablishing Neuromuscular Control were rated very good to excellent.

Future Recommendations

Due to the complexity of the shoulder complex, some components of rehabilitation were not discussed in the manual. The manual could be expanded to include the following topics: sport-specific mechanics such as the freestyle swim stroke or the javelin throw; potential injuries such as posterior dislocations, superior lateral anterior posterior lesion, and long head of the biceps tendonitis; muscle recruitment patterns; biofeedback; brachial plexus complications; modalities; psychological considerations; pharmacological agents; isokinetic

training; cardiorespiratory fitness; injury evaluation; and documentation requirements.

Summary

Athletes participating in sports requiring overhead motions, such as baseball, softball, volleyball, swimming, water polo, tennis, and various throwing events in track and field, present a challenge to the athletic trainer and sports medicine staff for various reasons. Because of this, a reference manual covering *Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions* was strongly indicated for student athletic trainers, as well as certified athletic trainers.

The manual provides background information on anatomy and biomechanics of the shoulder complex, interrelates these factors to scapulothoracic articulation and glenohumeral joint injuries, and combines professional experiences with current literature to establish a resource to aid athletic trainers in providing well-rounded rehabilitation programs. Due to the complexity of the shoulder complex, some components of rehabilitation were not discussed in the manual. These additional topics will help to expand the manual in the future. The manual was evaluated by team physicians, certified athletic trainers, a biomechanist, and a physical therapist. Their responses indicated that the manual was well written overall, easy to read and understand, and would be an excellent teaching tool.

REFERENCES

Arnheim, D.D., & Anderson, M.K. (1991). Essentials of athletic training (2nd ed.). St. Louis, MO: Mosby Year Book.

Arnheim, D.D., & Prentice, W.E. (2000). Principles of athletic training (10th ed.). St. Louis, MO: McGraw-Hill.

Booher, J.M., & Thibodeau, G.A. (1994). Athletic injury assessment (3rd ed.). St. Louis, MO: Mosby-Year Book.

Borsa, P.A., Lephart, S.M., Kocher, M.S., & Lephart, S.P. (1994). Functional assessment and rehabilitation of shoulder proprioception for glenohumeral joint instability. Journal of Sport Rehabilitation, 3, 84-104.

Dillman, C.J., Fleisig, G.S., & Andrews, J.R. (1993). Biomechanics of pitching with emphasis upon shoulder kinematics. Journal of Orthopedic and Sports Physical Therapy, 2, 402-408.

Donnelly, J.E. (1990). Living anatomy (2nd ed.). Champaign, IL: Human Kinetics.

Kamkar, A., Irrgang, J.J., & Whitney, S.L. (1993). Nonoperative management of secondary shoulder impingement syndrome. Journal of Orthopedic Sports Physical Therapy, 5, 212-224.

Kenal, K.A., & Knapp, L.D. (1996). Rehabilitation of injuries in competitive swimmers. Sports Medicine, 22, 337-347.

Kendall, F.P., McCreary, E.K., & Provance, P.G. (1993). Muscle testing and function (4th ed.). Baltimore: Williams & Wilkins.

Korel, L.E. (1996). The properties of water and their effect on aquatic therapy. Athletic Therapy Today, 1, 36-39.

Magee, D.J. (1992). Orthopedic physical assessment (2nd ed.). Philadelphia: W.B. Saunders.

McCann, P.D., & Bigliani L.U. (1994). Shoulder pain in tennis players. Sports Medicine, 17, 53-64.

Mikesky, A. E., Edwards, J.E., Wigglesworth, J.K., & Kunkel, S. (1995). Eccentric and concentric strength of the shoulder and arm musculature in collegiate baseball pitchers. American Orthopedic Society for Sports Medicine, 23, 638-642.

Prentice, W.E. (1999). Rehabilitation techniques in sport medicine (3rd ed.). St. Louis, MO: Mosby-Year Book.

Prentice, W.E., & Kooima, E.F. (1989, Spring). The use of proprioceptive neuromuscular facilitation techniques in the rehabilitation of sport-related injury. Athletic Training, 26-31.

Schmitt, L., & Snyder-Mackler, L. (1999). Role of scapular stabilizers in etiology and treatment of impingement syndrome. Journal of Orthopaedic & Sports Physical Therapy, 29, 31-38.

Scriber, K. (1996). Prevention of shoulder injuries in the throwing athlete. Athletic Therapy Today, 1, 45-48.

Speer, K.P., Cavanaugh, J.T., Warren, R.F., Day, L., & Wickiewicz, T.L. (1993). A role for hydrotherapy in shoulder rehabilitation. American Journal of Sports Medicine, 3, 21-27.

Surburg, P.R., & Scharder, J.W. (1997). Proprioceptive neuromuscular facilitation techniques in sports medicine: A reassessment. Journal of Athletic Training, 32, 34-39.

Tippett, S.R., & Voight, M.L. (1995). Functional progressions for sport rehabilitation. Champaign, IL: Human Kinetics.

Warner, J.J., Micheli, L.J., Arslanian, L.E., Kennedy, J., & Kennedy, R. (1990). Patterns of flexibility, laxity, and strength in normal shoulders and shoulders with instability and impingement. American Orthopedic Society for Sports Medicine, 18, 366-375.

Wilk, K.E., & Arrigo, C. (1993). Current concepts in the rehabilitation of the athletic shoulder. Journal of Orthopaedic and Sports Physical Therapy, 18, 365-376.

Wolin, P.M., & Tarbet, J.A. (1997). Rotator cuff injury addressing overhead overuse. The Physician and SportsMedicine, 25, 54-74.

Zachazewski, J.E., Magee, D.J., & Quillen W.S. (1996). Athletic injuries and rehabilitation. Philadelphia: W.B. Saunders.

APPENDIX A

San Jose State University Human Subjects Exemption Letter

**San José State
UNIVERSITY**

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Vice President
Associate Vice President
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TO: Nicole Makris
2055 NE Skyview Dr., #C105
Pullman, WA 99163

FROM: Nabil Ibrahim, N. Ibrahim
AVP, Graduate Studies & Research

DATE: May 2, 2000

The Human Subjects-Institutional Review Board has approved
your request to use human subjects in the study entitled:

**"Therapeutic Exercise Manual for Rehabilitation
of Repetitive Overhead Motions"**

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The Board's approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D., immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at:
(408) 924-2480.

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Appendix B

Agreement to Participate in Research Consent Form

Responsible Investigator: Nicole K. Makris

Title of Protocol: Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions

1. I have been asked to participate in the development of a reference manual for student athletic trainers providing rehabilitation for shoulder injuries resulting from repetitive, high velocity, explosive overhead motions.
2. My participation will require reviewing and evaluating the reference manual, and providing my comments and recommendations on a questionnaire.
3. There are no anticipated risks of participating in this project.
4. This project may benefit student athletic trainers by providing a reference manual that describes and illustrates appropriate exercises and therapy for the rehabilitation of injuries resulting from repetitive overhead motions.
5. I understand all information is confidential.
6. I understand this project may be published, but no information that could identify me will be given out.
7. I understand that by completing the questionnaire, I will receive a free copy of the manual.
8. If I have any questions about the research or questionnaires I can call Nicole Makris at 509-335-5747. Complaints may be presented to Dr. Carol Christensen, Dept. Chair, at 408-924-3010. Questions about the research, subjects' rights, or research-related injury may be presented to Nabil Ibrahim, Ph.D., Associate Vice President for Graduate Studies and Research, at 408-924-2480.
9. I understand that no service of any kind, to which I was otherwise entitled, will be lost or jeopardized if I choose not to participate in this study.
10. I understand that I may refuse to participate in the study. If I decide to participate in the study, I am free to withdraw at any time without prejudice to my relations with San Jose State University or any other participating institutions.
11. I have received a signed and dated copy of my consent form.

THE SIGNATURE OF THE SUBJECT ON THIS DOCUMENT INDICATES AGREEMENT TO PARTICIPATE IN THE STUDY.

THE SIGNATURE OF THE RESEACHER ON THIS DOCUMENT INDICATES AGREEMENT TO INCLUDE THE ABOVE NAMED SUBJECT IN THE RESEARCH AND ATTESTATION THAT THE SUBJECT HAD BEEN FULLY INFORMED OF HIS OR HER RIGHTS.

Subject's Signature: _____ **Date:** _____

Investigator's Signature: _____ **Date:** _____

APPENDIX C

Questionnaire Establishing a Need

Please answer yes or no to the following questions:

1. **YES or NO** Do you feel there is a need to create a reference for student athletic trainers for the prevention and rehabilitation of overhead shoulder injuries, such as shoulder instability and impingement?
2. **YES or NO** Do you feel there is a need for a manual that provides a variety of therapeutic exercise examples for the scapulothoracic and glenohumeral joints to assist student trainers in developing a well-balanced rehabilitation program?
3. **YES or NO** Do you feel there is a need for a manual that interrelates the scapulothoracic articulation and glenohumeral joint anatomy and biomechanics of overhead activities to the rehabilitation?
4. **YES or NO** Do you feel there is a need for a manual to outline specific components, such as strength, endurance, range of motion, neuromuscular control, proprioception, closed-kinetic-chain, plyometrics, aquatic therapy, and functional progressive activities, in developing rehabilitation programs for the shoulder complex?
5. **YES or NO** Do you feel there is a need to develop a manual that allows student athletic trainers to be creative with therapeutic exercises and develop individualized rehabilitation programs for student athletes, as well as developing a personal style in rehabilitation?
6. **YES or NO** Do you feel there is a need to develop a manual that allows student athletic trainers to develop well-balanced rehabilitation programs in a systematic and organized fashion?
7. **YES or NO** Do you feel there is a need to develop a manual that introduces a wide variety of rehabilitation techniques of the shoulder complex to student athletic trainers?
8. **YES or NO** Do you feel there is a need for a manual to present information so that an entry-level student athletic trainer can better understand how the anatomy and biomechanics of the shoulder complex affect the rehabilitation process?

COMMENTS: _____

APPENDIX D1

Letter to Experts for Review of Exercise Selection

Name
Address

Name:

I have chosen to develop a manual for the rehabilitation of athletes participating in overhead motions for my Master's thesis. The definition of an overhead athlete is any athlete competing in a sport that emphasizes repetitive overhead motions, such as baseball, softball, volleyball, tennis, swimming, water polo, and various throwing events in track and field.

The purpose of the manual is to create a reference for student athletic trainers for the prevention and rehabilitation of overhead shoulder injuries such as shoulder instability or impingement. The manual is divided into sections emphasizing range of motion and flexibility; strength and endurance; neuromuscular control (closed-kinetic-chain and plyometric training); aquatic therapy; functional progressive activities; and preventive, in-season programs.

Areas of concern include excessive anterior joint capsule laxity, posterior joint capsule tightness, limited posterior and anterior shoulder musculature flexibility, imbalances of strength and endurance of the dynamic stabilizers, mechanical stresses disrupting normal biomechanics, poor sport-specific mechanics, and abnormal postural alignment.

The purpose of the questionnaire is to combine research and your professional experience. The following therapeutic exercises were collected from current literature. Please review the list and feel free to add additional exercises or suggestions to develop a well-rounded selection of exercises that can be used when rehabilitating injuries resulting from repetitive, high velocity, explosive, overhead motions. Please complete and return the questionnaire in 2 weeks with the self-addressed, stamped envelope provided.

Your feedback is extremely important. If you have any questions, please feel free to contact me at home (509) 338-9652, work (509) 335-5747, or by email nmakris@wsu.edu.

Sincerely,

Nicole K. Makris, ATC

APPENDIX D2

Rehabilitation Experience Survey

Personal Information

1. Area of discipline (i.e., ATC, PT, MD, Biomechanist with a Ph.D, or Strength and Conditioning Coach): _____
2. Number of years experience in your discipline: _____
3. Indicate specific overhead sports you have worked with, and number of years experience:
 - a) Baseball _____ years
 - b) Softball _____ years
 - c) Volleyball _____ years
 - d) Swimming _____ years
 - e) Tennis _____ years
 - f) Water Polo _____ years
 - g) Various throwing events in Track and Field _____ years
 - h) Other _____ and _____ years

APPENDIX D3**Evaluation of Therapeutic Exercises****Suggestions for Additional Exercises****Range of Motion and Flexibility:**

Strength and Endurance:

Neuromuscular Control (PNF, closed-kinetic-chain, and plyometric training):

Aquatic Therapy:

Functional Progressive Activities:

Preventive In-season Program: What exercises should be performed on a consistent basis during the in-season? (volume, intensity, number of days?)

Other comments (e.g., exercise that shouldn't be included):

Appendix D4

Therapeutic Exercise Selection

RANGE OF MOTION**Passive Range of Motion**

- 1) T-Bar Supine Flexion
- 2) T-Bar Supine Extension
- 3) T-Bar ABDuction
- 4) T-Bar ADDuction
- 5) T-Bar Supine Internal Rotation
- 6) T-Bar Supine External Rotation
- 7) Codman's or Pendulum Exercise
- 8) Wall Corner Stretch
- 9) Supine Roller Pectoralis Stretch
- 10) Apley's Towel Stretch

Assisted Range of Motion

- 1) Shoulder Flexion
- 2) Shoulder Extension
- 3) Shoulder Horizontal ADDuction Stretch
- 4) Latissimus Dorsi, Teres Minor, and Triceps Stretch
- 5) Shoulder External Rotation Stretch
- 6) Shoulder Internal Rotation Stretch

Active Range of Motion

- 1) Wall Climbs
- 2) Posterior Shoulder Stretch
- 3) Rope and Pulley Range of Motion Exercise

MUSCULAR STRENGTH AND ENDURANCE TRAINING**Isometric Exercise**

- 1) Shoulder Flexion
- 2) Shoulder Extension
- 3) Shoulder ADDuction
- 4) Shoulder ABDuction
- 5) Shoulder External Rotation
- 6) Shoulder Internal Rotation

Isotonic Exercise

- 1) Isolated Progressive Resistive Shoulder Joint Exercise - using dumbbells, wall pulley, theraband, or manual resistance.
 - a) Shoulder Flexion
 - b) Shoulder Extension
 - c) Shoulder ADDuction
 - d) Shoulder ABDuction
 - e) Shoulder Horizontal ADDuction (Flexion)
 - f) Shoulder Horizontal ABDuction (Extension)

- g) Prone Shoulder External (lateral) Rotation (0°, 45°, 90°)
- h) Theraband Shoulder External (lateral) Rotation (0°, 45°, 90°)
- i) Side Lying Shoulder Internal (medial) Rotation
- j) Theraband Shoulder Internal (medial) Rotation (0°, 45°, 90°)
- k) Empty Can (Scaption)
- l) ABC's
- 2) Isolated Progressive Resistive Shoulder Girdle Exercise - using dumbbells, wall pulley, theraband, or manual resistance.
 - a) Shoulder Shrugs
 - b) Bent-Over-Rows
 - c) Reverse Fly's
 - d) Chest Press
 - e) Shoulder Press
 - f) Latissimus Pull-Downs
 - g) Latissimus Pull-Overs
 - h) Serratus Anterior Punches
 - i) Theraband Serratus Anterior Punches
 - j) Shoulder Retraction
 - k) Theraband Shoulder Retraction
 - l) Theraband D1 Flexion
 - m) Theraband D1 Extension
 - n) Theraband D2 Flexion
 - o) Theraband D2 Extension
- 3) Body Blade Dynamic Shoulder Exercises
 - a) Internal/External Rotation - Progression
 - b) Flexion/Extension - Progression
 - c) ABDuction/ADDuction - Progression
 - d) Horizontal ABDuction/ADDuction - Progression
 - e) Throwing Motion (Overhead) - Progression

REESTABLISH NEUROMUSCULAR CONTROL

- 1) Weight Shifting
 - a) Standing with hands supporting weight on table
 - b) Kneeling in a four-point position
 - c) Kneeling in a three-point position
 - d) Kneeling in a two-point position
 - e) Kneeling in a three-point position with BAPS board
- 2) Theraball Weight Shifting
- 3) Tilt Board Balancing
 - a) Side to Side
 - b) Forward and Backwards
 - c) Push-ups while balancing
- 4) BAPS Board Balancing
- 5) Scapular Movement Awareness
- 6) Theraball Prone Rhythmic Stabilization

- a) Table Supported
- b) Knee Supported
- c) Full Push-Up Position
- d) Push-Up Position with feet on a chair
- 7) Supine Bar Rhythmic Stabilization
- 8) Internal and External Rotation Rhythmic Stabilization
- 9) Quadriped Rhythmic Stabilization

CLOSED-KINETIC-CHAIN EXERCISE

- 1) Wall or Floor Press-Ups
- 2) Wall or Floor Push-Ups
 - a) Wide Stance Push-Ups
 - b) Narrow Stance Push-Ups
 - c) Staggered Hands Push-Ups
 - d) Wall Corner - Corner Out, Corner Inward
 - e) Boxes - Alternating Box Push-Ups
 - f) Ball Push-Ups - while balancing on a plyoball
 - g) Wobble Board Push-Ups
- 3) Theraball Walk-Outs
- 4) Theraball Lateral Arches
- 5) Theraball Push-Ups
- 6) Stair Climbing
- 7) Weight Shifting Fitter

PLYOMETRIC TRAINING

- 1) Double-Arm Toss
- 2) Single-Arm Toss
- 3) Two-Arm Toss with Trunk Rotation
- 4) Two-Arm Overhead Toss
- 5) Kneeling Single-Arm Toss
- 6) Kneeling Two-Arm Toss
- 7) Single-Arm Toss on Unstable Surface
- 8) Seated Single-Arm Weighted-Ball Throw
- 9) Ball Arcs
- 10) Push-Ups with a Clap
- 11) Theraband External and Internal Rotation Plyo's
- 12) Supine Ball Drops

PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION

- 1) Shoulder Joint D1 pattern
- 2) Shoulder Joint D2 pattern

AQUATIC THERAPY

- 1) Shoulder Flexion and Extension
- 2) Shoulder ABDuction and ADDuction
- 3) Shoulder Horizontal ABDuction and ADDuction
- 4) Shoulder Internal and External Rotation

FUNCTIONAL PROGRESSIVE THROWING PROGRAM

- 1) Interval Throwing Program

Appendix E1**Rehabilitation Techniques for Shoulder Injuries from Repetitive Overhead Motions**

Rehabilitation Techniques for Shoulder Injuries

**Resulting from Repetitive Overhead
Motions**

Nicole K. Makris, ATC

Illustrations by
Jonathan Willey, ATC

Rehabilitation Techniques for Shoulder Injuries

Resulting from Repetitive Overhead Motions

Nicole K. Makris, ATC

San Jose State University, San Jose, CA

Illustrations by

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PREFACE

Athletes participating in sports requiring overhead motions, such as baseball, softball, volleyball, swimming, water polo, tennis, and various throwing events in track and field, present a challenge to the athletic trainer and sports medicine staff.

