Biomechanical Relationships Within The Shoulder Joint

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The shoulder joint consists primarily of the glenoid fossa of the scapula and humeral head. Relationships between the humerus and scapula are particularly apparent in successful gymnastics performance. Although humerus movements are more obvious than scapula actions, the scapula plays an integral part in productive shoulder joint function. There would be little success during gymnastics performance without a scapula that fully accommodates movements of the humerus. A problem arises when there is inadequate cooperation between these bony segments at the shoulder joint. Gymnastics performance typically is associated with a wide range of humerus movements, from such action patterns as hyper-flexion to hyper-extension and from hyper-abduction to adduction.

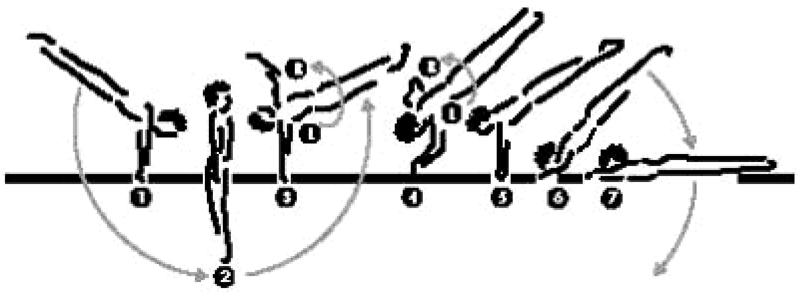
Less than adequate scapula involvement will create inevitable problems. The gymnast is predisposed to injury as a result. One example of this situation can come from a lack of cooperation as the humeral head contacts the acromion process or grinds the glenoid labrum lining the glenoid fossa. Consequently, every effort should be made to understand how the scapula relates to and cooperates with humerus movement.

Shoulder Joint

Identifying and understanding shoulder joint interactions can be important when trying to understand how the gymnast moves from one skill to the next. Gymnastics combinations typically involve a close relationship between bony segments within the shoulder joint and are associated with a wide variety of movements around three principal axes. Consequently, basic biomechanical considerations that deal with anatomical and mechanical principles are essential to this process in dealing with joint interactions. Figures 1 and 2 illustrate some of the multiple actions of the humerus at the shoulder joint that are associated with gymnastics performance.

MOVEMENTS ABOUT AXES. The shoulder joint is multi-axial or triaxial and possesses the greatest range of motion of any human joint. A good example of the multidimensional shoulder joint is illustrated in Figure 1. Movements in frames 1-2 demonstrate left and right humerus extension around the mediolateral axis. Frames 2-3 illustrate a combination of all three axes as the left humerus moves further into extension, while medially rotating around the longitudinal axis and abducting about the anteroposterior axis. The right humerus demonstrates transverse adduction in frames 3-5 around the longitudinal axis. At release in frame 3, the left arm first moves into slight transverse abduction and then quickly returns to the bar through transverse adduction. Both movements of the left humerus are around the longitudinal axis. The right humerus duplicates these actions in frames 3-5.

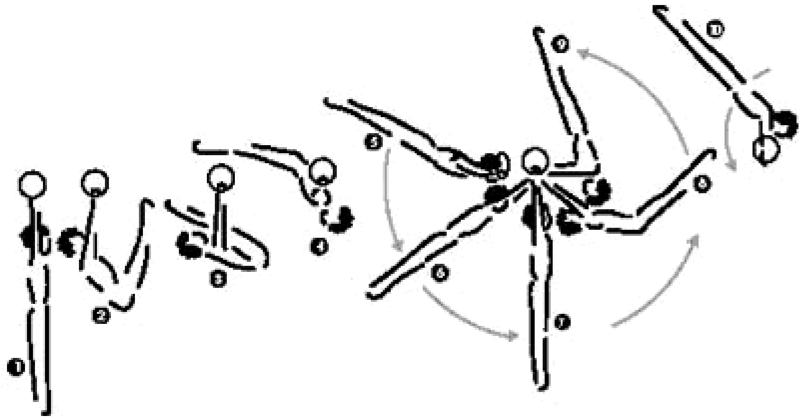
A handstand position can be reached in Figure 1, frame 5, when sufficient angular momentum about the mediolateral axis is produced from frame 1-3. No further increase or decrease in angular momentum is possible once the bar has been released at frame 3. External torque is not present when the gymnast is free of support. Superior shoulder joint flexibility will allow the gymnast to swing through greater angular displacement on the left humerus in frame 3 and will permit a transfer of angular momentum to the longitudinal axis into frame 4. An opportunity to produce greater angular impulse is provided when the left hand remains on the bar longer. This can have a positive influence on increasing angular momentum and in controlling transfer of angular momentum from axis to axis.



