Biomechanics

The Stemme Forward: Biomechanical Relationships

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The use of basic anatomical and mechanical principles of human motion can be one of the important steps leading to performance virtuosity and mitigated judging deductions. Kreighbaum and Barthels (1996) suggest knowledge of a few basic movement principles provides needed information for improving athletic performance. This has implications for the gymnastics community by suggesting that performance enhancement can be uncomplicated and is associated with the use of basic movement principles. Therefore, the purpose of this discussion is to examine several biomechanical relationship existing in anatomical and mechanical aspects of the stemme forward to “L” support (Figure 1).

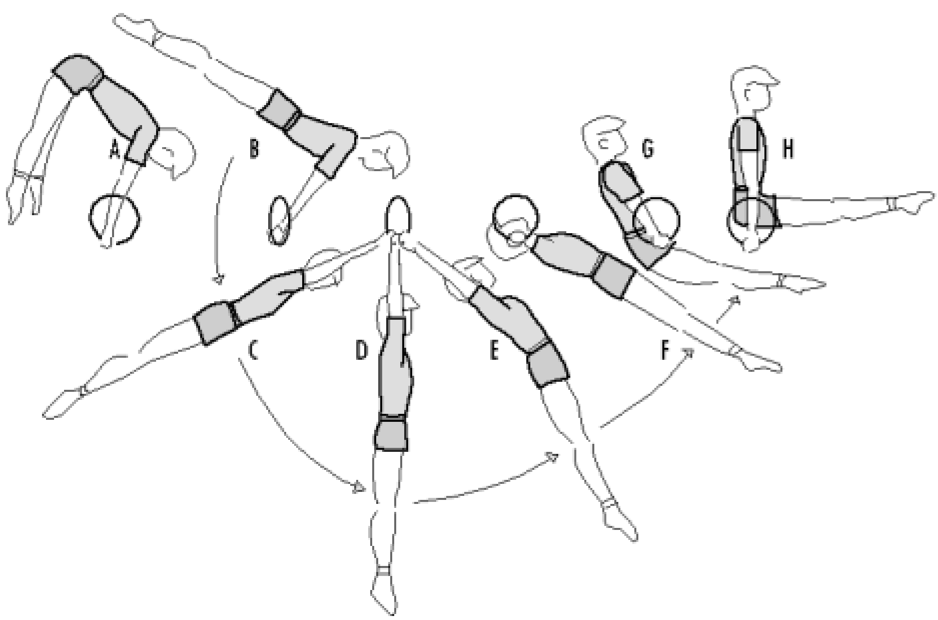

Figure 1

Alliance of Anatomical and Mechanical Concepts

There is a relationship between anatomical and mechanical aspects of human motion. An example of this relationship can be shown in the stemme forward (Figure 1) and the connection between anatomical components of the human body and transferring angular momentum. For the gymnasts to effectively transfer angular momentum from one body segment to another there must be a sequence of functional muscle group contractions. Consequently, the transfer of angular momentum and a coalition with functional muscle groups will provide the focus for this biomechanical discussion.

Transfer of angular momentum

Angular momentum can be transferred from one body segment to another. Luttgens et al. (1992) indicate the transfer mechanism occurs as forces are generated by functional muscle groups and summated from one body segment to another. This is shown in Figure 1 as the overall angular momentum produced in the swing at frame E is transferred to the arms through frame H as the gymnasts rises against the resistive force of gravity to the “L” support position above the rings.

Functional muscle groups. One muscle does not usually act along, rather there is a group of muscles acting to contribute to the desired joint movement. A number of muscles, contributing to a common joint action, exert tension to accomplish a specified movement. Kreighbaum and Barthels (1996) suggest that a muscle group is named based on the joint movement created. Frames E to G provide an example in Figure 1 with the muscles causing shoulder adduction; therefore, this functional muscle group is referred to as the shoulder adductors. Further example exists with the muscles causing hip flexion (frames F-H) being connected with the functional muscle group called hip flexors. Table 1 provides the primary muscles connected with shoulder adductor and hip flexor functional muscle groups involved in the transfer of angular momentum (frames E-H) during the stemme forward upswing phase.