Areas of concern include excessive anterior joint capsule laxity, posterior joint capsule tightness, limited posterior and anterior shoulder musculature flexibility, strength and endurance imbalances of dynamic stabilizers, mechanical stresses which disrupt normal biomechanics, poor sport-specific mechanics, and abnormal postural alignment, which lead to shoulder instability or impingement.

This manual will highlight areas of concerns, and present rehabilitation techniques consisting of range-of-motion and flexibility, strength and endurance, neuromuscular control (closed-kinetic-chain and plyometric training), aquatic therapy, functional progressive activities, and a preventive in-season program. The purpose of the therapeutic exercise manual is to combine and present these concepts as an educational reference for student athletic trainers who provide care for overhead athletes.

CHAPTER ONE

Introduction

Athletes participating in sports requiring repetitive, high velocity, explosive overhead motion, such as baseball, softball, volleyball, tennis, swimming, water polo, and various throwing events in track and field can be referred to as **Overhead Athletes**. Injuries to the shoulder complex commonly occur in overhead athletes and present a challenge to the athletic trainer and sports medicine staff.

Pain has been reported in up to 24% of young players ranging from 12 to 19 years-of-age, and as high as 50% in older players. The competitive and recreational swimmer performs over 1 million arm cycles each year during training, and a baseball pitcher may throw over 200 pitches each game. This sets up the shoulder complex for microtrauma and overuse injuries leading to shoulder dysfunction.

Etiology of Shoulder Dysfunction

Two common etiologies of shoulder pain and dysfunction in overhead athletes are **Shoulder Instability** and **Shoulder Impingement Syndrome**. Shoulder instability is the inability of the static and/or dynamic stabilizers to maintain the humeral head within the glenoid fossa. Shoulder impingement occurs when abnormal migration of the humeral head compromises soft tissue,

leading to inflammation.

Shoulder injuries may occur when repetitive overhead motions result in forces that exceed the passive mobility, stability, and dynamic control of the glenohumeral joint. In sports emphasizing overhead motions, an relationship has been observed between impingement syndrome and glenohumeral joint instability. Subacromial impingement secondary to functional scapular instability is another proposed mechanism of secondary impingement in overhead athletes.

Types of Shoulder Impingement

Shoulder impingement syndrome can be classified as primary or secondary impingement. **Primary Shoulder Impingement** is the crowding of the rotator cuff, specifically the supraspinatus tendon on the coracoacromial or the subacromial arch, along with posterior capsule tightness, and excessive superior migration of the humeral head due to weakness of the humeral head depressors. **Secondary Shoulder Impingement** is due to a decrease in subacromial and coracoacromial space due to glenohumeral or scapulothoracic instability. Figure 2.5 illustrates how the coracoacromial ligament, acromion, and coracoid process borders and

narrows the subacromial arch.

Glenohumeral Joint Instability

Glenohumeral joint instability may be triggered by weakness of the rotator cuff mechanism and biceps tendon. This weakness leads to overload of the static stabilizers of the glenohumeral joint during overhead motions, resulting in glenohumeral joint laxity and later instability. This causes the dynamic stabilizers to become fatigued. Weakness of this mechanism results in abnormal migration of the humeral head, causing secondary impingement of the rotator cuff by the coracoacromial arch.

Appropriate and Effective Rehabilitation Programs

Historically, a "cookbook" rehabilitation program has been implemented for an injured athlete. A cookbook approach offers the same exercises to every athlete with the same injury. Such an approach may not meet the needs of the injured athlete. For example, a rehabilitation program for a volleyball player should be different than for a wrestler diagnosed with the same condition.

The difference is due to functional sport-specific needs. A rehabilitation program should be based on specific adaptations to imposed demands, otherwise known as the **SAID Principle**. This suggests that all rehabilitation programs should be geared toward the sport-specific demands or stresses placed on the injured body part.

An effective rehabilitation program must prepare the athlete for the demands that will be placed on the

injured area once rehabilitation has been completed. A well-balanced rehabilitation program should break down the athlete's role in the sport. Once specific activities have been broken down into required fundamental movements, the athlete's injured body part is stressed progressively until function is adequate for the athlete to return to full participation.

Protocols for Rehabilitation

Several protocols have been designed for rehabilitation of the injured shoulder. These protocols focus on strengthening the rotator cuff muscles in addition to restoring normal range of motion, endurance, and pain control. Additional programs suggest kinesio logic repair, which involves specific training of the rotator cuff and scapular rotators to establish proper scapulohumeral rhythm. Proper scapulohumeral rhythm acts to lessen the risk of impingement by synchronizing scapulothoracic motion with glenohumeral joint motion.

Adequate strength of the rotator cuff decreases impingement by depressing the humeral head during elevation of the arm. In addition, strengthening the rotator cuff provides dynamic stability to the glenohumeral joint by controlling excessive humeral head migration.

Factors Influencing Rehabilitation Goals

When designing a rehabilitation program, several questions should be addressed including:

- 1) What is the specific injury?

- 2) What sport and/or position does the athlete play, and what are the demands placed on the injured body part?
 - 3) How much time is left in the season? A decision must be made regarding whether it is realistic for the athlete to return to full participation.
 - 4) Does the athlete compete in other sports? If so, which sport is more important?
 - 5) Do the rules of the game prohibit protective equipment, casts, or padding?
 - 6) What is the motivation, cooperation, compliance, competitiveness, and pain threshold of the athlete?
- functional progressive activities, used to develop rehabilitation programs.
 - 5) To develop a format that allows student athletic trainers to develop creative, individualized rehabilitation programs for athletes.
 - 6) To present a variety of therapeutic exercises to create well-balanced rehabilitation programs in a systematic and organized fashion.
 - 7) To present information so that an entry-level student athletic trainer can better understand how the anatomy and biomechanics of the shoulder complex affect the rehabilitation process.

Purpose of the Manual

The purposes of the manual are the following:

- 1) To create a reference for student athletic trainers for the prevention and rehabilitation of surgical and non-surgical overhead shoulder injuries, such as shoulder instability and impingement.
- 2) To provide a variety of therapeutic exercise examples for the scapulothoracic articulation and glenohumeral joint to assist student athletic trainers in developing a well-balanced rehabilitation program.
- 3) To interrelate the scapulothoracic articulation and glenohumeral joint anatomy and biomechanics of overhead activities to the rehabilitation process.
- 4) To outline specific components, such as strength, endurance, range of motion, neuromuscular control, proprioception, closed-kinetic-chain, plyometrics, aquatic therapy, and

Assumptions

Assumptions in the manual are the following:

- 1) Athletic trainers have access to rehabilitation equipment which is mentioned in the manual, such as dumbbells, theraband, plyoballs, T-bar, fitter, wobble boards, tilt boards, stools, plyoballs, trampoline, and an aquatic center.
- 2) All rehabilitation programs developed for athletes by student athletic trainers are cleared and supervised by a certified athletic trainer.
- 3) Protocols mentioned in the manual are in accordance with the policies and procedures of the athletic training program, and the National Athletic Trainers' Association undergraduate competencies in athletic training.
- 4) The manual does not create new protocols or therapeutic exercises, but is an accumulation of

information in current medical literature.

Limitations

Limitations of the manual are the following:

- 1) Specific stages of rehabilitation, such as tissue healing and time frames to return to full participation, are not provided for specific injuries.
- 2) The manual does not address all components of rehabilitation.
- 3) The therapeutic exercise manual is limited to the shoulder complex, specifically the scapulothoracic articulation and glenohumeral joint.
- 4) The manual is an educational reference that should be used in conjunction with academic preparation, under the direct supervision of a certified athletic trainer, and within the philosophy of the athletic training program.
- 5) The manual does not include therapeutic modalities, psychological considerations, social considerations, isokinetics, pharmacological agents, cardiorespiratory fitness, injury evaluation, or documentation requirements of rehabilitation programs.
- 6) Information gathered for the development of the manual was primarily collected from literature emphasizing sports with overhead motion such as baseball, softball, volleyball, swimming, water polo, tennis, and various throwing events in track and field.

Delimitations

This manual is written for the following:

- 1) Entry-level student athletic trainers who are not certified, or recently certified, with academic preparation in anatomy, biomechanics, and rehabilitation principles of the shoulder complex.
- 2) Student athletic trainers developing rehabilitation programs for student athletes in overhead sports such as baseball, softball, volleyball, tennis, swimming, water polo, and various throwing events in track and field.
- 3) Student athletic trainers with an interest in developing creative, challenging, rehabilitation programs for athletes participating in overhead sports.

References

The information in the manual is from various sources, which can be found in the reference section. Some studies collected from the literature review are indicated, but for the most part, specific references were not cited for ease of reading.

CHAPTER TWO

Functional Anatomy and Biomechanics

FUNCTIONAL ANATOMY

The shoulder complex is made up of three bones: the scapula, the clavicle, and the humerus. The scapula is characterized as a flat, triangular bone. The clavicle is an "S" shaped bone, commonly called the collarbone, and the humerus is the long bone of the upper arm. These bones make up three joints and one articulation consisting of the following (Figure 2.1):

- 1) Acromioclavicular Joint
- 2) Glenohumeral Joint
- 3) Scapulothoracic Articulation
- 4) Sternoclavicular Joint

The shoulder complex is the most freely moving

joint in the body, allowing excessive range of motion without enormous stability in sports with repetitive, high velocity, explosive, overhead motions.

Figure 2.1

"The shoulder complex is the most freely moveable joint in the body, without enormous stability"

Glenohumeral Joint

The glenohumeral joint refers to the articulation of the humeral head, glenoid fossa, and scapula. The glenohumeral joint is a shallow, multiaxial, ball-and-socket synovial joint that depends on muscles rather than bones or ligaments for stability. The

glenohumeral joint is so shallow that the glenoid fossa is only two-thirds the size of the humeral head.

Primary stabilizers of the glenohumeral joint can be classified as passive or active. These primary stabilizers work independently and cooperatively to provide stability while allowing incredible range of motion within the shoulder joint.

Passive or Static Stabilizers

The passive or static stabilizers of the glenohumeral joint consist of the labrum and joint ligaments. The labrum is a fibrocartilage ring attached tightly to the

bottom half of the glenoid, and loosely to the top half. The labrum increases the glenoid depth, adding to glenohumeral joint stability. The superior, middle, and inferior glenohumeral joint ligaments are thickenings of the synovial capsule, which add additional passive stabilization to the glenohumeral joint.

Active or Dynamic Stabilizers

Active or dynamic stabilizers of the glenohumeral joint consist of the following:

- 1) Supraspinatus
- 2) Infraspinatus

3) Teres Minor

4) Subscapularis

These muscles are collectively referred to as the rotator cuff muscles, or SITS.

The primary function of the rotator cuff is to provide stabilization, approximation, and centralization of the humeral head within the glenoid fossa. This decreases abnormal migration of

Figure 2.2 Anterior view of the rotator cuff musculature.

1) Acromion Process	5) Subscapularis
2) Coracoid Process	6) Humerus
3) Supraspinatus	7) Teres Minor
4) Clavicle	8) Infraspinatus

The primary function of the rotator cuff is stabilization, approximation, and centralization of the humeral head!

the humeral head, specifically superior translation during overhead motion.

There are eight basic glenohumeral joint movements:

- 1) Flexion and Extension—in the coronal axis.
- 2) ABDuction and ADDuction—in the sagittal axis.
- 3) Horizontal ABDuction and ADDuction—in the longitudinal axis.
- 4) Medial/Internal and Lateral/External Rotation in the longitudinal axis.

In addition, there is circumduction, which is a combination of movements of flexion, abduction, extension, and adduction.

Primary Movers of the Glenohumeral Joint

In addition to the rotator cuff musculature, primary movers of the glenohumeral joint are the pectoralis major, latissimus dorsi, long head of the biceps brachii, deltoid, and teres major. Branches of the posterior cord and the suprascapular, axillary, and lateral pectoral nerves innervate the muscles of the glenohumeral joint.

Shoulder Girdle

The shoulder girdle refers to the articulation of the following:

- 1) Acromioclavicular Joint
- 2) Sternoclavicular Joint
- 3) Scapulothoracic Articulation

The sternoclavicular joint provides the only bony connection for the shoulder girdle to the axial skeleton. The

Figure 2.3 Posterior view of shoulder and trunk.

1) Rhomboid Minor	7) Triceps
2) Supraspinatus	8) Teres Major
3) Infraspinatus	9) Teres Minor
4) Teres Major	10) Deltoid
5) Rhomboid Major	11) Trapezius
6) Latissimus Dorsi	

acromioclavicular joint is a synovial joint with a fibrous capsule and an articular disc. Joint stability within the acromioclavicular joint depends primarily on the acromioclavicular and coracoclavicular ligaments. The sternoclavicular joint is a saddle-shaped synovial joint, stabilized by a thick capsule and disc between the clavicle and the manubrium sternum.

Movements of the acromioclavicular and sternoclavicular joints are the following:

- 1) Elevation
- 2) Depression
- 3) Protrusion
- 4) Retraction
- 5) Rotation

Figure 2.4 Ligaments of the shoulder girdle.

1) Coracoclavicular	5) Capsule
2) Acromioclavicular	6) Costoclavicular
3) Coracoacromial	7) Interclavicular
4) Coracohumeral	8) Sternoclavicular

- 3) Trapezius
- 4) Rhomboid Major
- 5) Rhomboid Minor
- 6) Levator Scapulae
- 7) Pectoralis Major
- 8) Pectoralis Minor

These muscles are obliquely oriented, providing for rotational and linear motions of the scapula.

There are seven basic movements of the scapulothoracic articulation.

- 1) ADDuction
- 2) ABDuction
- 3) Lateral (Upward) Rotation
- 4) Medial (Downward) Rotation
- 5) Anterior Tilt
- 6) Elevation
- 7) Depression

The scapulothoracic articulation is not considered a true joint because it does not have a capsular pattern, or a closed-pack position. The scapula articulates between the second and seventh ribs, and at rest, the medial borders are parallel and approximately four inches apart.

Primary Movers and Stabilizers of the Scapulothoracic Articulation

Primary movers and stabilizers of the scapulothoracic articulation are muscles that attach the scapula and thorax to the vertebral column. They consist of the following:

- 1) Serratus Anterior
- 2) Latissimus Dorsi

Figure 2.5 The coracoacromial ligament borders and narrows the subacromial arch.

1) Clavicle	4) Glenoid Fossa
2) Coracoacromial Ligament	5) Subacromial Arch
3) Coracoid Process	6) Acromion

Biomechanics

The movements of the scapulothoracic articulation are not performed in isolation, but are associated with movements at the sternoclavicular and acromioclavicular joints. These three joints and one articulation participate in shoulder motion in an inseparable, coordinated, synchronized, and smooth pattern called **Scapulohumeral Rhythm**. Scapulohumeral rhythm has two functions:

- 1) To maintain the glenoid fossa in an optimal position to receive the articular surface of the humeral head.
- 2) To maintain the scapula in the optimal length-tension relationship of the muscles acting on the humerus.

Scapulohumeral rhythm can be divided into glenohumeral-scapulothoracic and acromioclavicular-scapulothoracic contributions. Normal maximal shoulder elevation is 180° . The glenohumeral joint contribution is 120° , and the scapulothoracic articulation contributes 60° .

Overall, there is a 2:1 ratio of motion in the glenohumeral-scapulothoracic portion of scapulohumeral rhythm. Thus, for every 2° of glenohumeral elevation, there is 1° of scapulothoracic rotation.

