

Incorporating Kinetic-Chain Integration, Part I: Concepts of Functional Shoulder Movement

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CONSIDER THIS: In an overhead motion, the shoulder is capable of moving at speeds up to 6,000° per second.¹ Furthermore, the deceleration phase of an overhead throw involves a strong eccentric component that has been measured at approximately double the acceleration force.² Add in the number of repetitions that an athlete performs over a 2-hr practice (times 5 days a week), and it is no surprise that sports involving repetitive overhand kinematics become host to a variety of shoulder injuries. These injuries (generally overuse in nature) often become chronic, and unless removal from participation is warranted, injury symptoms tend to become the focus of in-season treatment rather than correction of underlying pathology. This column, Part 1 of two, examines the rationale of functional hip integration as it relates to overhead motion in sport, with special attention paid to kinetic-chain dysfunction. Part 2 will cover a preventive exercise program.

Functional Anatomy

Applications of preventive shoulder exercise should address all components of kinetic-chain movement (articular, muscular, and neural) as they relate to the biomechanics of the activity. Traditional shoulder exercises have focused on strengthening the rotator-cuff musculature in isolated nonfunctional patterns. These patterns are often single-plane dominant and do not replicate the stabilization and eccentric loading that occur during sport activity. In addition, these exercises tend to focus on glenohumeral kinematics rather than involving multijoint integration (working the shoulder, spine, hips, and lower extremities together in functional

patterns). In order to efficiently decrease forces imposed on the shoulder during the middle and late phases of overhead motion it is essential to obtain neuromuscular balance and proper arthrokinematics throughout the entire contraction spectrum of movement.

Sport-specific shoulder function involves transfer of ground-reaction force through core musculature to the upper extremities.³⁻⁷ During the cocking phase of overhead throwing, shoulder external rotation and contralateral hip internal rotation (relative to the pelvis) load the upper extremity in preparation for forward propulsion.³ This force transfer occurs via global muscle subsystems (see Table 1). The follow-through phase of an overhead throw comprises shoulder internal rotation coupled with ipsilateral hip internal rotation and lead-leg external rotation (both relative to the pelvis). Multiplanar loading of the lead leg is an important event that helps decelerate overhand-throwing mechanics and regain balance on the ipsilateral limb.³ During assessment, pay special attention to the core and lower extremity muscles responsible for this transfer of force in accordance with movement patterns.

Functional Flexibility

Optimal length-tension and force-couple relationships of the kinetic chain provide the basis of dynamic upper extremity stability. Before beginning a preventive exercise program, flexibility demands and deficits should be addressed with special focus on relative flexibility. Relative flexibility is manifested by a series of interdependent joints (kinetic chain) seeking the path of least resistance through a movement pattern.¹² Articular compensations precede ensuing altered accessory

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TABLE 1. GLOBAL MUSCLE SUBSYSTEMS

Serape	Deep Longitudinal	Posterior Oblique	Anterior Oblique	Lateral
Internal oblique ↓	Biceps femoris ↓	Gluteus maximus ↓	Adductors and ipsilateral internal oblique ↓	Adductors ↓
Contralateral external oblique ↓	Sacrospinous ligament ↓	Thoracolumbar fascia ↓	Contralateral external oblique and external rotators	Gluteus medius and tensor fascia latae ↓
Serratus anterior ↓	Thoracolumbar fascia ↓	Contralateral latissimus dorsi		Contralateral quadratus lumborum
Rhomboid	Contralateral erector spinae			

Note. Subsystems provide ground-reaction-force transfer from the lower to the upper extremities. Arrows indicate force transfer between dynamic and static stabilizing structures.

movement, resulting from the creation of a new range of motion relative to distorted joint position rather than muscle lengthening.^{12,13} Relative-flexibility anomalies commonly seen in the shoulder occur with static stretching of the internal and external rotators (see Figure 1). The creation of relative flexibility by stretching in these distorted positions can lead to the development of faulty movement patterns resulting in altered muscle activation (prime movers become slow to activate, and synergists, stabilizers, and neutralizers become over-active), decreased neuromuscular efficiency, muscle imbalance, and secondary joint stress.¹³⁻¹⁸

Flexibility Analysis

Assessing relative flexibility can be difficult. The clinician's attention is often limited to a specific area of painful or "tight" tissues. It is essential that not only the injured site be evaluated, but also the examiner should also note kinetic-chain alterations linking the injured site to dysfunctional joint, muscular, and neural structures. Common altered pathologies encountered might include reciprocal inhibition, synergistic dominance, increased joint-shear stress, changes in arthrokinematics, and static or dynamic postural-distortion patterns.^{12-14,18,19}

Relative-flexibility assessment should be broken down into static posture and functional-movement patterns. Static posture, although not functional, can provide a basis for abnormal joint position and muscle imbalance. Standard plumb lines are used to represent a line of anatomical reference. Furthermore, intersection of normal sagittal and frontal plumb lines indicates a position of equilibrium, indicating balanced weight distribution and joint positioning that produce maximal move-



Figure 1 Relative flexibility of the shoulder rotators creating accessory motion of the kinetic chain. Increased cervical and lumbar lordosis, anterior pelvic tilt, and anterosuperior glenohumeral-joint translation.

ment efficiency.²⁰ Deviations from these lines can result in a cascade of altered relationships between muscular, neural, and articular systems, thereby predisposing the individual to injury during active movement.^{12-14,18,19}

Assessing functional-movement patterns addresses altered joint kinematics in relation to the movement being performed. Two such assessments include squat testing and modified single-leg-balance excursion tests. When using this type of testing for the shoulder it is essential that multiplanar upper extremity movement be incorporated into a total body movement. Reaching with the upper and lower extremities in and through various planes of motion is a great way to modify this form of testing. The examiner then observes for abnormal joint mechanics, painful ROM, or movement compensations (Figures 2 and 3). ■