Table 1 Primary Muscle Groups involved in Upswing Phase

Muscle Group	Joint	Muscles Involved
Shoulder Adductors	Shoulder	Pectoralis Major
		Latissimus Dorsi
		Teres Major
Hiop Flefors	Hip	Psoas
		Illiacus
		Rectus Femoris
		Pectineus

Analysis of Stemme Forward to L-Support

The stemme forward to L-support is a skill performed on the rings that requires angular momentum through the bottom of the swing, subsequent swing against gravity, and an abrupt cessation of angular momentum as static equilibrium is established in the L-support. The primary mechanical mechanism in completing this skill incorporates a transfer of angular momentum to linear momentum. This mechanism utilizes a change from the circular path of the body's center of gravity (CG) in frames B to F, about the mediolateral axis at the hands in the saggital plane, to a curvilinear path in frames F to H as the CG then following a relatively straight line from below the rings to a point above the rings.

Mechanical aspects in the downswing phase

The downswing phase from frame B to D serves to utilize the external force of gravity that is instrumental in producing angular momentum. Angular momentum is best produced with the body fully extended as the gymnast moves away from the rings early in frame B. Failure to first move through the planche position, however, will result in points deducted during the judging process. Extension away from the rings from frame B to C produces a large external torque as gravity acts through the body's CG. Moving the CG away from the rings, early in frame A, allows gravity to act as an effective motive force and is essential to a well performed stemme forward.

A forward motive force on the rings in frame B results in moving the rings outward. This action maximizes rotational enertia prior to frame C. Such a maneuver allows for the greatest possible distribution of the gymnast's mass away from the axis of rotation at the rings. A hollow chest technique and the rings placed the greatest possible distance from the CG, produces the desired rotational inertia. Rotational inertia equals the product of the gymnast's mass and mass distribution and is considered to be an important component in angular momentum. Angular momentum is the product of rotational inertia and angular velocity. Consequently, maximal rotational inertia created from the early long body technique and gravity's influence on establishing maximal angular velocity on the downswing provide a desirable level of angular momentum at frame D.

Anatomical aspects in the downswing phase

Anatomical aspects dealing with the downswing phase of the stemme forward are integrally tied to the mechanics of the skill. Blending anatomical and mechanical aspects of human motion can provide the practitioner with information needed to improve performance. Examples of this relationship can be observed in adjusting the angle of muscle insertions to improve the production of torque, securing proper alignment of skeletal structures for manipulating rotational inertia, and producing adequate joint range of motion for maximizing angular momentum created from the force of gravity.

Passing through the planche position in frame B is dependent upon proper skeletal alignment and the way in which the lumbar spine, pelvis, and femur interplay. Kreighbaum and Barthels (1996) consider the pelvis as the fulcrum of the body. Control of this segment, therefore, is essential for all gymnastics movements. Performance breakdown is guaranteed when the pelvis is not stabilized and will result in loosing proper skeletal alignment. The hollow chest and a stabilized pelvis are the basis for controlling the body and provide the framework for effective technique in many gymnastics movements. This is certainly the case in the movement sequence from frame B to C.

The CG is dependent upon skeletal alignment and will drop below the rings earlier than desired during performance of the planche when vertebral hyperextension is brought on by a strong hip flexor and weak abdominal relationship. A strong abdominal muscle group is primary in limiting forward anterior pelvic tilt and is essential in controlling the ill effects of an over zealous hip flexor muscle group. Typically the hip flexors shown in Table 1 develop faster than the abdominal muscle group and create an unbalanced strength relationship. This is often the case because of the active involvement of the hip flexors in daily activities. The problem can be compounded when a conditioning program does not begin by assessing this strength relationship.

Shoulder joint flexion occurs from frame B to C. A successful maneuver against the effects of gravity is instrumental in initiating the movement necessary for maximizing angular momentum on the downswing. The shoulder flexion muscle group consists of the biceps brachii, anterior deltoid, coracobrachialis, and the pectoralis major and is responsible for moving the CG above and away from the rings. Shoulder flexion is accomplished with an explosive, concentric contraction of the shoulder joint flexor muscle group, but is dependent upon a 2:1 ratio between the humerus and scapula (Arnheim and Prentice, 1993; Kreighbaum and Barthels, 1996). Full joint range of motion at the shoulder joint will permit this maneuver to be appropriately completed prior to frame C and allows the downswing to be fluent and artistically performed.