In the acromioclavicular-scapulothoracic portion of glenohumeral rhythm, the first 30° of scapular rotation during shoulder elevation is the result of the clavicle elevating at the sternoclavicular joint. The last 30° of scapular rotation during shoulder

elevation is the result of the acromioclavicular joint rotating and elevating. Disruption in this motion at any of the involved joints may affect the total motion produced. In addition, an imbalance, weakness, or dysfunction of the force couple may disrupt scapulohumeral rhythm.

Figure 2.6 Line of pull of the scapulothoracic musculature force couples, posterior view.

1) Latissimus Dorsi	5) Levator Scapulae
2) Trapezius (lower)	6) Trapezius (upper)
3) Trapezius (middle)	7) Serratus Anterior (upper)
4) Rhomboids	8) Serratus Anterior (lower)

Force Couples of the Shoulder Complex

Due to the complex biomechanics of the shoulder complex, force couples are essential to the stability and mobility of the shoulder during overhead motions.

Force couples are defined as equal and parallel forces acting in opposite directions, resulting in rotational movements (Kamkar, Irrgang, & Whitney, 1993). Force couples have also been described as divergent pulls of forces creating a pure rotation.

The force couples of the glenohumeral joint and scapulothoracic articulation are extremely important in maintaining support and function of the shoulder complex by preventing abnormal positioning of the glenohumeral joint and scapulothoracic articulation during repetitive, high velocity, explosive overhead motions.

Force couples decrease pathologies of shoulder impingement and instability by:

- 1) Minimizing vertical humeral displacement to avoid soft tissue trauma.

- 2) Efficiently elevating the scapula via the acromion process.
- 3) Horizontal compression of the humeral head for joint stability.
- 4) Providing a smooth, coordinated muscular contraction, and proper force distribution within the shoulder complex.

There are many force couples acting on the shoulder complex. The following are a few examples of force couples for the glenohumeral joint and scapulothoracic articulation. Figures 2.6-2.7 give examples of force couples acting on the glenohumeral joint and scapulothoracic articulation.

Glenohumeral Joint Force Couples

The first force couple of the glenohumeral joint occurs in the transverse plane, where the subscapularis is counterbalanced by the infraspinatus and teres minor. This prevents superior impaction of the humeral head into the acromion process, and compression of the soft tissue.

The second force couple of the glenohumeral joint occurs in the coronal plane between the anterior fibers of the deltoid and the inferior rotator cuff muscles. The co-contraction of this force couple compresses the humeral head within the glenoid fossa, maintaining joint congruency, and limiting humeral head displacement during shoulder movements. A third force couple involves the supraspinatus which assists the deltoid in abduction, and helps to stabilize the glenohumeral joint with the force of gravity by

Figure 2.7 Line of pull of the scapulothoracic musculature force couples, anterior view.

- 1) Pectoralis Major
- 2) Pectoralis Minor

depressing the humeral head during shoulder elevation. This also prevents impingement of soft tissues under the subacromial arch.

Scapulothoracic Articulation Force Couples

A force couple of the scapulothoracic muscles functions similarly to the glenohumeral joint by acting as a synergist and antagonist, stabilizing the scapula against the thorax during all shoulder motions. The force couple produced concentrically by the lower fibers of the serratus anterior and the upper fibers of the trapezius achieves upward rotation of the scapula, which is pertinent to scapulohumeral rhythm during shoulder elevation. During adduction of the shoulder, this force couple acts eccentrically to control downward rotation of the scapula.

The integrity of the force couple is important not only in proper scapulohumeral rhythm, but also in the dynamics of the shoulder complex by anchoring the scapula to the thorax. The serratus anterior shows high levels of activity during the late cocking, acceleration, and follow through phases of pitching. Activation of the serratus anterior during the late cocking phase is needed to eccentrically decelerate the retracting scapula. During acceleration, the serratus anterior concentrically protracts the scapula, along with adduction and internal rotation of the shoulder.

Weakness or fatigue of the serratus anterior prevents the scapula from stabilizing against the thorax, causing excessive winging of the vertebral border and the inferior angle of the scapula. This

excessive winging and tipping of the scapula will lead to abnormal gliding of the scapula and significantly decrease the subacromial space, thus causing impingement of soft tissue. If humeral elevation is not synchronized with upward scapular rotation, or if lowering of the arm is not synchronized with downward scapular rotation, scapulothoracic rhythm will be disrupted.

Disruption of the scapulohumeral rhythm leads to dysfunction of the scapulothoracic articulation and glenohumeral joint. This results in impingement of the rotator cuff and other soft tissue due to insufficient elevation of the acromion, which compresses the rotator cuff as it passes underneath the subacromial and coracoacromial arch.

Overall, when these force couples are not properly balanced or equalized, abnormal glenohumeral joint mechanics occur. The overhead athlete may exhibit posterior shoulder pain and weakness, causing shoulder dysfunction secondary to force couple imbalances.

CHAPTER THREE

Biomechanical Complications with Overhead Athletes

Overhead athletes perform repetitive overhead movements at high velocities with explosive forces, placing stress on the static and dynamic stabilizers of the shoulder complex. Weakness or fatigue of the scapular muscles after repeated use may lead to impingement due to failure to achieve the required scapular rotation with humeral elevation. This causes pain and leads to inhibition of the scapular muscles, resulting in further impingement.

Biomechanical Complications of Overhead Athletes

Overhead athletes present a challenge to the athletic trainer and supporting sports medicine staff. These athletes usually exhibit glenohumeral joint **hypermobility** resulting from significant laxity of the shoulder capsule, particularly the anterior portion of the shoulder capsule. This increased laxity of the anterior capsule is necessary to allow the athlete the excessive anterior translation of the humeral head required in the cocking phase in overhead motions. Due to this acquired capsular laxity, the

rotator cuff is stressed attempting to maintain glenohumeral joint congruency.

There is a sensitive relationship between the glenohumeral joint capsule laxity and stability. Joint laxity is necessary for the extreme range of motion, particularly external rotation, which is required for the successful completion of overhead motions, and yet have the ability to dynamically stabilize the humeral head.

Due to the laxity of the anterior capsule, the overhead athlete usually exhibits **excessive external rotation** of the shoulder of approximately 145°, and **restricted internal rotation** of approximately 75° or less. This adaptive response of extreme external rotation and limited internal rotation of the shoulder is due to repetitive stresses placed on the capsule.

In response to excessive anterior capsule laxity, there is a **loss of flexibility** in the posterior musculature and joint capsule, causing the humeral head to migrate anterosuperiorly during shoulder range of motion. This may contribute to secondary functional

POINTS OF INTEREST

- During acceleration, the scapula must be stabilized so that the glenohumeral joint can internally rotate about a fixed point. Shoulder girdle stabilizers must support the entire throwing arm.
- To stabilize the shoulder girdle—middle trapezius and rhomboids major/minor eccentrically contract, while the lower and upper trapezius and serratus anterior concentrically.
- Shoulder girdle fixation during the acceleration phase occurs through eccentric musculature contraction, so that rotation can occur around the point of maximum resistance. Sufficient fixation is necessary so that an effective transmission of force, which is generated by the lower extremity and trunk to the upper extremity can occur.
- During the deceleration phase—shoulder girdle moves into a position of horizontal flexion and internal rotation. Eccentric contraction of the posterior deltoid, supraspinatus, infraspinatus, teres minor, and subscapularis, in addition, the middle trapezius, rhomboids, pectoralis major, and latissimus dorsi.
- Deceleration should be smooth to allow equal disbursement of forces.

impingement.

The loss of flexibility of the posterior shoulder structures in the overhead athlete, combined with tight anterior chest structures, causes a large amount of stress to specific tissues during the deceleration phase of overhead activities, and may contribute to tensile tissue failure.

Musculature Imbalances

A study performed by Mikesky, Edwards, Wigglesworth, and Kunkel (1995) assessed bilateral, isokinetic, eccentric and concentric muscular strength of shoulder external and internal rotators in a group of collegiate baseball pitchers. The study indicated a strength and endurance imbalance between external and internal rotators.

In swimming, Kenal and Knapp

(1996) believe the external and internal strength imbalance develops from the forward propulsion in swimming, which is accomplished by repetitive motions of adduction and internal rotation of the glenohumeral joint during the power phase. This selectively trains the anterior chest wall and internal rotator cuff muscles, creating an imbalance in the dynamic stabilizers of the glenohumeral joint.

Swimming and throwing have common biomechanics based on shoulder adduction and internal rotation. A study by McMaster, Long and Caiozzo (1991) confirmed rotator cuff imbalances during adduction/abduction and external/internal rotation of members of the U.S. Men's National Water Polo Team. The specific repetitive activity of water polo, like

baseball pitching, emphasizes shoulder adduction and internal rotation. External rotators have normal strength while the internal rotators are overdeveloped due to the repetitive mechanics of throwing and swimming. This imbalance may result in abnormal shoulder mechanics, leading to injury, particularly in a lax shoulder.

Eccentric Loads Placed on the Decelerators

Athletic trainers, the supporting sports medicine staff, and coaches believe that many of the shoulder injuries of overhead sports occur during the follow-through phase, such as when the muscles of the shoulder and elbow are contracting eccentrically to decelerate the limb after the ball has been released, or the stroke is completed. Concentric strength is important during the

acceleration phase of overhead activities, but it is the eccentric strength required during the follow-through phase which is the most critical in decreasing shoulder injuries. Eccentric strength and endurance are more important than concentric strength and absolute strength in overhead motions.

Repetitive overhead motions performed at high velocities and with explosive forces stress the shoulder complex and may lead to inflammation of the shoulder joint capsule and the rotator cuff musculature. This type of prolonged microtrauma will decrease muscular efficiency, resulting in poor dynamic stability, increased humeral head displacement, and eventually functional instability that leads to progressive tissue failure.

POINTS OF INTEREST

- The rotator cuff provides joint stabilization, approximation, and centralization of the humeral head within the glenoid fossa.
- When the glenohumeral joint is externally rotated, the anterior capsule undergoes a tight wringing which may cause microtrauma and secondary inflammatory response to the capsule.
- Inadequate stabilization of the humeral head by the rotator cuff during horizontal extension, will produce compressive stress against the anterior capsule, glenoid labrum, or posterior capsule. Such compressive stresses may lead to inflammation, which results in fibrous tissue formation in the capsule, thus reducing capsular flexibility.
- Excessive abduction of the scapula is necessary to allow for the approximately 90-120° of horizontal flexion which occurs in the follow-through phase. Excessive scapular abduction has the potential for stretching the suprascapular nerve or medial scapular musculature, which results in weak and/or a progressively decreased scapular contribution to overhead activities.

CHAPTER FOUR

Rehabilitation Considerations

In the past, rehabilitation of the shoulder complex after an injury or repair was frequently delayed for several weeks. After several weeks of immobilization, only passive range of motion was initiated for the next several weeks.

This type of rehabilitation treatment approach in the younger athletic populations may result in significant atrophy of the shoulder complex musculature, causing range of motion compensation and prolonged complaints of pain and dysfunction. It is believed that strict immobilization increases the occurrence of functional instability. This functional instability is due to a decrease in the dynamic stability through rotator cuff inhibition or shutdown, muscular atrophy, and poor neuromuscular control.

Present Rehabilitation Protocols

Current trends in the rehabilitation process have shifted toward earlier, protected active and passive range of motion, strengthening, and stabilizing exercises for the rotator cuff musculature to reestablish voluntary stability of the humeral head within the glenoid fossa.

Several studies found that rehabilitation programs emphasizing

early range of motion and strengthening exercises have a lower incidence of recurring subluxations and dislocations due to a decrease in rotator cuff inhibition, muscular atrophy, and loss of neuromuscular control.

This trend toward earlier, aggressive, more progressive rehabilitation programs is possible by improved surgical procedures, such as advances in arthroscopic procedures and improved soft tissue fixation techniques and devices. With the advancement in surgical procedures, there is less tissue morbidity of the shoulder musculature. Arthroscopic advancements, in particular, decrease the amount of disrupted tissue by eliminating the need to resect the anterior deltoid during surgery.

In addition to better surgical techniques, there is a conservative trend of nonoperative treatment in shoulder dysfunction caused by shoulder instability and impingement. The nonoperative management of shoulder instability and impingement consists of rest, anti-inflammatory medications, and an extensive therapeutic exercise program emphasizing the function of the rotator cuff and scapulothoracic muscles.

Standardized Rehabilitation Programs

There is no "cookbook" approach in the rehabilitation of the shoulder complex for overhead athletes. An extremely important concept in rehabilitation of overhead athletes is **individualization**. This concept acknowledges that every athlete is different and unique, and the rehabilitation program should reflect this. The athlete's specific injury, sport activity, tissue status, static stability, body type, age, and desired goals should be carefully considered.

In addition, the time of the season that

the injury occurred affects the speed of the rehabilitation program. If the injury occurs in the beginning of the season, and the athlete has a prognosis of returning to participation, the rehabilitation process may be aggressive. If the injury occurs toward the end of the season, there is no need to rush the rehabilitation progression.

Different Rehabilitation Approaches for Different Sports

The athlete's specific sport is extremely important in developing a

POINTS OF INTEREST

- Without flexibility or full range of motion the initiation of a strengthening program would be ill-advised because inflexibility will enhance abnormal movement patterns.
- During active range of motion, all patterns should utilize proper muscle activation to insure synchronized and symmetrical muscle patterns to reduce musculature compensation. An athlete may perform patterns in front of a mirror for visual feedback.
- It is important not to start strengthening exercises until flexibility, synchrony of motion, and distinct contraction in all shoulder muscles through normal range of motion have been achieved. Strengthening before the return of normal motion enhances abnormal patterns of movement, which leads to a cycle of strength and motion loss.
- Initial exercises should be performed without weight and then progress to 1-2 lbs. (watch for substitution or compensation). There is no need to exceed 5 lbs. of resistance. Weights larger than 5 lbs. tend to precipitate a loss of muscular balance around the throwing shoulder.
- Initial strength programs should emphasize the supraspinatus. Once a strong contraction of the supraspinatus and proper scapulohumeral rhythm are established, advanced strengthening techniques may be utilized.
- Exercises should emphasize slow concentric and eccentric contractions.
- Strengthen the musculature as a unit.

rehabilitation program. For example, the rehabilitation program for a baseball pitcher is dramatically different from that of a running back in football. The baseball pitcher's exercise prescription should reflect functional activities and positioning involved in throwing, such as 90° of shoulder abduction, internal and external rotation emphasizing eccentrics, concentric exercises, and plyometric training. In contrast, a running back in football can be placed on an exercise program emphasizing strengthening below 90° of shoulder abduction.

The athlete's desired functional goals should be considered, and the rehabilitation program should have progressive steps to accomplish these functional desires.

Several protocols have been

developed for the rehabilitation of the injured shoulder. Most of these protocols focus on strengthening the rotator cuff and the scapulothoracic musculature in addition to restoring normal range of motion, endurance, and pain control. Physical modalities such as ultrasound, heat, and cold, have been suggested to control pain and inflammation.

The following chapters will discuss current information on restoring or maintaining scapulothoracic articulation and glenohumeral joint range of motion, muscular strength and endurance, and neuromuscular control. In addition, the use of functional progressive activities and aquatic therapy will be discussed.

Rehabilitation Protocol

Rotator Cuff Surgical Repair

I. Protective Phase (Weeks 0-6)

GOALS: Protect repaired rotator cuff and promote healing, gradually restore shoulder range of motion, decrease pain and inflammation.

WEEK 1

- 1) Brace for everyday activities and sleeping
- 2) Pendulum exercises (small circles)
- 3) Active assisted range-of-motion exercises, no external rotation (T-Bar)
- 4) Rope and pulley exercises consisting of flexion/extension (Days 3-4)
- 5) Elbow range-of-motion and hand-gripping exercises
- 6) Isometric exercises consisting of abduction, flexion, external and internal rotation
- 7) Passive range-of-motion exercises consisting of flexion, external and internal rotation
- 8) Pain control modalities

WEEK 2

- 1) Continue use of the brace for everyday activities and sleeping
- 2) Continue all exercises listed above
- 3) Initiate active assisted flexion with T-Bar
- 4) Pendulum exercise initiate forward/backward movements
- 5) Gradually progress arm adduction motion

WEEK 3

- 1) Initiate active assisted range-of-motion with T-Bar
 - External/internal rotation with arm at side and progress to the scapular plane
 - Supine flexion/extension
- 2) Strengthening Exercise
 - Theraband internal/external rotation-arm at side
 - Initiate rhythm stabilization with arm at 100-125° flexion
 - Continue isometric exercise consisting of shoulder flexion, extension, abduction, and elbow flexors
- 3) Continue range-of-motion stretching exercises
- 4) Continue use of abduction brace at 25°

WEEK 4

- 1) Continue use of abduction brace/pillow at 25°
- 2) Continue all range-of-motion exercises listed above
- 3) Initiate gentle external/internal rotation stretches at 90° abduction
- 4) Continue strengthening exercises listed above
 - Humeral head stabilization exercises at 30°, 75°, 100°, 125°
 - External/internal rotation isotonics with tubing
 - Isometrics

WEEK 5

- 1) Discontinue use of brace
- 2) Range-of-motion exercises
 - Active assisted range-of-motion exercises with T-Bar in flexion/extension
 - Pendulum exercise
 - Rope and pulley
 - Gentle capsular stretches

3) Strengthening exercise

- Continue rhythmic stabilization drill (45°, 90°, and 125° flexion/extension)
- Scapular plane exercises in external/internal rotation
- External/internal rotation tubing drills with arm at side
- Resisted biceps/triceps
- Weight of arm (shoulder abduction and flexion)

II. Intermediate Phase (Weeks 7-12)

GOALS: Full, nonpainful range-of-motion (Weeks 7-8), restoration of strength and endurance, increased functional activities.