The resistive effect of the force of gravity has a profound influence on the forward upward swing in Figure 1, frames 3-5. This resistive influence is particularly effective when the gymnast is free of support (frame 4). When there is no further angular momentum remaining forward around the mediolateral axis, the gymnast must begin to prepare for the downward swing in frames 5-7. Preparation is to distribute the mass away from the hands with a diagonal action of both the right and left humerus in frames 5-6. This results in a combination of humerus flexion (mediolateral axis) and transverse abduction (longitudinal axis). Frame 7 simply results in a static position at the shoulder joint as the upper arms come in contact with the parallel bars in order to resist the pull of gravity. Angular momentum is increased in moving from frame 5 to 7 when the net torque is increased with an extended body (gravity provides a motive torque) as well as with an upward action force from the hands to the bars. The resulting reaction torque from the bars provides increased angular momentum around the mediolateral axis at the bar contact points.

ANATOMICAL COOPERATION. The gymnast relies on cooperation between the scapula and the humerus when performing most gymnastics skills. Successful cooperation of these two anatomical segments of the shoulder joint hinge on a 2:1 ratio (Amheim and Prentice, 1997; Kreighbaum and Barthels, 1996). Consequently, when the humerus moves 90 degrees within the glenoid fossa, the scapula moves approximately 45 degrees. This translates as an important scapulohumeral rhythm that exists in a biomechanical relationship.

The scapula cooperates with the humerus in several ways. First, the scapula provides a firm base for shoulder joint muscles to attach at their origin. This outfits the humerus with a means to translate around the various axes and to overcome inertia. Figure 1 (frames 2-3) and Figure 2 (frames 3-5), provide examples of explosive humerus movement into hyper-extension (left) and abduction (right and left), respectively. Figure 2, frames 3-4, further illustrates overcoming inertia as the body is moved upward against gravity. Second, muscles that move the scapula provide a means of cooperation by aligning the glenoid fossa in order to accommodate humerus movement. Cooperation is further established by the rotator cuff muscles as they stabilize and fine tune the position of the humeral head in the glenoid fossa.



HUMERUS AND SCAPULA RELATIONSHIPS. There is a close relationship between movements of the humerus and scapula during gymnastics performance. For example, when the humerus moves into extension in Figure 2, frames 1-3, the scapula rotates downward and depresses to better position the glenoid fossa for the moving humeral head. Frames 3-4 illustrate humerus transverse abduction as the rings are moved outward and the body rises above the rings. This is only possible as the scapula accommodates the humeral head by moving into adduction, downward rotation, and medial tilt. The humerus then begins moving into abduction from frames 4-5 with pressure downward on the rings. The scapula aligns the glenoid fossa by moving into abduction, upward rotation, and elevation. A stabilized and elevated scapula is necessary in frames 5-7 to allow the gymnast to swing fluently through the bottom.

The gymnast reaches maximum angular momentum in frame 7 followed by conservation of angular momentum in frames 8-9 as the humerus moves into extension. This is associated with a simultaneous decrease in rotational inertia (moment of inertia) at the shoulder joint. The distribution of the gymnast's mass is reduced in this upward swing to permit increased angular velocity as the angle at the shoulder joints decrease. Movement of the scapula provides the appropriate relationship with the humerus as it downwardly rotates and depresses slightly. Further external torque is now needed from the rings during the upswing in frames 9 to 10 as the angle at the shoulder joint increases. Additionally, this change demands an external motive torque because a larger overall rotational inertia now results as the torso lengthens. The external motive torque required near the completion of the sequence acts to maintain sufficient angular momentum to combat the increased rotational inertia and the resistive external torque from gravity.

Shoulder Joint Trauma

The gymnast is subject to shoulder joint trauma when the scapula does not fully cooperate with the humerus during high resistance and repetitive joint range of motion activities. Progressive resistance exercise and a wide variety of preparatory and lead-up activities can improve the relationship between the humerus and scapula. Associated connective and muscle tissue quality is enhanced when appropriate, pain-free gymnastics activities are balanced with year-round conditioning and periodic health assessments. Rotator cuff impingement syndrome and thoracic outlet syndrome are examples of injuries that can develop when the athlete is not properly conditioned and inappropriate medical decisions are allowed. Predisposition to injury is likely when a lack of shoulder joint stability is coupled with limited understanding of how the shoulder joint functions. The shoulder joint lacks inherent stability because of the shallow glenoid fossa and limited ligamentous support. Well prepared shoulder joint connective and muscle tissues provide needed stabilization for increasing joint integrity. Therefore, healthy connective tissue and rotator cuff muscles are particularly needed and well suited for allowing the gymnast to perform at a high level.

References

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