An extended body position is maintained and controlled through frames C and D in order to increase angular momentum. The primary mechanism for maintaining the extended body position is in shoulder girdle elevation and slight posterior pelvic tilt during the downswing in frames C and D. The mechanism relating to the shoulder girdle consists of scapula elevation at the sternoclavicular joint through concentric contraction of the shoulder girdle elevators (levator scapulae, trapezius 1 and 2, and the rhomboids). The elevated shoulder girdle position is then maintained, with the external motive force of gravity, and the internal force of the shoulder girdle elevators, enabling the gymnast to maximize the distance of the CG away from the rings on the downswing. The pull of the gravitational force provides a significant contribution in allowing the elevated shoulder girdle position to be maintained as the body nears from D. Consequently, the muscles of the shoulder complex can relax into frame D without loosing the large rotational inertia. Complimenting the contribution of the shoulder complex in securing angular momentum is the position of the pelvis. A straight, long body in the downswing is enhanced by slight posterior tilt of the pelvis. The abdominal and hamstring muscle groups are prime movers in securing posterior pelvic tilt and will contribute to the hollow body technique when relaxation and flexibility of the antagonistic musculotendinous units (hip flexor, erector spinae and quadratus lumborum muscles) allow proper pelvic positioning.

Mechanical aspects in the upswing phase

Previously produced angular momentum continues in the upswing phase (frames E-H), but with significant transfer from the entire body to right and left arm segments. Prior to the transfer process and as a lead in, Frame E demonstrates forward displacement of the pelvis and chest, creating slight hyperextension of the lumbar spine. The arched body position is accompanied by a slight decrease in angular velocity of the legs and feet. This is the mechanism required to initiate a shifting or transfer of angular momentum to the arms in frames F and G.

Accompanying the transfer of angular momentum to linear momentum is a change in the path of the CG from a point away from the rings (axis of rotation) to a point closer to the rings. Frame G depicts a redistribution of body segments about the CG during linear translation. Hip joint and trunk flexion in frame G now provide a shorter resistance arm and an improved means by which linear translation of the CG can be directed against gravity to a support position. Completion of hip flexion and shoulder adduction in frames G to H allow the gymnast to reach static equilibrium in the L-support (frame H). Appropriate mechanics in frames F and G are associated with complete elbow joint extension and progressive bending at the hip joints, rather than elbow flexion and early, excessive hip joint flexion.

Anatomical aspects in the upswing phase

Anatomical aspects significantly lend to smooth transfer of angular momentum in the upswing. Anatomical considerations such as muscular strength and normal joint range of motion are critical in smooth transition from the downswing to the upswing phase and in moving against the resistive force of gravity in completing the upswing.

As the angular momentum of the swing from frame D continues into frame E, slight shoulder joint hyper flexion, coupled with upward rotation and stabilization of the scapula, allow the gymnast to continue to rise as the chest leads and the lower body segments experience reduced angular velocity. It is at this point in the upswing that the shoulder joint adductors, shown in Table 1, are the primary internal force contributors in continuing linear momentum. The shoulder joint adductor and hip joint flexor muscle groups (Table 1) are placed on stretch in frame E, providing the implementation of the length-tension mechanism and subsequent increased force production in these muscle groups. This increased motive force is necessary to overcome the external resistive force of gravity in frames F to H.

Frame E places the gymnast in an important position for the transfer of angular momentum to begin. The initial transfer takes place in the transition from frame E to F. As the lower body experiences reduced angular velocity, while maintaining a large rotational inertia around the mediolateral axis, the arms begin adduction at the shoulder joint. Transfer of angular momentum from the entire body to the arms takes place as the summation of forces change from the total body segment to the arm segments. Reduced rotational inertia produced with hip joint flexion in frames G and H provide needed conservation of angular momentum as the body rises to secure the L-support (frame H). The position in frame H terminates in static equilibrium with the abdominal and hamstring muscle groups securing slight posterior pelvic tilt and a stable base upon which the hip flexor muscle group (Table 1) established 90 degrees at the hip joint.

*Figure 1 was based on illustrations in the *1984-1988 Junior Olympic Age Group Compulsories.*

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Statistical Method. The relationship of selected biomechanical variables with performance of race. walking was calculated by using Pearsonâ€™s product moment correlation. The hypothesis was.Â There is more mobility at. shoulder joint, arms move more forward. 2. This arm action results in more stride length and in the vertical position knee is straightened. completely and resulting in high centre of gravity.Â relationship with the performance of race walking in single and double supporting phase. However angles of Left knee and Right hip showed significant relationship with the. performance of race walking in double supporting phase. erformance in rowing is a complex matter, as is performance in any sport. It requires high physiological power production, effective technique, strong psychology, and smart race strategy. The main purpose of biomechanics in rowing is improvement of technique. Previous authors have presented charts of rowing biomechanics based on mechanical relationships between variables (Affeld, Schichl, & Ziemann, 1993; Kleshnev, 2007). Because this book is intended mainly for coaches and rowers, we have organized the general picture by the components of rowerâ€™s technical skills that can be analyzed to d