WEEK 7

1) Range-of-motion exercise

- AAROM T-Bar exercise
- Joint mobilization
- Rope and pulley
- Self-capsular stretches

2) Strengthening exercise

- Continue all strengthening exercises listed above
- Initiate neuromuscular control drills of the scapular musculature
- Initiate prone horizontal abduction to neutral, prone horizontal abduction with external rotation at 100°, prone rowing, etc.

WEEK 8-10

1) Continue stretching and range-of-motion exercise

- Self-capsular stretches
- ARROM exercise
- Joint mobilization
- Gentle contract-relax motion

2) Strengthening exercise

- Continue manual resistance stabilization (PNF patterns with rhythmic stabilization, 90/90 external/internal rotation, rhythmic stabilization)
- Scapular strengthening exercises

WEEKS 10-12

- 1) Continue exercises outlined above

III. Advanced Strengthening Phase (Weeks 13-24)

GOALS: Improve strength, endurance, and power. Gradually increase stress on healing tissue; prepare to return to functional activities.

WEEKS 13-14

- 1) Continue range-of-motion and stretching exercise
 - Active assisted range-of-motion with T-Bar
 - Capsular stretches
- 2) Strengthening exercises
 - "Throwers Ten" exercise program
 - Shoulder abduction
 - External/internal rotation at scapular plane
 - Shoulder flexion at scapular plane
 - PNF D2
 - Prone horizontal abduction (neutral rotation)
 - Prone rowing
 - Push-ups
 - Press-ups
 - Biceps curls and triceps extension
 - Wrist flexion/extension
 - Continue PNF D2 flexion/extension with manual resistance (rhythmic stabilization)
 - Scapular neuromuscular control exercise
 - Closed-kinetic-chain exercise
 - Latissimus dorsi pull down
 - Scapular depression
 - Plyoball exercises

WEEKS 15-16

- 1) Continue all exercises listed above in Weeks 13-14
- 2) Initiate plyometric throwing drills

WEEKS 17-24

- 1) Initiate interval throwing program
- 2) Continue all stretching exercises
- 3) Continue all strengthening exercises

NOTE: The following rehabilitation protocol for rotator cuff surgery is amended from Resnick, R (1997). Keys to a comeback: surgical advances unlock hope for athletes with rotator cuff tears. Sports Medicine Update, 12, 12-17.

CHAPTER FIVE

Other Considerations

When rehabilitating shoulder injuries due to repetitive, high velocity, explosive overhead motions, an athletic trainer can no longer just isolate the glenohumeral joint or scapulothoracic articulation. The shoulder by itself is incapable of generating the force necessary to throw a baseball at velocities of 90-100 miles per hour, or serve a tennis ball 120 miles per hour. So what generates the force necessary for these skills? The answer is the spine. The spine is a pivotal component of the kinematics chain, which functions as a transfer link between the lower and upper extremities.

In addition to force production, other factors leading to shoulder injury consist of:

- 1) Ball sizes and weights
- 2) Lack of a firm foundation, such as in swimming and water polo
- 3) External devices, such as a tennis racket

These factors may increase or decrease projectile release velocity and angular elbow acceleration, potentially increasing shoulder injuries.

Spine Involvement in Force Production

The spine, consisting of the lumbar, thoracic, and cervical segments, is a force generator capable of accelerating the arm at high explosive velocities and decreasing shear forces at the

glenohumeral joint during the deceleration phase. Limited flexibility or weakness of the musculature attached to the trunk has profound effects upon spine function, which places greater stress upon the glenohumeral joint and rotator cuff. Shoulder rehabilitation and injury prevention programs should include exercises for the pelvis, lumbar, thoracic, and cervical spine.

Ground Reactive Forces

In overhead motions, the primary function of the shoulder complex musculature is to stabilize and protect throughout the range of motion. During the throwing motion, the shoulder musculature is not responsible for creating force, nor is it the primary mover of the arm, but its role is to transfer kinetic energy generated through the kinematic chain. So where does this force come from? There is a transfer of forces from the lower extremity to the spine, which continues to the upper extremity through **ground reactive forces**.

However, some sports lack ground reactive forces to help generate force production, such as swimming and water polo. Toyoshima et al. (1974) studied hip, trunk, and shoulder segment contributions in the throwing motion along with ball velocity relationships. Without restriction,

normal throwing peak velocities equaled 100%; peak velocities decreased to 84% when forward stride was restricted, 63% with the lower body restricted, and 53% when the lower body and trunk were restricted.

The absence of a stable base in swimming and water polo may result in increased forces to the shoulder stabilizers, thus increasing potential injury. In addition, a larger and heavier ball in water polo causes a shift of forces to the shoulder stabilizers, reducing elbow angular acceleration and ball release velocities. Studies indicate peak ball release velocities to be approximately half of the velocity of a baseball on land due to the lack of ground reaction forces in water polo.

Force Production in Overhead Motions

The pelvis and spine contribute potential energy to the overall force production during overhead motions. During the wind-up phase, the muscles of the legs and torso generate potential energy by raising the center of gravity. The amount of force produced depends on how efficiently the kinematic chain converts this potential energy into kinetic energy. If there is a disruption of this transfer, the dissipation of energy is absorbed by the last component of the kinetic chain, or the weakest link, thus overloading the rotator cuff and leading to injury.

The key to reducing the shoulder overload is to transform anterior-posterior forces into a rotational force in the upper extremity. In addition, utilizing larger muscle groups of the axial skeleton to generate forces will increase

efficiency of the overhead motion.

Amateur or less skilled pitchers exhibit high percentages of maximal muscle activation of all rotator cuff muscles throughout the pitching motion. Professional or highly skilled pitchers exhibit decreased initiation of the supraspinatus during abduction, and more isolated activation of the remaining rotator cuff muscles. In addition, highly developed pitchers tend to have better muscular coordination and the ability to utilize larger muscles for force production. During throwing or a tennis serve, there is an orderly sequence of motions consisting of:

- 1) Wind-up
- 2) Stride
- 3) Arm Cocking
- 4) Arm Acceleration
- 5) Arm Deceleration

During the wind-up and early arm cocking phase, the lower extremity develops force by forward motion. If the athlete is right handed, there is a counterclockwise rotation of pelvis and trunk (when viewed from above), with the arm externally rotated behind the body.

Lateral trunk flexion determines arm abduction. The shoulder musculature is minimally involved in producing abduction during the early cocking phase. Large muscles outside the rotator cuff are responsible for subsequent acceleration of the arm, particularly the anterior chest musculature. The scapulothoracic musculature stabilizes the scapula against the thorax. The small musculature of shoulder complex functions primarily to keep the humeral head within the glenoid, particularly

during deceleration. Trunk rotation at the end of the overhead motion causes the torso to absorb most of the eccentric forces, decreasing shoulder complex involvement in the deceleration phase. This reduces stress placed on the serratus anterior and other stabilizers, which are eccentricity stabilizing the scapula and maintaining the humeral head within the glenoid.

Lumbar Spine Involvement

The lumbar spine provides a level foundation that remains stable during overhead motions. Limited flexibility and weakness of the spine are associated with a lack of control during overhead motions. This causes abnormal dissipation of force and alters shoulder biomechanics.

During the cocking phase, the lumbar spine presents some degree of lordosis. The key concept is '**controlled lordosis**'. If muscular stabilizers of the lumbosacral spine fatigue, causing a 'passive' lordotic posture, this will increase hip extension which will place a greater reliance on the iliofemoral ligament. Lordosis is harmful in a few ways. Early spine extension leads to 'locking out' of the spine, which prevents achievement of the 170-175° of shoulder external rotation. Trunk fatigue induces lumbar spine lordosis, which places the pitching shoulder and arm behind the acceleration phase (slow arm theory), causing a high ball release point, which decreases pitching accuracy and increases potential shoulder injuries.

During this condition, in order to deliver the pitch at a high velocity, either more energy has to be expended by trunk flexors and rotators to bring the

spine and torso forward, or more force has to be generated at the level of the scapular and shoulder musculature to compensate for the biomechanical disadvantaged position of the scapulothoracic and glenohumeral joints, thus leading to overload injuries.

The obliques serve as a trunk rotator, the rectus abdominis as an anterolateral flexor, and the lumbar paraspinals as lateral flexors and rotators. The gluteus maximus on the throwing arm side acts as a push off force, and the gluteus on the nonthrowing side acts as a pelvic stabilizer during hip flexion. There tends to be greater muscular activation of the nonthrowing side in highly skilled pitchers. This is significant because the activation patterns of these muscles creates contralateral flexion and counterclockwise rotation of the trunk, which contribute to the forces producing abduction of the throwing arm. Thus, the appropriately timed and coordinated activation of muscles influencing spine motion reduces the need for the shoulder muscles to act as the prime movers of the arm.

Another possible explanation for increased lumbar lordosis is inflexible hip flexors, which decreases stride length and causes the pitcher to open up too soon, or throw across the body.

The lumbar spine influences the shoulder on the basis of its ability or inability to laterally flex. Noted above, the major source of abduction during overhead motions is the combination of lateral spine flexion and trunk rotation which helps the arm achieve a fully cocked position.

Thoracic Spine Involvement

The thoracic spine influences scapulothoracic position and glenohumeral motion. During overhead motions, there is first lateral and upward rotation of the scapula, and then migration of the scapula around the thorax during the transitions from cocking to follow through. To allow this, approximately 15 cm of retraction/protraction, and 65° of rotation/abduction must occur. Poor posture, leading to alteration of the shape of the thorax (i.e., thoracic kyphosis), produces both abduction and protraction of the scapula. This changes the orientation of the glenoid, which reduces the clearance space for the humeral head and increases forward shear.

Cervical Spine Involvement

The primary role of the cervical spine is to allow full rotation so that the athlete may visually see the target. This rotation is accomplished by lateral bending and flexion/extension of the cervical spine. When viewing the athlete from above, if a right-handed athlete has decreased cervical range of motion this leads to compensation. This causes premature counterclockwise rotation of the throwing shoulder and early axial trunk rotation. The shoulder can no longer become 'fully loaded', creating the slow arm phenomenon.

Compensation causes the elbow to drop, resulting in greater trunk rotation to allow full external rotation and abduction of the shoulder. This increases the tensile forces placed upon the ligaments of the shoulder and elbow and may stress neurologic structures such as the suprascapular and long

thoracic nerves. Repeated traction can lead to neurapraxic or axonotmetic lesions with loss of external rotation strength and scapular control indicated by scapular winging. Tennis players are vulnerable to this problem due to the severity of the overhead reaching motion while serving.

In addition, the cervical spine may be involved in force generation during throwing or a tennis serve. Initial rotation and lateral flexion of the cervical spine toward the nonthrowing shoulder may aid the throw by abducting the shoulder. This is also prevalent in throwing events such as the discus where larger and more forceful rotation of the cervical spine is required.

In swimming, restricted cervical motion could alter the amount of axial rotation (log rolling), or shoulder abduction and external rotation needed in order to breathe and produce enough force to allow the swimmer to propel forward. This increased axial rotation causes a decrease in mechanical efficiency. Increased abduction and external rotation causes impingement, and increased force developed in the latissimus dorsi and pectoralis major place tensile load on the rotator cuff which is trying to reduce labral shear by containing the humeral head in the glenoid fossa.

CHAPTER SIX

Range of Motion and Flexibility

Restoring or maintaining normal range of motion (ROM) is one of the primary goals in any rehabilitation program to regain normal function. When there is an injury, there is almost always a loss of ROM due to pain, swelling, muscle guarding, muscle spasm, and inactivity. This results in the shortening of connective tissue and muscle.

Flexibility is defined as the ability to move a joint or series of joints through a full, nonrestricted, and pain-free ROM. Range of motion can be divided into passive and active range of motion.

Passive Range of Motion

Passive ROM is defined as unrestricted ROM for a segment which is produced entirely by an external force such as gravity, a machine or device, another individual, or using another part of the individual's own body to produce motion. There is no voluntary muscle contraction. Acute or post-surgical ROM is restricted by inflammation and pain. Passive ROM is indicated to decrease the complications of immobilization or guarding in order to:

- 1) Maintain joint and soft-tissue integrity
- 2) Minimize the formation of contractures
- 3) Maintain mechanical elasticity of the

muscles

- 4) Assist in circulation
- 5) Enhance synovial movement for cartilage nutrition, and diffusion of materials in the joint
- 6) Decrease or inhibit pain
- 7) Assist with the healing process following injury or surgery
- 8) Maintain the individual's awareness of movement

Active Range of Motion

Active ROM is defined as movement within the unrestricted ROM for a segment that is produced by an active contraction of the muscles crossing the joint. Active ROM accomplishes the same goals as passive ROM with the added benefits resulting from the muscle contraction:

- 1) Maintain physiologic elasticity and contractility of the participating muscles
- 2) Provide sensory feedback from the contracting muscles
- 3) Provide a stimulus for bone growth and integrity
- 4) Increase circulation and prevent thrombus formation
- 5) Develop coordination and motor skills for functional activities

Anatomical factors limiting normal ROM and flexibility are:

- 1) Muscles, tendons, and surrounding fascial sheaths. When performing stretching exercises to improve ROM and flexibility about a joint, take advantage of the highly elastic properties of muscles and tendons.
- 2) Connective tissues such as joint ligaments and joint capsules. These structures have some elasticity, but if immobilized for long periods of time, they tend to lose elasticity and actually shorten.
- 3) Bony structures.
- 4) Fat which can be wedged between two lever arms, restricting full ROM.
- 5) Skin contractures caused by scarring of ligaments, joint capsules, and musculotendinous units.

Procedures for Applying ROM Techniques

- 1) Based on evaluation and the stage of rehabilitation, determine the individual's goals when deciding whether to use passive or active ROM techniques.
- 2) Place the individual in a comfortable position that allows you to move the segment through the indicated ROM.
- 3) Free the area from restrictive clothing.
- 4) Position yourself so that proper body mechanics can be used.
- 5) To control movements, grasp the extremity around the joints. If joints are painful, modify grip.
- 6) Support areas of poor structural integrity, such as a hypermobile joint.
- 7) Move the segment through its full, pain-free ROM, in addition motions should be smooth and rhythmic.

Guidelines and Precautions for Stretching

- 1) Warm-up the segment.
- 2) To increase flexibility, the muscle must be overloaded or stretched beyond its normal ROM, but not to the point of pain.
- 3) Stretch only to the point of tightness, resistance to stretch, or perhaps some discomfort. Remember the stretch should not be painful.
- 4) Increased ROM will be specific to the muscle or joint being stretched.
- 5) Exercise caution when stretching muscles that surround painful joints.
- 6) Avoid overstretching the ligaments and joint capsules that surround the joint.
- 7) The individual being stretched should continue normal breathing during a stretch. Do not hold breath.
- 8) Stretching should be done at least 3 times per week for minimal improvement. For maximum results, stretch 5-6 times per week.

Shoulder Range of Motion

Shoulder Flexion and Extension

Shoulder ABDuction and ADDuction, Anterior View

Shoulder Horizontal ABDuction and ADDuction

Shoulder ABDuction, Posterior View-True Glenohumeral ABDuction

Shoulder ABDuction, Posterior View-Combined Scapulothoracic Rotation

Shoulder Internal and External Rotation with Arm at Side

Shoulder Internal and External Rotation with Shoulder Abducted to 90°

Passive Range of Motion

T-Bar Flexion

Position: Lying on back

Procedure: Grip the T-bar with the involved arm at the top of the T-bar, keeping elbow straight. With the opposite arm, use the bar to move the involved arm overhead as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Latissimus dorsi, teres major/minor, posterior deltoid, triceps, and inferior capsule.

T-Bar Extension

Position: Lying on back

Procedure: Grip the T-bar with the involved arm at the bottom of the T-bar, keeping elbow straight. With the opposite arm, use the bar to move the involved arm into extension as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Anterior deltoid, coracobrachialis, pectoralis major, biceps, and anterior capsule.

T-Bar ABDuction

Position: Standing or lying on back

Procedure: Grip the T-bar with the involved arm at the top of the T-bar, keeping elbow straight. With the opposite arm, use the bar to move the involved arm into abduction as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Latissimus dorsi, teres major/minor, pectoralis major/minor, posterior deltoid, triceps, and inferior capsule.

T-Bar Horizontal ABDuction

Position: Standing or lying on back

Procedure: Grip the T-bar with the involved arm at the top of the T-bar, elbow flexed. With the opposite arm, use the bar to move the involved arm into horizontal abduction as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Pectoralis major, anterior deltoid, long head of the biceps, and anterior joint capsule.

T-Bar Horizontal ADDuction

Position: Standing or lying on back

Procedure: Grip the T-bar with the involved arm at the top of the T-bar, keeping elbow straight. With the opposite arm, use the bar to move the involved arm into horizontal adduction as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Posterior deltoid, infraspinatus, teres minor, rhomboids, middle trapezius, and the posterior capsule.

T-Bar Internal Rotation

Position: Lying on back

Procedure: Grip the T-bar with the involved arm at the top of the T-bar, elbow flexed to 90° and shoulder abducted to 90°. With the opposite arm, use the bar to move the involved shoulder into internal rotation as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Subscapularis, pectoralis major, latissimus dorsi, teres major, anterior deltoid, and anterior joint capsule.

T-Bar External Rotation

Position: Lying on back

Procedure: Grip the T-bar with the involved arm at the top of the T-bar, elbow flexed to 90° and shoulder abducted in a progression of 0° , 90° , and 135° . With the opposite arm, use the bar to move the involved shoulder into external rotation as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Latissimus dorsi, teres major/minor, posterior deltoid, triceps, and inferior capsule.

Codman's or Pendulum Exercise

This technique is useful as a general stretch of the joint structures. In addition, pendulum exercises lubricates the glenohumeral joint by shifting the synovial fluid within the capsule, and is useful in the early stages of rehabilitation when motion above 90° is restricted. This self-mobilization technique is assisted by gravity, which places traction on the humeral head from the glenoid fossa. This relieves pain through gentle traction and oscillating movements.

Position: Stand with trunk flexed about 90° or lie prone on a treatment table, with involved shoulder over the edge.

Procedure: The arm hangs loosely downward in a position of 90° flexion. A pendulum or swinging motion of the arm is initiated by having the patient move the trunk slightly back and forth. Motions of flexion, extension, horizontal abduction, adduction, and circumduction can be performed.

Progression:

- 1) No hand-held weight
- 2) Hand-held weight
- 3) Small arcs of motion to larger arcs

Precautions: All arcs of motion should be pain free.

Wall Corner Stretch

Position: Push-up position, placing hands on the inside corner of adjacent walls.

Procedure: Allow one's body weight to sink into the corner as far as possible and hold for 15-30 sec, repeat 3-4 times.

Muscles: Pectoralis major/minor, anterior deltoid, coracobrachialis, and anterior joint capsule.

Supine Roller Pectoralis Stretch

Position: Lying on back, elbows at 90° flexion, shoulders abducted to 90° and externally rotated.

Procedure: Laying on a half-roll, allow anterior chest muscles to relax as far as possible, hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Pectoralis major/minor, anterior deltoid, coracobrachialis, and anterior joint capsule.

Apley's Towel Stretch

Position: Standing

Procedure: Hold a towel at one end with the involved shoulder flexed, abducted, and externally rotated (as if one was going to scratch one's back). With uninvolved shoulder, grip the opposite end of the towel and pull down as far as possible. Reverse procedure into extension, adduction, and internal rotation. Hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Inferior joint capsule, triceps, latissimus dorsi, teres major/minor. Reverse procedure for the anterior joint capsule.

Assisted Range of Motion

Shoulder Flexion Stretch

Position: Lying on back

Procedure: Grasp athlete's involved arm under the elbow with your lower hand. With the top hand, cross over and grasp the athlete's wrist and palm. Lift the arm through the available range as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Latissimus dorsi, teres major/minor, posterior deltoid, triceps, and inferior capsule.

Shoulder Extension Stretch

Position: Lying on back or side lying

Procedure: Grasp the athlete's arm under the elbow with your lower hand. With the top hand, cross over and grasp the athlete's wrist and palm. Extend the athlete's shoulder as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Anterior deltoid, coracobrachialis, pectoralis major, biceps, and anterior capsule.

Shoulder Horizontal ADDuction Stretch

Position: Lying on back

Procedure: Grasp the athlete's wrist with your inside hand, add traction to the shoulder and horizontally adduct. At the same time, with your outside hand cup the lateral border of the scapula and attempt to adduct the scapula as far as possible. Hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Posterior deltoid, infraspinatus, teres minor, rhomboids, middle trapezius, and posterior capsule.

Latissimus Dorsi, Teres Minor, and Triceps

Position: Lying on back

Procedure: Athlete fully flexes involved shoulder. Grasp athlete's involved wrist with your inside arm and flex elbow as tolerated. At the same time, using your outside arm, place pressure on the distal posterior elbow and move into further flexion as far as possible. Hold for 15-30 sec, repeat 3-4 times.

Muscles: Latissimus dorsi, teres major/minor, posterior deltoid, triceps, and inferior capsule.

Shoulder External Rotation Stretch

Position: Lying on back

Procedure: The athlete abducts shoulder and elbow to 90°. Place your inside hand on the anterior capsule and push down (supporting anterior capsule). At the same time, externally rotate shoulder as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Latissimus dorsi, teres major/minor, posterior deltoid, triceps, and inferior capsule.

Progressions: Alter the stretch by abducting shoulder at 0°, 45°, 90°, and 135°. In addition, the shoulder can be horizontally adducted with the same degrees of external rotation.

Caution: This may elicit pain with impingement athletes.

Shoulder Internal Rotation Stretch

Position: Lying on back

Procedure: The athlete abducts shoulder and flexes elbow to 90°. Place your inside hand on the anterior capsule and push down. At the same time, internally rotate shoulder as far as possible and hold for a count of 15-30 sec, repeat 3-4 times.

Muscles: Subscapularis, pectoralis major, latissimus dorsi, teres major, anterior deltoid, and anterior capsule.

Progressions: Alter the stretch by abducting shoulder at 0°, 45°, 90°, and 135°. In addition, the shoulder can be horizontally adducted with the same degrees of internal rotation. **CAUTION:** This may elicit pain with impingement athletes.

Active Range of Motion

Wall Climbs

This technique is useful when attempting to regain full range of motion in flexion and abduction. Range of motion should be restricted to a pain-free arc.

Position: Standing

Procedure: Facing the wall for forward flexion, (or in abduction face the involved shoulder toward the wall). Use the fingers of the involved arm to "walk" the shoulder into flexion or abduction until desired motion is achieved. Repeat 5-10 times.

Progression:

- 1) Table to wall
- 2) Add hand weights

Posterior Shoulder Stretch

Position: Standing

Procedure: Internally rotate the involved shoulder. Place the dorsal side of the hand on the involved PSIS, horizontally adduct shoulder as far as possible. Hold for 15-30 sec, and repeat 3-4 times.

Muscles: Posterior deltoid, infraspinatus, teres minor, and posterior joint capsule.

Caution: May cause pain for athletes with impingement. To feel a comfortable stretch, the angle of internal rotation may vary with athletes.

Variation: Athletes with excessively tight posterior shoulder structures may need assistance from an athletic trainer to perform this exercise.

Rope and Pulley Exercise

This exercise may be used as an active-assistive exercise when trying to regain full overhead motions. Range of motion should be restricted to a pain-free arc.

Position: Standing

Procedure: Grasp one side of the pulley with involved arm and the other with the uninvolved arm. In a slow, smooth, controlled manner, pull down on the pulley or rope, elevating involved shoulder into forward flexion or abduction.

CHAPTER SEVEN

Regaining Muscular Strength and Endurance

It is critical in a rehabilitation program to develop and maintain strength and endurance for returning to a competitive functional level following an injury.

Muscle Strength is defined as the ability of a muscle to generate force against a resistance. Muscle weakness or imbalances can result in abnormal movements that impair normal shoulder mechanics. Developing muscle strength is critical to an athlete's overall fitness and athletic performance. **Muscle Endurance** is defined as the ability to perform repetitive muscular contractions against a resistance for an extended period of time.

Overload Principle

The overload principle is extremely important in increasing muscular strength and endurance. To improve muscular strength and endurance, muscles must be forced to work at a higher level than they are accustomed to, therefore requiring an increased effort against progressively increased resistance. In the rehabilitation setting, progressive overload is limited by the healing process. An aggressive approach to rehabilitation may exacerbate pain and swelling. The rate of progression is best

determined by the injured athlete's response to a specific exercise.

Rehabilitation Progression

Rehabilitation program progression in the shoulder complex should emphasize proximal stability and progress to distal mobility. Since the scapula provides proximal stability by acting as an anchor to the thorax, thus allowing distal segment mobility, the scapulothoracic articulation must first be corrected before moving on to the glenohumeral joint. Stability of the scapulothoracic articulation cannot be achieved by one muscle alone. Proper functioning of all the scapulothoracic muscles is necessary to achieve dynamic stability of the scapula. Isolated strengthening of just one of the scapulothoracic muscles will create a muscular imbalance.

The movement progress from straight planes to circular movements, then diagonal patterns emphasizing quality, not quantity, of movement. A functional, stable scapulothoracic articulation is critical for the overhead athlete and enhances sport performance by dynamically maintaining a consistent length-tension relationship for the shoulder girdle.

musculature. The muscles involved in the scapulothoracic articulation do not need to produce large amounts of force. Therefore, muscular endurance is the goal. It is recommended that exercises should be quantified by time and repetition, and not based on the number of sets and repetitions.

Prime Movers and Stabilizers

The shoulder joint muscles can be classified into prime movers and stabilizers. The **prime movers** are known as the accelerators of the shoulder, and are characterized as double-jointed muscles that internally rotate the shoulder. The prime movers consist of the pectoralis major, latissimus dorsi, teres major, and triceps brachii muscles. The accelerators can be effectively exercised with manual resistance, isokinetic exercise, and plyometric exercise training.

The **prime stabilizers** are known as the decelerators, which are characterized as single-jointed muscles that abduct and externally rotate the shoulder, producing slow, controlled movements. The stabilizers consist of the infraspinatus, teres minor, and posterior deltoid muscles. The decelerators can be trained effectively using exercise tubing which applies consistent load to the musculotendinous unit or by stimulating an eccentric or decelerated type of contraction.

The **dynamic stabilizers** must exert force over a long period of time, thus requiring strength, power, and

endurance. Endurance training is vital in preventing fatigue. Once the muscle fatigues, there is a higher risk of subluxation and impingement due to the loss of dynamic stabilization. The scapular stabilizers must function along with the rotator cuff to stabilize and rotate the scapula during overhead motions. The stable base of the scapula permits smooth, controlled motion of the humerus by the rotator cuff, while also providing joint stability.

The rotator cuff muscles can be strengthened with a pulley while standing or sitting, theraband or surgical tubing connected to a wall, side-lying with a hand-held weight, prone in horizontal abduction, and the empty can exercise.

Strengthening the dynamic stabilizers of the shoulder complex should initially consist of exercises in the inner range of motion, progress to the outer ranges, and slowly to

functional activities. Exercises should progress from slower, controlled velocities to faster velocities that simulate game situations as the joint can tolerate.

Scapular Plane Exercises

Scapular plane exercises are often recommended for strengthening the internal and external rotators of the shoulder. The scapular plane is defined as shoulder elevation between a 30° and 40° in the frontal plane. This position is often used because it places minimal stress on the shoulder capsule

Endurance training is vital in preventing fatigue, which leads to shoulder injuries!

and places the glenohumeral joint in a functional plane of movement. Shoulder abduction combined with external and internal rotation is progressed from 0° to 30-40°, and then 90°. This progression maximally challenges the dynamic stabilizers of the shoulder complex and progresses from a position of maximal joint stability to one of minimal stability.

POINT OF INTEREST

- The following exercises are limited only by one's imagination. Exercises can be altered by using hand-held weights, weight cuffs, theraband, manual resistance, etc.

Isometric Training

Shoulder Flexion

Position: Standing

Procedure: Stand facing the wall with the elbow flexed to 90° and make a fist. Place a pillow or towel between fist and the wall, and press against the wall into flexion. Hold for 5-10 seconds and repeat 10-15 times.

Muscles: Anterior deltoid, pectoralis major, and long head of the biceps.

Shoulder Extension

Position: Standing

Procedure: Stand facing the wall with elbow flexed to 90° and make a fist. Place a pillow or towel between posterior elbow and the wall, and press against the wall into extension. Hold for 5-10 seconds and repeat 10-15 times.

Muscles: Latissimus dorsi, teres major, and triceps.

Shoulder ADDuction

Position: Standing

Procedure: Place a pillow or towel between the involved shoulder and the body. Flex elbow to 90° and adduct the arm, pressing against the body. Hold for 5-10 seconds and repeat 10-15 times.

Muscles: Pectoralis major, teres major, latissimus dorsi, and the long head of the triceps.

Shoulder ABDuction

Position: Standing

Procedure: Place a pillow or towel between the involved shoulder and the wall. Flex elbow to 90° and abduct the arm against the wall. Hold for 5-10 seconds and repeat 10-15 times.

Muscles: Supraspinatus, infraspinatus, and teres minor.

Shoulder External Rotation

Position: Standing

Procedure: Stand with involved arm against the wall or door frame with elbow flexed to 90°. Externally rotate shoulder, pressing the fist against the wall, hold for 5-10 seconds, and repeat 10-15 times.

Muscles: Supraspinatus, infraspinatus, and teres minor.

Shoulder Internal Rotation

Position: Standing

Procedure: Standing within a door frame, involved arm at side, elbow flexed to 90° with fist against wall. Internally rotate the shoulder, pressing against the wall. Hold for 5-10 seconds and repeat 10-15 times.

Muscles: Subscapularis, anterior deltoid, latissimus dorsi, and teres major.

Isotonic Training

Progressive Resistive Shoulder Joint Exercises

Shoulder Flexion

Position: Standing

Procedure: Start with both arms at side, holding hand-held weights/theraband. Keeping elbows straight, forward flex either one or both shoulders to just above 90°, then lower the weights to starting position and repeat.

Muscles: Anterior deltoid, pectoralis major, and long head of the biceps.

Shoulder Extension

Position: Lying on stomach

Procedure: With weight cuffs, allow arms to lie limp in front. Keeping elbow straight, slowly extend shoulder as far as possible, then lower back to starting position and repeat.

Muscles: Latissimus dorsi, teres major, triceps, and posterior deltoid.

Shoulder ADDuction

Position: Standing

Procedure: Attach theraband to a secure object at shoulder height. Grasp the theraband with involved shoulder abducted to 90°. Pull arm into adduction, keeping elbow straight. Return to starting position and repeat.

Muscles: Pectoralis major, teres major, latissimus dorsi, and the long head of the triceps.

Shoulder ABDuction

Position: Standing

Procedure: With weight cuffs at side, keep elbows straight in a neutral position. Slowly abduct shoulder just above 90°, then lower the weight to the starting position and repeat.

Muscles: Middle deltoid and supraspinatus.

Shoulder Horizontal ADDuction

Position: Lying on back

Procedure: With weight cuffs, arms horizontally abducted. Keeping elbows straight, slowly adduct arms horizontally, then lower weights to starting position and repeat.

Muscles: Subscapularis, pectoralis major, coracobrachialis, and biceps.

Shoulder Horizontal ABDuction

Position: Lying on stomach or bending over into trunk flexion.

Procedure: Holding onto hand-held weights, arms horizontally abducted, keeping elbows straight, slowly abduct arms horizontally, then lower weights to starting position and repeat.

Muscles: Infraspinatus and teres minor.

Prone Shoulder External Rotation

Position: Lying on stomach with arm hanging off the edge of the table.

Procedure: Holding hand-held weight or weight cuffs, flex elbow and abduct shoulder to 90°. Slowly externally rotate shoulder, then lower the weight to the starting position and repeat.

Muscles: Supraspinatus, infraspinatus, and teres minor.

Variation: Combine shoulder horizontal abduction exercise. At the end of scapular abduction, externally rotate shoulder.

Theraband Exercises

- Always attach one end of the theraband to a secure object such as a wall, doorway, or another part of one's body (i.e., by stepping on one end or holding it with uninvolved arm).
- Always move through a full range of motion.
- To increase resistance move away from the fixation of the theraband.
- To decrease resistance move closer to the fixation of the theraband.

Theraband Shoulder External Rotation

Position: Sitting or standing

Procedure: Uninvolved side toward the wall. Slightly abduct involved arm to prevent any compromise of the neurovascular structures, flex elbow to 90°. With the involved arm, grasp the end of the theraband and externally rotate shoulder as far as possible, then return to starting position and repeat.

Muscles: Supraspinatus, infraspinatus, and teres minor.

Progression: Always start slightly abducted, then progress to 45°, 90°.

Side Lying Shoulder Internal Rotation

Position: Lying on involved side on the edge of the table.

Procedure: Elbow flexed to 90° with arm at side. Hold hand-held weight and internally rotate shoulder (pulling hand inward across the body), then lower weight to starting position and repeat.

Muscles: Subscapularis, anterior deltoid, latissimus dorsi, and teres major.

Progressive Resistive Exercise (PRE)

- PRE is the most popular exercise prescription of athletic trainers and sports medicine staff.
- PRE utilizes isotonic contractions which consist of concentric and eccentric contractions.
- PRE can be creative and diverse by using a variety of equipment such as free weights (barbells and dumbbells), weight cuffs, various theraband resistance, and various exercise machines.

Theraband Shoulder Internal Rotation

Position: Sitting or standing

Procedure: Involved side toward wall. Slightly abduct involved arm to prevent any compromise of the neurovascular structures and flex elbow to 90°. With the involved arm, grasp the end of the theraband and internally rotate shoulder as far as possible. Return to starting position and repeat.

Muscles: Subscapularis, anterior deltoid, latissimus dorsi, and teres major.

Progression: Always start slightly abducted, then progress to 45°, 90°.

Empty Can

Position: Standing

Procedure: Holding hand-held weight, shoulders horizontally abducted to 45° and internally rotated (thumbs pointing down). Slowly flex shoulder and lower the weight to starting position, repeat.

Muscles: Supraspinatus

Caution: Internally rotating the shoulder may cause pain in athletes with severe impingement; therefore, perform exercises in neutral position or with thumbs pointing up.

ABC's

Position: Standing or lying on back

Procedure: Holding hand-held weights with involved arm flexed to 90°. Keeping the elbow straight, move the weight as if spelling the alphabet, repeat.

Muscles: Subscapularis, deltoid, latissimus dorsi, teres major/minor, supraspinatus, infraspinatus, pectoralis major, coracobrachialis, and biceps.

Progression: Start with small letters and progress to larger letters.

Isotonic Training

Progressive Resistive Shoulder Girdle Exercises

Shoulder Shrugs

Position: Sitting or standing

Procedure: Holding hand-held weights, raise shoulders up toward ears and roll backwards slightly (retracting scapula), then return to starting position and repeat.

Muscles: Upper trapezius and levator scapulae

Alterations: Shrug shoulders, then perform empty can exercise to overload the supraspinatus.

Bent-Over Rows

Position: Standing

Procedure: Holding hand-held weight with involved arm. Slightly flex trunk and knees. The athlete can support the upper body with the uninvolved arm on a table. Extend shoulder, pulling scapula into adduction, then slowly lower the weight, return to starting position, and repeat.

Muscles: Middle trapezius, rhomboids, levator scapulae.

Reverse Fly's

Position: Standing

Procedure: Holding hand-held weights, slightly flex hips. Horizontally abduct shoulders, pulling the scapula into adduction. Slowly lower the weight, returning to starting position and repeat.

Muscles: Middle deltoid, teres minor, infraspinatus, rhomboids, and middle trapezius.

Chest Press

Position: Lying on back

Procedure: Hold hand-held weights with arms horizontally abducted as far as possible, elbows flexed to 90°. Horizontally adduct and extend elbows overhead, then slowly lower the weight to starting position and repeat.

Muscles: Pectoralis major, anterior deltoid, coracobrachialis, and triceps.

Alterations: Incline press and decline press.

Shoulder Press

Position: Standing or sitting

Procedure: Holding hand-held weights, arms horizontally abducted, externally rotated, and elbows flexed to 90°. Press the weights overhead, extending elbows, then slowly lower the weight to starting position and repeat.

Muscles: Supraspinatus, infraspinatus, teres minor, middle deltoid, upper trapezius, levator scapula, and triceps.

Latissimus Pull-Downs

Position: Standing

Procedure: Attach theraband overhead to a secure object. Grasp the ends of the theraband in either a wide or narrow position and pull scapulas down into adduction and depression. Slowly return to starting position and repeat.

Muscles: Latissimus dorsi, teres major, pectoralis minor, and biceps.

Latissimus Pull-Overs

Position: Lying on back

Procedure: Holding hand-held weights, arms overhead with elbows straight, pull arms back toward stomach, then slowly lower the weight to starting position and repeat.

Muscles: Latissimus dorsi, teres major, pectoralis minor, and biceps.

Progression: Athlete holds onto a stick with both hands in the same position. Athletic trainer can apply manual resistance. Emphasize the eccentric contraction by having the athlete control resistance when returning to starting position.

Serratus Anterior Punches

Position: Lying on back

Procedure: Holding hand-held weights, keeping elbows straight, shoulders flexed to 90°. Protract scapula and push arms up toward the ceiling, slowly return to starting position and repeat.

Muscles: Serratus anterior

Theraband Serratus Anterior Punches

Position: Standing

Procedure: Attach theraband at shoulder height. Facing away, grasp the theraband in hands with elbows straight and arms flexed to 90°. Push arms forward, protracting scapula, then slowly return to starting position and repeat.

Muscles: Serratus anterior

Shoulder Retraction

Position: Lying face down on a table

Procedure: Holding hand-held weights, arms hanging off table with elbows straight or flexed. Adduct scapula, then slowly return to starting position and repeat.

Muscles: Rhomboids and middle trapezius

Theraband Shoulder Retraction

Position: Standing or lying face down on a table.

Procedure: Hold theraband with arms flexed to 90°, keep elbows straight. Adduct scapula, then slowly return to starting position and repeat.

Muscles: Rhomboids and middle trapezius

Theraband D1 Flexion

Position: Standing

Procedure: Secure theraband to an object on the floor. Grasp the opposite end of theraband with involved arm extended, externally rotated and slightly abducted. Slowly flex, internally rotate and adduct arm, crossing the chest toward opposite ear. Slowly return to starting position and repeat.

Theraband D1 Extension

Position: Lying on back

Procedure: Attach theraband to a secure object above head. Grasp the opposite end of theraband with involved arm crossing over chest, shoulder flexed, internally rotated, and adducted. Slowly extend, externally rotate and abduct shoulder, then slowly return to starting position and repeat.

Theraband D2 Flexion

Position: Standing

Procedure: Attach theraband to a secure object at floor level. Begin with arm crossed over trunk into extension, internally rotated and adducted (thumb in pocket). Slowly flex, externally rotate, and abduct. Slowly return to starting position and repeat.

Theraband D2 Extension

Position: Standing

Procedure: Attach theraband to secure object above head. Begin with arm flexed, externally rotated, and abducted. Slowly extend, internally rotate, and adduct shoulder, crossing over the trunk. Slowly return to starting position and repeat.

Body Blade Dynamic Stabilization

Internal and External Rotation

Position: Standing

Procedure: Involved arm at side with body blade facing up and down. Start oscillating blade back and forth (internally and externally). Oscillate 20-60 sec, 3-4 times.

Progression: Keep blade at one position or moving through a particular ROM. (i.e., oscillate blade while internally and externally rotating shoulder as far as possible, keeping arm adducted or abducted up to 90°. Increase time and sets.

Flexion and Extension

Position: Standing

Procedure: With involved shoulder in flexion, hold the body blade sideways. Start oscillating blade up and down. Oscillate 20-60 sec, 3-4 times.

Progression: Keep blade at specific angles of flexion, or up to full flexion and back down to starting position. Increase time and sets.

ABDuction and ADDuction

Position: Standing

Procedure: With involved arm abducted to 90°, hold the body blade sideways. Start oscillating blade up and down. Oscillate 20-60 sec, 3-4 times.

Progression: Keep blade at specific angles of abduction, or through full abduction ROM while maintaining blade oscillations up and down. Increase time and sets.

Horizontal Flexion and Extension

Position: Standing

Procedure: Hold the body blade up and down with elbow extended. Start oscillating blade side to side for 20-60 sec, 3-4 times.

Progression: Increase time and sets.

Scapular Protraction and Retraction

Position: Standing

Procedure: Hold the body blade up and down or sideways, keeping elbow extended. Start oscillating blade back and forth for 20-60 sec, 3-4 times.

Progression: Increase time and sets.

Throwing

Position: Standing

Procedure: Hold the body blade sideways with arm extended, internally rotated, and adducted across the trunk. Start oscillating blade up and down while flexing, externally rotating and abducting shoulder. Then slowly return to starting position, oscillate throughout the ROM for 20-60 sec, 3-4 times.
NOTE: This motion simulates the throwing motion.

Progression: Increase time and sets.

CHAPTER EIGHT

Reestablishing Neuromuscular Control

Reestablishing neuromuscular control is a critical component in the rehabilitation program of the shoulder complex. As mentioned, there is a delicate balance between mobility and stability in the shoulder complex. Therefore, dynamic stability from capsuloligamentous structures is even more crucial for maintaining functional stability.

Static and dynamic stabilizers interact to provide stability for the glenohumeral joint, which involves an intricate balance of muscular strength, endurance, flexibility, and neuromuscular control.

What is Neuromuscular Control?

Historically, rehabilitation programs have been directed towards restoring muscular strength, muscular endurance, and joint flexibility following a shoulder injury, without considering the role of the neuromuscular mechanism. The **neuromuscular mechanism** contributes to joint stability by stimulating articular mechanoreceptors, which provide the athlete with sensations of kinesthesia and joint position.

Injury to the articular and muscular structures results in a mechanical disturbance and loss of joint sensation due to the damage to the articular and

peripheral mechanoreceptors. This disrupts joint stabilization and neuromuscular coordination and stabilization, contributing to repetitive, chronic injuries and a progressive decline in the joint.

Joint proprioception refers to conscious and unconscious awareness of joint positioning, while **kinesthesia** is the sensation of joint motion or acceleration.

Proprioceptive and kinesthetic signals are transmitted to the spinal cord through afferent sensor pathways. The efferent motor response to sensory information is referred to as neuromuscular control.

The neuromuscular response provides neurological feedback that controls muscular action to protect against excessive strain on static stabilizers of the joint. Articular ligaments play an important role in

The neuromuscular mechanism contributes to joint stability by providing sensations of kinesthesia and joint position.

normal joint kinematics by providing mechanical restraints, but they also provide important neurological feedback that directly mediates muscular reflex stabilization of a joint.

Proprioception is mediated by peripheral receptors in articular, muscular, and cutaneous structures. Articular structures include free-nerve endings and proprioceptive mechanoreceptors consisting of Pacinian corpuscles, Ruffini endings, and Golgi Tendon Organs.

Mechanoreceptors are specialized neurons that transduce mechanical deformation into electrical stimuli, indicating joint motion and positioning.

Muscle spindles, which are sensitive to changes in length, and Golgi Tendon Organ-like endings, which are sensitive to changes in muscle tension, are slow adapting and important in signaling actual joint positioning or change. Pacinian corpuscles are rapid adapting and sensitive to sudden motions of acceleration or deceleration.

These articular mechanoreceptors have been identified in the glenoid labrum and glenohumeral joint ligaments. Stimulation of these receptors enhances the proprioceptive mechanism, and reflex musculature stabilization of the joint. There is a link between proprioceptive deficits and joint pathology in athletes, individuals presenting acute traumatic joint pathology, and people with degenerative joint disease.

Neuromuscular Control of Athletes with Overhead Motions

Overhead-throwing athletes must possess a delicate neuromuscular balance between flexibility and stability to permit the mobility necessary for their sport. Loss of normal coordinated neuromuscular firing occurs as a result of capsuloligamentous trauma and proprioceptive deficits.

This unstable condition places increased physiologic demands on the dynamic stabilizers to compensate for the loss of static stability.

A rehabilitation program must restore normal joint stability and proprioception of both mechanical restraints, and strengthen the muscles which coordinate the

Articular ligaments not only provide static stability, but acts as a important neurological feedback, which directly mediate muscular reflex stabilization of a joint.

neuromuscular-controlling mechanism required for joint stability. This is extremely important during the sudden changes in joint position common in athletes with repetitive, high velocity, overhead motions. A lag in the neuromuscular reaction time can result in joint

instability and impingement.

The objective of proprioceptive rehabilitation is to enhance cognitive joint position and motion, enhance muscular stabilization of the joint in the absence of static structural restraints, and facilitate synergy and synchrony of muscular firing patterns necessary for functional activities.

To obtain rehabilitation objectives, the activities must maximally recruit the muscles responsible for humeral and scapular rotation and stabilization. Three techniques that help reestablish proprioception, kinesthesia, and joint position sense are proprioceptive neuromuscular facilitation, closed-kinetic-chain exercises, and plyometric training.

Shoulder mechanoreceptor feedback mechanism: Progression of functional instability of the shoulder joint from microtrauma.

NOTE: Adapted from Borsa et al., (1994), pg 91.

Neuromuscular Control

Weight Shifting

Position: On hands and knees, kneeling, or leaning against table.

Procedure: The athletic trainer applies random directional pressure to which the athlete must respond to maintain a static position. In the two- and three-point position, the arm that is supported in a closed-kinetic-chain is using shoulder force couples to maintain neuromuscular control.

Progression:

- 1) Standing with hands supporting weight on table.
- 2) Kneeling in a four-point position.
- 3) Kneeling in a three-point position.
- 4) Kneeling in a two-point position.
- 5) Kneeling in a three-point position with involved shoulder balancing on a BAPS board.

Tilt Board Balancing

Position: Kneeling or push-up position

Procedure: Place hands shoulder width apart on tilt board. Balance and hold for a count of 15-30 sec, 3-4 times

Progression:

- 1) Side to side
- 2) Forward and backward
- 3) Push-ups while balancing

BAPS Board Balancing

Position: Kneeling or push-up position

Procedure: Place hands shoulder width apart on BAPS board. Balance and hold for a count of 15-30 sec, 3-4 times

Progression: Push-ups while balancing

Scapular Movement Awareness

Position: Athlete is side lying on uninvolved shoulder, with the involved arm abducted and internally rotated to 90°. The athlete's hand is placed on the table to fix the distal segment and assist in isolating the scapulothoracic muscles.

Procedure: The athlete is asked to slowly elevate and depress the scapula against the athletic trainer's manual resistance. Scapular protraction and retraction are also performed.

Progression: Scapular PNF diagonal patterns.

Supine Bar Rhythmic Stabilization

Position: Lying on back

Procedure: One or both shoulders flexed to 90°, shoulder width apart. Grip the bar horizontally in front of body. Maintain shoulder position while the athletic trainer randomly puts pressure in different directions. A workout bout consists of 30 sec to 1 min, 3-4 times.

Progression: Start off slow with light pressure, then increase the speed while increasing pressure.

Internal and External Rhythmic Stabilization

Position: Lying on back

Procedure: One or both shoulders abducted and internally rotated, elbows flexed to 90°. Maintain shoulder position while athletic trainer randomly puts pressure in horizontal abduction/adduction, internal/external rotation.

Progression: Start off slow with light pressure, then increase the speed while increasing pressure.

Theraball Rhythmic Stabilization

Position: Knee or foot supported push-up position.

Procedure: Place hands shoulder width apart on the theraball. The lower extremity is stabilized on a table, chair, or in a kneeling position. Balance and maintain position as the athletic trainer randomly jerks the theraball in different directions. Workout bouts consists of 30 sec to 1 min, 3-4 times.

Progression: Start off slow with light pressure, then increase the speed while increasing the pressure.

- 1) Table supported
- 2) Knee supported
- 3) Full push-up position
- 4) Push-up position with feet on a chair

CHAPTER NINE

Closed-Kinetic-Chain

Closed-Kinetic-Chain Concepts for the Upper Extremity

Closed-kinetic-chain exercises have been popular for the lower extremity, but similar concepts can be used for the upper extremity. **Closed-kinetic-chain** exercise is defined as exercise performed with the distal segment fixed to an immovable object. Examples of upper extremity closed-kinetic-chain exercises include push-ups, press-ups, and hand-supported weight shifts.

These exercises can be useful in providing joint **approximation forces** which promote co-contraction about the joint, enhancing the dynamic joint stabilizers, and maintaining neuromuscular control.

Concepts of the Kinetic-Chain

The concept of the kinetic-chain involves a link system. This link system consists of pinned joints connected by a series of overlapping, rigid segments. In a closed link system or closed-kinetic-chain, each body segment receives and transfers force from an adjacent body segment, and is thus either affected or affects motion of the connected components.

Thus, in a closed link system movements at one joint produce movements at all adjacent joints. When the distal segment is fixed, joint movements and the muscle recruitment

pattern differ than if the distal segment was not fixed.

It has been suggested that closed-kinetic-chain exercises are safer due to muscle co-contraction. These exercises tend to be more functional than open-kinetic-chain exercises. Closed-kinetic-chain exercises effectively facilitate the integration of proprioceptive and joint position sense feedback.

Hand-Supported-Weight-Shifting Exercises

Hand-supported-weight-shift exercises can be employed early in the rehabilitation program to enhance dynamic stability of the shoulder, and may progress in later stages by having the athletic trainer apply random directional pressure to which the athlete must respond to maintain a static position.

Hand-supported-weight-shift exercises can be started in a three- or two-point position and advanced to an unstable surface such as a wobble board or a plyoball. Progression from a stable surface to an unstable surface while balancing will further challenge the dynamic stabilizers.

Closed-Kinetic-Chain Exercise

Wall Press-Ups

Position: Standing

Procedure: Face wall with palms flat on wall, shoulder width apart, and elbows straight. Press shoulders back, protracting scapulas, then slowly return to starting position and repeat.

Muscles: Serratus anterior

Progression: Slowly increase body weight for resistance by increasing the angle of the body.

Wall Push-Ups

Position: Standing

Procedure: Facing the wall with palms flat on the wall, feet and hands shoulder width apart. Lean into the wall, then return to starting position and repeat.

Progression: Add press-ups. Change hand placements to wide, narrow, staggered, or wall corner. In addition, athletic trainer can lightly push athlete on the back toward the wall to increase deceleration forces.

Push-Ups

Position: Push-up position

Procedure: Place hands shoulder width apart, flex elbows and drop body to the floor.

Progression: Knee supported push-ups to feet. Add press-ups. Change hand placements to:

- 1) Wide
- 2) Narrow
- 3) Staggered
- 4) Alternating Box
- 5) Ball Push-ups
- 6) Wobble Board

Theraball Walk-Outs

Position: Prone on theraball, push-up position

Procedure: Keeping back straight, walk forward until ball rests under shins/toes, then walk back.

Progression: When the athlete is in the push-up position with theraball under shins/toes, have the athlete move slightly side to side, front to back, and/or in a circular pattern both clockwise and counterclockwise.

Theraball Lateral Arches

Position: Prone on theraball, push-up position

Procedure: Keeping back straight, walk forward until ball rests under toes, laterally step one direction, then back the other way.

Progression: Add push-ups, alternating box of different heights and small ball push-ups.

Theraball Push-Ups

Position: Push-up position

Procedure: Walk forward until ball rests under shins/toes. Place hands shoulder width apart, flex elbows, and drop body to the floor.

Progression: Add press-ups. Change hand placements to:

- 1) Wide
- 2) Narrow
- 3) Staggered
- 4) Alternating Box
- 5) Ball Push-ups
- 6) Wobble Board

Stair Climbing

Position: Push-up position

Procedure: Place hands on the foot-plates of a stair climber with feet supported on the floor or chair.

Progression: Feet supported on theraball.

Weight-Shifting Fitter

Position: Kneeling or push-up position

Procedure: Shoulders directly over fitter with elbows locked, fitter sideways. Shift weight side to side on fitter. Perform exercise for 20-60 sec, 3-4 times.

Progression: Increase resistance, time, and sets.

Alternatives: Place the fitter up and down.

CHAPTER TEN

Plyometric Training

Peak performance in sport requires technical skill and power. Power is the combination of speed and strength. Through traditional weight training strength can be increased, but the speed of movement is limited. Success in most activities depends on the speed at which a muscular force, or power, can be generated.

What is Plyometric Training?

Plyometrics is defined as quick, powerful movements involving a pre-stretch of the muscle that activates the stretch-shortening cycle, producing a subsequently stronger concentric contraction.

The main purpose of plyometric training is to increase the excitability of the nervous system for improved reactive ability of the neuromuscular system, and to decrease the amount of time required between the eccentric muscle contraction and the initiation of the concentric contraction.

A lag time between the eccentric muscle contraction, in the cocking phase, to the concentric muscle contraction, in the acceleration phase, may displace the humeral head leading to excessive stress to the rotator cuff, thus causing impingement!

Plyometric Training for the Overhead Athlete

Movements of the shoulder in repetitive overhead motions involve a cocking phase. This cocking phase places a pre-stretch on the adductor and internal rotator musculature of the shoulder to facilitate the explosive, concentric, muscular contraction that accelerates the arm. Plyometric training, or more appropriately the stretch-shortening mechanism, causes a pre-stretch prior to the contraction which helps facilitate the muscle spindles that assist in enhancing explosive, concentric muscular contraction.

Three Phases of the Stretch-Shortening Cycle

There are three phases in the stretch-shortening mechanism:

- 1) Setting or eccentric phase, where there is a rapid pre-stretch applied to the musculotendinous unit that stimulates the muscle spindles.
- 2) Amortization phase, representing the time between the eccentric and concentric phases. This time should be as short as possible.
- 3) Concentric muscular contraction from the pre-stretch stimulus.

Rehabilitation

There is an increase in muscular

performance in the overhead athlete when stretch-shortening rehabilitative exercises are utilized. The performance enhancement appears to occur from neural adaptation, increased speed of the myotatic reflex, desensitization of the Golgi Tendon Organ, or enhanced neuromuscular control, and not from morphological changes of the muscle.

POINTS OF INTEREST

- To isolate the shoulder complex, kneel while performing plyometric exercises.
- The throwing motion uses the whole body. Therefore, to make plyometric exercises more functional, have the athlete stand, utilizing the kinetic chain.

Plyometric Training

Double-Arm Toss

Position: Standing or kneeling

Procedure: Two hands holding an appropriately weighted plyoball in the overhead throwing position. In a controlled manner, throw the ball with both arms into the center of the trampoline. On the rebound catch the ball, decelerate, and then immediately accelerate in the opposite direction, and repeat.

Progression: Increase plyoball weight.

Two-Arm Toss with Trunk Rotation

Position: Standing or kneeling

Procedure: Two hands holding an appropriately weighted plyoball, laterally rotate trunk toward involved side. In a controlled manner, rotate trunk toward opposite side, following through with plyoball throwing it into the center of the trampoline. On the rebound catch the ball, decelerate, return to starting position, and repeat.

Progression: Increase plyoball weight.

Single-Arm Toss

Position: Standing or kneeling

Procedure: Involved shoulder holds an appropriately weight plyoball in the throwing position. In a controlled manner, throw the ball into the center of the trampoline. Catch the ball, decelerate, then immediately accelerate in the opposite direction, and repeat.

Progression: Increase plyoball weight.

Single-Arm Toss on Unstable Surface

Position: Standing

Procedure: Involved shoulder holds an appropriately weight plyoball in the throwing position while balancing on a wobble or tilt board. In a controlled manner, throw the ball into the center of the trampoline. Catch the ball, decelerate, then immediately accelerate in the opposite direction, and repeat.

Progression: Increase plyoball weight.

Push-Up Boxes

Position: Push-up position

Procedure: Two boxes shoulder width apart. Place each palm on a box and drop body until a stretch is felt in the anterior muscles, then return to starting position.

Progression: Perform a push-up while placing one hand on box and the other on the floor. Lateral step placing hands on both boxes, perform a push-up, and finally continue to side-step to opposite box repeating push-up with one hand on box and the other on the floor. Replace a box with plyoball.

Seated Single-Arm Weighted-Ball Throw

Position: Sitting

Procedure: Involved elbow flexed at 90° supported by the table and horizontally abducted. The athletic trainer tosses the ball to the athlete's hand, creating an overload in lateral rotation that forces the athlete to dynamically stabilize in that position, and then toss ball back to the athletic trainer.

Progression: Increase plyoball weight.

Ball Arcs

Position: Standing

Procedure: 6 inches to a foot away from wall, face the wall with involved shoulder abducted. Holding an appropriately weighted plyoball, bounce the ball against the wall in full abduction.

Progression: Athlete can stay in a specific angle of abduction to increase strength, or work throughout the full range of motion.

Push-Ups with a Clap

Position: Push-up position

Procedure: In push-up position, athlete pushes off the ground, clap hands, and catches body weight.

External and Internal Rotation Theraband Plyo's

Position: Standing or sitting

Procedure: Use a theraband connected to a wall or fixed object at shoulder height. In a throwing position with involved shoulder 90° abducted and externally rotated, quickly internally or externally rotate shoulder to facilitate a concentric contraction followed by a controlled eccentric contraction when returning to starting position.

Supine Ball Drops

Position: Lying on back

Procedure: Either one or two hands in front of body. Athlete catches an appropriately weighted plyoball that the athletic trainer drops, quickly decelerating ball and pushing it back to the athletic trainer.

Progression: Increase plyoball weight.

CHAPTER ELEVEN

Aquatic Therapy

The use of water as a treatment dates back to the Greeks and Romans. Early aquatic therapy programs were based on the traditional swimming strokes, but physical therapists and athletic trainers realized that the properties of water allowed people to do things that they could not do on land. Today aquatic therapy is used either in the form of a traditional whirlpool treatment or as an exercise medium.

Benefits of Aquatic Therapy

The benefits vary depending on the intensity and duration of exercise. Effects and benefits of aquatic therapy include:

- 1) Increased circulation to the muscles
- 2) Increased heart rate, respiratory rate, and general muscle metabolism
- 3) Decreased blood pressure, sensitivity of sensory nerve endings, pain, and joint effusion
- 4) General muscle relaxation
- 5) Improved range of motion and flexibility, strength, coordination, ambulation, mood, and feelings of well-being

The effects of exercise and the warmth of water, approximately 80° to 92°F, work together to produce a variety of physiological and psychological effects.

Force Principles

Exercise can be adapted to water by taking into account the force principles

that apply to water such as density, buoyancy, movement of force, hydrostatic pressure, viscosity, and cohesion medium. With an understanding of these principles, an appropriate exercise program in the water can help the athlete progress through all stages of rehabilitation.

Basic Principles

The basic principles of strength and functional gains are the same as for a land-based exercise program. The only difference is that in the water, the exercise can be assisted or resisted by buoyancy. **Buoyancy-assisted** motions can be used to help increase range of motion, or when an athlete is unable to perform the motion against resistance. Buoyancy-assisted motions occur in a vertical plane, while **buoyancy-resisted** motions occur when the motion is perpendicular to the surface of the water. Additional resistance can be added to motions by increasing the speed of movement or by adding a floating device.

Using aquatic therapy in the rehabilitation of shoulder injuries has shown that the hydrostatic pressure may provide biofeedback in the form of proprioceptive information.

Floating devices can be used for buoyancy-assisted or resistive movements in all arcs of motion, as on

land at any stage of therapy. Using the principles of water pressure and resistance, athletic trainers can adapt a water exercise program to meet the goals of almost any athlete. However, aquatic exercise is most effective when used in conjunction with traditional land therapy.

Aquatic Therapy

Shoulder Flexion and Extension

Position: Standing

Procedure: Flex and extend shoulders using water as resistance or assistance.

Progression: Add paddles or foam blocks. Increase time and reps.

Shoulder ABDuction and ADDuction

Position: Standing

Procedure: Abduct and adduct shoulders using water as resistance or assistance.

Progression: Add paddles or foam blocks. Increase time and reps.

Shoulder Horizontal ABDuction

Position: Standing

Procedure: Horizontally abduct and adduct shoulder using water as resistance or assistance.

Progression: Add paddles or foam blocks. Increase time and reps.

Shoulder Internal and External Rotation

Position: Standing

Procedure: Internally and externally rotate shoulders using water as resistance or assistance.

Progression: Add paddles or foam blocks. Increase time and reps.

CHAPTER TWELVE

Functional Throwing Progression

Before Returning to Full Participation

To complete the rehabilitation process is to reeducate the injured segment and adjacent segments in sport-specific demands. This is called functional progression. **Functional progression** is a series of activities that simulate sport activities. Progression starts off easy and progresses to full sport participation.

Functional Progression Considerations

To safely return an athlete to full participation, there are several considerations to be addressed in the functional progression.

The mechanics of each sport can be divided into smaller components or skills. These small components can vary from easy to difficult, and low to high intensities. It is imperative that athletic trainers understand the demands placed on the athlete and the injured body part once an athlete is cleared to return to full participation. Activities should be ranked from easy to difficult, and should be in the order in which they occur in the activity. For example, in the functional progression of a baseball throw, the order is as follows:

- 1) Grip the ball
- 2) Stance
- 3) Back swing of the upper limb
- 4) Forward swing of the upper limb
- 5) Release of the ball
- 6) Follow-through

These activities are low intensity and basic. Advanced functional progression in the last phases of the rehabilitation program is the interval-throwing program with a progressive return to participation. This phase stresses the glenohumeral joint and scapulothoracic articulation in sport-specific activities. Once the athlete has been cleared for advanced functional activities, a program of short-distance tossing is progressed to longer throws while increasing velocity.

Purpose of Functional Progressive Exercises

A gradual interval-throwing program is designed to minimize risk of reinjury and emphasize proper overhead mechanics. Due to differences between individuals and different pathologies, there is no set time table for return-to-sport functional exercise progressions. To reduce risk of reinjury, each program must be tailored to the needs of the individual athlete.

Interval Throwing Program

Phase 1

45-Foot Phase

- Step 1: a) Warm-up Throwing
b) 45 ft X 25 Throws
c) Rest 15 min
d) Warm-up Throwing
e) 45 ft X 25 Throws

- Step 2: a) Warm-up Throwing
b) 45 ft X 25 Throws
c) Rest 10 min
d) Warm-up Throwing
e) 45 ft X 25 Throws
f) Rest 10 min
g) Warm-up Throwing
h) 45 ft X 25 Throws

120-Foot Phase

- Step 7: a) Warm-up Throwing
b) 120 ft X 25 Throws
c) Rest 15 min
d) Warm-up Throwing
e) 120 ft X 25 Throws

- Step 8: a) Warm-up Throwing
b) 120 ft X 25 Throws
c) Rest 10 min
d) Warm-up Throwing
e) 120 ft X 25 Throws
f) Rest 10 min
g) Warm-up Throwing
h) 120 ft X 25 Throws

60-Foot Phase

- Step 3: a) Warm-up Throwing
b) 60 ft X 25 Throws
c) Rest 15 min
d) Warm-up Throwing
e) 60 ft X 25 Throws

- Step 4: a) Warm-up Throwing
b) 60 ft X 25 Throws
c) Rest 10 min
d) Warm-up Throwing
e) 60 ft X 25 Throws
f) Rest 10 min
g) Warm-up Throwing
h) 60 ft X 25 Throws

150-Foot Phase

- Step 9: a) Warm-up Throwing
b) 150 ft X 25 Throws
c) Rest 15 min
d) Warm-up Throwing
e) 150 ft X 25 Throws

- Step 10: a) Warm-up Throwing
b) 150 ft X 25 Throws
c) Rest 10 min
d) Warm-up Throwing
e) 150 ft X 25 Throws
f) Rest 10 min
g) Warm-up Throwing
h) 150 ft X 25 Throws

90-Foot Phase

- Step 5: a) Warm-up Throwing
b) 90 ft X 25 Throws
c) Rest 15 min
d) Warm-up Throwing
e) 90 ft X 25 Throws

- Step 6: a) Warm-up Throwing
b) 90 ft X 25 Throws
c) Rest 10 min
d) Warm-up Throwing
e) 90 ft X 25 Throws
f) Rest 10 min
g) Warm-up Throwing
h) 90 ft X 25 Throws

180-Foot Phase

- Step 11: a) Warm-up Throwing
b) 180 ft X 25 Throws
c) Rest 15 min
d) Warm-up Throwing
e) 180 ft X 25 Throws

- Step 12: a) Warm-up Throwing
b) 180 ft X 25 Throws
c) Rest 10 min
d) Warm-up Throwing
e) 180 ft X 25 Throws
f) Rest 10 min
g) Warm-up Throwing
h) 180 ft X 25 Throws

- Step 13: a) Warm-up Throwing
b) 180 ft X 25 Throws
c) Rest 10 min
d) Warm-up Throwing
e) 180 ft X 25 Throws
f) Rest 10 min
g) Warm-up Throwing
h) 180 ft X 25 Throws

- Step 14: Begin throwing off the mound or return to respective position.

Interval Throwing Program

Phase 2

Stage 1: Fastball Only

- Step 1: Interval Throwing
15 throws off mound 50%
- Step 2: Interval Throwing
30 throws off mound 50%
- Step 3: Interval Throwing
45 throws off mound 50%
- Step 4: Interval Throwing
60 throws off mound 50%
- Step 5: Interval Throwing
30 throws off mound 75%
- Step 6: 30 throws off mound 75%
45 throws off mound 50%
- Step 7: 45 throws off mound 75%
15 throws off mound 50%
- Step 8: 60 throws off mound 75%
15 throws off mound 50%

Stage 2: Fastball Only

- Step 9: 45 throws off mound 75%
15 throws in batting practice
- Step 10: 45 throws off mound 75%
30 throws in batting practice
- Step 11: 45 throws off mound 75%
45 throws in batting practice

Stage 3

- Step 12: 30 throws off mound 75%
Warm-up
15 throws off mound 75%
Breaking balls
45-60 throws in batting practice
(Fastball Only)
- Step 13: 30 throws off mound 75%
30 breaking balls 75%
30 throws in batting practice
- Step 14: 30 throws off mound 75%
60-90 throws in batting practice
25% breaking balls
- Step 15: Simulated game: Progress by
15 throws per workout

NOTE: Following Interval Programs from—
Prentice, W.E. (1999). Rehabilitation techniques in sports medicine (3rd ed.). St. Louis: Mosby-Year Book, p. 382-383.
Tippett, S.R., & Voight, M.L. (1995). Functional progressions for sport rehabilitation. Champaign, IL: Human Kinetics, p. 95-96.

Each stage of the interval program must be completed without complications or pain. Therefore, pain should be an athletic trainer's guide to for the rate of progression. It is not unusual for an athlete to experience postexercise soreness, but sharp pain is an indication to stop progression and reevaluate before continuing.

Full Return to Participation Guidelines

The functional progression program should be reevaluated on a regular basis. In every program there will be setbacks;

sometimes it takes two steps forward and one step back to achieve the final product of the rehabilitation process, which is to return the injured athlete to full participation in a quick and safe manner.

Making the decision to return an athlete to participation is difficult. The athlete should feel physically and mentally prepared before returning. Returning too soon can be detrimental. If the athlete is not prepared, there is a potential for reinjury or disruption in the healing process that could result in a long, painful recovery.

Criteria for returning an athlete to

full participation:

- 1) Physician's release
- 2) Full pain-free ROM
- 3) Equal and bilateral muscular strength and endurance
- 4) No swelling or ecchymosis
- 5) Reestablish neuromuscular control
- 6) Pass all functional tests
- 7) Possible bracing
- 8) Mentally ready

Tennis Shoulder

Advanced Elite Player

Day 1 30 min. - F,FV,L
 Day 2 45 min. - F,FV,L
 Day 3 45 min. - F,FV,L,B
 (low-waist high or below)
 Day 4 45 min. - Same as day 3
 Day 5 1 hr. - F,FV,L,F, few BV
 (Low-waist high or below)
 Day 6 1 hr - F,FV,L,B,BV (low)
 Day 7 1 hr - Same as day 6
 Day 8 1 hr - (AM) same as day 7
 30 min. - (PM) F,FV,L,B,BV (low)
 Day 9 1 hr - (AM) F,FV,L,B
 Day 10 1 hr - (AM) F,FV,L,B,O (easy) few S
 (easy)
 1 hr - (PM) same as AM
 Day 11 1 hr - (AM) F,FV,L,B,BV,O (easy) S
 (easy)
 1 hr - (PM) same as AM
 Day 12 1 hr - (AM) F,FV,L,B,BV,O,S (easy)
 1 hr - (PM) same as AM
 Day 13 1 hr - (AM) F,FV,L,B,BV,O,S
 1 hr - (PM) same as AM
 Day 14 1 hr - Same as day 13
 Day 15 - Resume normal practice-play
 schedule

NOTE: The following tennis shoulder program is from Tippet, S.R., & Voight, M.L. (1995). Functional progressions for sport rehabilitation. Champaign, IL: Human Kinetics, p. 95-96.

Recreational Player

Day 1 30 min. - F,FV,L
 Day 2 45 min. - Same as day 1
 Day 3 1 hr - Same as day 1
 Day 4 1 hr - F,FV,L,B
 Day 5 1 hr - F,FV,L,BV
 Day 6 1 hr - Same as day 5
 Day 7 1 hr - F,FV,L,B,BV, few O (easy)
 Day 8 1 hr - Same as day 7
 Day 9 1 hr - F,FV,L,B,BV,O,S (easy)
 Day 10 1 hr - Same as day 9
 Day 11 1 hr - F,FV,L,B,BV,O,S
 Day 12 - Resume to normal practice-play
 schedule

NOTE: Day progression refers to actual playing days, not chronological days.

F—Forehand	B—Backhand	S—Serve
FV—Forward Volley	BV—Backhand Volley	SL—Slice
U—Underspin	T—Topspin	AT—American Twist
FL—Flat	O—Overhead	FL - Forehand Lob
BL—Backhand Lob	L—Lob (either F or B)	

GLOSSARY

Active range of motion (AROM) - joint motion that occurs because of muscle contraction (Arnheim & Prentice, 2000, p. G-1).

Agonist muscles - muscles directly engaged in contraction as related to muscles that relax at the same time to allow joint motion (Arnheim & Prentice, 2000, p. G-1).

Antagonist muscles - muscles that counteract the action of the agonist muscle (Arnheim & Prentice, 2000, p. G-1).

Atrophy - wasting away of tissue or of an organ; diminution of the size of a body part (Arnheim & Prentice, 2000, p. G-1).

Autogenic inhibition - relaxation of the agonist muscle after a contraction (Arnheim & Prentice, 2000, p. G-1).

Biomechanics - branch of study that applies the laws of mechanics to living organisms and biological tissue (Arnheim & Prentice, 2000, p. G-1).

Chronic injury - injury with a long onset and duration (Arnheim & Prentice, 2000, p. G-1).

Circumduction - act of moving a limb, such as the arm or hip, in a circular manner (Arnheim & Prentice, 2000, p. G-1).

Collision sport - sport in which athletes use their bodies to deter or punish opponents (Arnheim & Prentice, 2000, p. G-2).

Concentric (positive) contraction - the muscle shortens while contracting against resistance (Arnheim & Prentice, 2000, p. G-2).

Eccentric (negative) contraction - the muscle lengthens while contracting against resistance (Arnheim & Prentice, 2000, p. G-2).

Force couple - depressor action by the subscapularis, infraspinatus, and teres minor muscles to stabilize the head of the humerus and to counteract the upward force exerted by the deltoid muscle during abduction of the arm (Arnheim & Prentice, 2000, p. G-2).

Functional progression - a series of sport-specific movement patterns progressed according to the physical and psychological tolerance of an individual in preparation for return to preinjury sport functions (Tippett & Voight, 1995, p. 102).

Golgi tendon organ - a deep, muscle-tendon mechanoreceptor responsible for monitoring tension within the muscle-tendon unit (Tippett & Voight, 1995, p. 102).

Isometric exercise - the muscle contracts statically without changing length (Arnheim & Prentice, 2000, p. G-3).

Isotonic exercise - the muscle shortens and lengthens through a complete range of motion (Arnheim & Prentice, 2000, p. G-3).

Joint capsule - saclike structure that encloses the ends of bones in a diarthrodial joint (Arnheim & Prentice, 2000, p. G-3).

Kinesthesia - sensation or feeling of movement; the awareness one has of the spatial relationships of one's body and its parts (Arnheim & Prentice, 2000, p. G-3).

Mechanoreceptors - specialized groups of cells that function to convert mechanical distortion of tissue into electrical activity that is subsequently transmitted to the central nervous system (Tippett & Voight, 1995, p. 102).

Microtrauma - injury produced by submaximal loading of a body part that occurs in a repetitive, cyclic fashion (Tippett & Voight, 1995, p. 102).

Muscle endurance - the ability to perform repetitive muscular contractions against resistance (Arnheim & Prentice, 2000, p. G-3).

Muscular strength - the maximal force that can be applied by a muscle during a single, maximal contraction (Arnheim & Prentice, 2000, p. G-3).

Muscle spindle - a complex receptor

located within intrafusal muscle fibers that is responsible for monitoring the tension within the muscle-tendon unit (Tippett & Voight, 1995, p. 102).

Overhead athletes - athletes competing in sports that emphasize repetitive overhead motions such as baseball, softball, volleyball, tennis, swimming, and various throwing events in track and field

Pacinian corpuscles - a rapidly adapting articular mechanoreceptor responsible for sensing the initiation and/or cessation of joint movement (Tippett & Voight, 1995, p. 102).

Passive range of motion (PROM) - movements that are performed completely by the examiner without assistance or muscle contraction by the athlete (Arnheim & Prentice, 2000, p. G-4).

Plyometrics - a mode of training developed in eastern Europe that emphasizes a quick, eccentric muscle contraction to produce a greater subsequent concentric muscle contraction (Tippett & Voight, 1995, p. 102).

Proprioception - the ability to determine the position of a joint in space (Arnheim & Prentice, 2000, p. G-4).

Proprioceptive neuromuscular facilitation (PNF) - stretching and strengthening techniques that involve combinations of alternating contractions and muscle relaxation

(Amheim & Prentice, 2000, p. G-4).

Ruffini endings - a slowly adapting articular mechanoreceptor responsible for sensing stretch within the joint capsule (Tippett & Voight, 1995, p. 103).

REFERENCES

- Alexander, R.M. (1991) Optimum timing of muscle activation for simple models of throwing. Journal of Theoretical Biology, 150, 349-372.
- Arnheim, D.D., & Anderson, M.K. (1991). Essentials of athletic training (2nd ed.). St. Louis, MO: Mosby Year Book.
- Arnheim, D.D., & Prentice, W.E. (2000). Principles of athletic training (10th ed.). St. Louis, MO: McGraw-Hill.
- Bak, K., & Fauno, P. (1997). Clinical findings in competitive swimmers with shoulder pain. The American Orthopaedic Society for Sports Medicine, 25, 254-260.
- Booher, J.M., & Thibodeau, G.A. (1994). Athletic injury assessment (3rd ed.). St. Louis, MO: Mosby-Year Book.
- Borsa, P.A., Lephart, S.M., Kocher, M.S., & Lephart, S.P. (1994). Functional assessment and rehabilitation of shoulder proprioception for glenohumeral joint instability. Journal of Sport Rehabilitation, 3, 84-104.
- Decter, E.M. (1997). Posterior instability: An open surgical approach. Sports Medicine Update, 12, 18-20.
- Dillman, C.J., Fleisig, G.S., & Andrews, J.R. (1993). Biomechanics of pitching with emphasis upon shoulder kinematics. Journal of Orthopedic and Sports Physical Therapy, 2, 402-408.
- Donnelly, J.E. (1990). Living anatomy (2nd ed.). Champaign, IL: Human Kinetics.
- Fu, F.H., Harner, C.D., & Klein, A.H. (1991). Shoulder impingement syndrome: A critical review. Clinical Orthopedic Related Research, 269, 162-173.
- Hunt, S. (1997). Rhythmic stabilization: a functional rehabilitation technique for posterior shoulder instability. Sports Medicine Update, 12, 8-9.
- Kamkar, A., Irrgang, J.J., & Whitney, S.L. (1993). Nonoperative management of secondary shoulder impingement syndrome. Journal of Orthopedic Sports Physical Therapy, 5, 212-224.
- Kenal, K.A., & Knapp, L.D. (1996). Rehabilitation of injuries in competitive swimmers. Sports Medicine, 22, 337-347.
- Kendall, F.P., McCreary, E.K., & Provance, P.G. (1999). Muscle testing and function (4th ed.). Baltimore, MD: Williams & Wilkins.
- Korel, L.E. (1996). The properties of water and their effect on aquatic therapy. Athletic Therapy Today, 1, 36-39.
- Magee, D.J. (1992). Orthopedic physical assessment (2nd ed.). Philadelphia, PA: W.B. Saunders.
- McCann, P.D., & Bigliani L.U. (1994). Shoulder pain in tennis players. Sports Medicine, 17, 53-64.

McMaster, W.C., Long, S.C., & Caiozzo, V.J. (1991). Isokinetic torque imbalance in the rotator cuff of the elite water polo player. American Journal of Sports Medicine, 19, 72-75.

Mikesky, A. E., Edwards, J.E., Wigglesworth, J.K., & Kunkel, S. (1995). Eccentric and concentric strength of the shoulder and arm musculature in collegiate baseball pitchers. American Journal of Sport Medicine, 23, 638-642.

Pappas, A.M., Zawacki, R.M., & McCarthy, C.F. (1985). Rehabilitation of the pitching shoulder. American Journal of Sports Medicine, 13, 223-235.

Perry, J. (1983). Anatomy and biomechanics of the shoulder in throwing, swimming, gymnastics, and tennis. Clinics in Sports Medicine, 2, 247-270.

Poolos, R.J. (1997). Rehabilitating posterior instability: A conservative management and rehabilitation program for posterior glenohumeral subluxations. Sports Medicine Update, 12, 21-23.

Prentice, W.E. (1999). Rehabilitation techniques in sports medicine (3rd ed.). St. Louis, MO: Mosby-Year Book.

Prentice, W.E., & Kooima, E.F. (1989, Spring). The use of proprioceptive neuromuscular facilitation techniques in the rehabilitation of sport-related injury. Athletic Training, 26-31.

Resnick, R. (1997). Keys to a comeback: Surgical advances unlock hope for athletes with rotator cuff tears. Sports Medicine Update, 12, 12-17.

Schmitt, L., & Synder-Mackler, L. (1999). Role of scapular stabilizers in etiology and treatment of impingement syndrome. Journal of Orthopedic & Sports Physical Therapy, 29, 31-38.

Scriber, K. (1996). Prevention of shoulder injuries in the throwing athlete. Athletic Therapy Today, 1, 45-48.

Speer, K.P., Cavanaugh, J.T., Warren, R.F., Day, L., & Wickiewicz, T. L. (1993). A role for hydrotherapy in shoulder rehabilitation. American Journal of Sports Medicine, 3, 21-27.

Surburg, P.R., & Schader, J.W. (1997). Proprioceptive neuromuscular facilitation techniques in sports medicine: A reassessment. Journal of Athletic Training, 32, 34-39.

Tippett, S.R., & Voight, M.L. (1995). Functional progressions for sport rehabilitation. Champaign, IL: Human Kinetics.

Toyoshima, S., Hoshikawa T., Miyashita, M., & Aguri, T. (1974). Biomechanics (4th ed.). Baltimore, MD: University Park Press.

Walendzak, D. (1999, November). The shoulder complex-simplified. T&C, 37-41.

Warner, J.J., Micheli, L.J., Arslanian, L.E., Kennedy, J., & Kennedy, R. (1990). Patterns of flexibility, laxity, and strength in normal shoulders and shoulders with instability and impingement. American Orthopedic Society for Sports Medicine, 18, 66-375.

Wilk, K.E., & Arrigo, C. (1993). Current concepts in the rehabilitation of the athletic shoulder. Journal of Orthopedic and Sports Physical Therapy, 18, 365-376.

Wolin, P.M., & Tarbet, J.A. (1997). Rotator cuff injury addressing overhead overuse. The Physician and Sports Medicine, 25, 54-74.

Young, J.L., Herring, S.A., Press, J.M., & Casazza, B.A. (1996). The influence of the spine on the shoulder in the throwing athlete. Journal of Back and Musculoskeletal Rehabilitation, 7, 5-17.

Zachazewski, J.E., Magee, D.J., & Quillen W.S., (1996). Athletic injuries and rehabilitation. Philadelphia, PA: W.B. Saunders.

Appendix E2

Letter to Validators

Name
Address

Name:

I have chosen to develop a manual for the rehabilitation of athletes participating in overhead motions for my Master's thesis. The definition of an overhead athlete is any athlete competing in a sport that emphasizes repetitive overhead motions, such as baseball, softball, volleyball, tennis, swimming, water polo, and various throwing events in track and field.

The purpose of the manual is to create a reference for student athletic trainers for the prevention and rehabilitation of overhead shoulder injuries such as shoulder instability or impingement. The manual is divided into sections emphasizing range of motion and flexibility; strength and endurance; neuromuscular control (closed-kinetic-chain and plyometric training); aquatic therapy; functional progressive activities; and preventive, in-season programs.

Areas of concern include excessive anterior joint capsule laxity, posterior joint capsule tightness, limited posterior and anterior shoulder musculature flexibility, imbalances of strength and endurance of the dynamic stabilizers, mechanical stresses disrupting normal biomechanics, poor sport-specific mechanics, and abnormal postural alignment. The manual was developed by combining research and professional experiences of various sports medicine providers.

The following questionnaire should be used to evaluate clarity and quality of the Therapeutic Exercise Manual for the Rehabilitation of Athletes Participating in Repetitive Overhead Motions, an educational reference for student athletic trainers who provide care for overhead athletes. Please review the manual, complete the questionnaire, and return it using the self-addressed, stamped envelope. The manual is yours to keep.

Your feedback is extremely important for the evaluation and validation of the manual. If you have any questions, please feel free to contact me at home (509) 338-9652, work (509) 335-5747, or by email at nmakris@wsu.edu. Thank you for your participation.

Sincerely,

Nicole K. Makris, ATC

APPENDIX E3**Validation Questionnaire****Rating Scale**

- 1 - Excellent
- 2 - Very Good
- 3 - Good
- 4 - Fair
- 5 - Unsatisfactory

Chapter One

- _____ 1. Rate the clarity of the introduction.
- _____ 2. Rate the directions.

Chapter Two

- _____ 1. Rate the clarity and quality of the literature review of the functional anatomy of the shoulder complex.
- _____ 2. Rate the clarity and quality of the literature review of the biomechanics of the shoulder complex.

Chapter Three

- _____ 1. Rate the clarity and quality of the biomechanical complications with overhead athletes.

Chapter Four

- _____ 1. Rate the clarity and quality of the specific rehabilitation considerations.

Chapter Five

- _____ 1. Rate the clarity and quality of the other considerations.

Chapter Six

- _____ 1. Rate the clarity and quality of the range of motion and flexibility background information.
- _____ 2. Rate the clarity and quality of the therapeutic exercises selected.
- _____ 3. Rate the clarity and quality of the illustrations.
- _____ 4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.

Chapter Seven

- _____ 1. Rate the clarity and quality of the muscular strength and endurance background information.
- _____ 2. Rate the clarity and quality of the therapeutic exercises selected.
- _____ 3. Rate the clarity and quality of the illustrations.
- _____ 4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.

Chapter Eight

- _____ 1. Rate the clarity and quality of the background information on reestablishing neuromuscular control.
- _____ 2. Rate the clarity and quality of the therapeutic exercises selected.
- _____ 3. Rate the clarity and quality of the illustrations.
- _____ 4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.

Chapter Nine

- _____ 1. Rate the clarity and quality of the closed-kinetic-chain background information.
- _____ 2. Rate the clarity and quality of the therapeutic exercises selected.
- _____ 3. Rate the clarity and quality of the illustrations.
- _____ 4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.

Chapter Ten

- _____ 1. Rate the clarity and quality of the plyometric background information.
- _____ 2. Rate the clarity and quality of the therapeutic exercises selected.
- _____ 3. Rate the clarity and quality of the illustrations.
- _____ 4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.

Chapter Eleven

- _____ 1. Rate the clarity and quality of the aquatic therapy background information.
- _____ 2. Rate the clarity and quality of the therapeutic exercises selected.
- _____ 3. Rate the clarity and quality of the illustrations.
- _____ 4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.

Chapter Twelve

- _____ 1. Rate the clarity and quality of the background information for functional throwing progression.
- _____ 2. Rate the clarity and quality of the therapeutic exercises selected.
- _____ 3. Rate the clarity and quality of the illustrations.
- _____ 4. Rate the clarity and quality of the instructions, variations, and modifications of the therapeutic exercises selected.

Overall Rating

- _____ 1. Rate the overall accuracy of the manual.
- _____ 2. Rate the overall quality of the manual.
- _____ 3. Rate the potential for use as an educational reference for student athletic trainers working with overhead athletes.

Comments: