
BIODEX

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Objective Assessment and Importance of Stability and Motor Control in Sports Performance

by

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Stability is a complex process involving actions of biomechanical, motor, sensory and central nervous system (CNS) components. Fundamental goal of maintaining stability in relation to whole body is to keep center of body mass over a base of support.

Number of joints systems, muscles involved, complexity of sports movements and situations requires perfect coordination of body movement patterns.

In order to adapt to constantly changing situation in such dynamic environment as sports performance, optimal information input from various body sensors (visual, vestibular, somatosensory) is required. The CNS plays a crucial role in modifying input and providing optimal information to muscles to perform the best possible motor response [Hanson 1994]. Stability is often divided into two basic conditions: static and dynamic.

Static stability describes the ability to maintain "static" condition when there is no significant body movement to control. Dynamic stability – essence of sport performance- is required when body moves and simultaneously is controlled for purposeful action and movement. Dynamic stability requires optimal alignment of all human body segments in order execute the best movement. In this aspect dynamic stability should be understood as not only optimal position of body in respect to base of support but also in position of particular body segments in alignment to each other.

To introduce the reader into the presented subject basic terms and definitions will be presented.

Postural stability by definition is described as ability to maintain body's center of gravity (COG) over base of support (BOS).

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Limits of stability (LOS) measures two-dimensional quantity defining the largest possible COG sway angle as a function of sway direction center from the center position. It can be represented as an angle of body sway into specific direction or sometimes describes movable base of support angle that supports body. LOS depends on many variables: body height, direction of sway, feet position, coordination skills etc.

To maintain stability and balance a person uses various available strategies controlled by different levels of our nervous system.

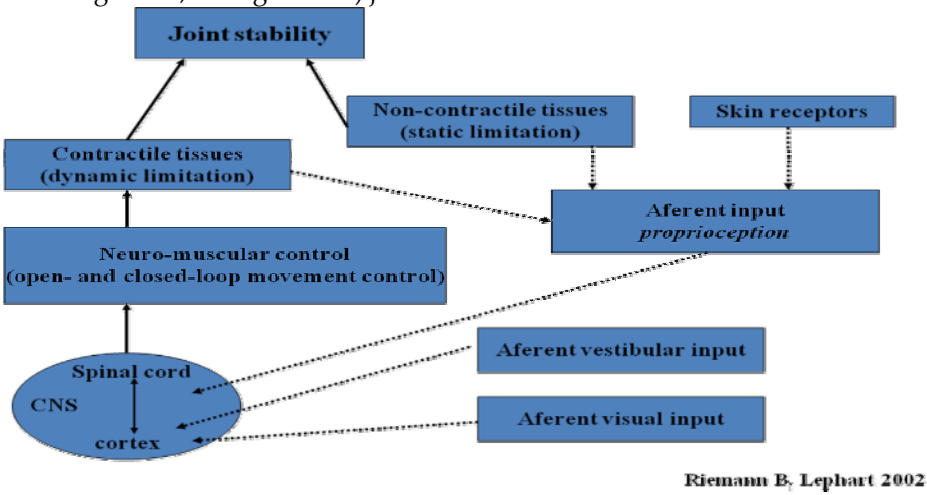
Basic level relates to physiological reflexes (for example stretch reflex) that are fastest yet not the most coordinated movements. However these reflexes play an important role in increasing stiffness of body segments that improve ability of body to maintain balance and influence tonus of muscles involved around those segments.

Higher than reflex level is part of our CNS responsible for automated postural movements, that involve coordinated action of muscle of trunk, extremities directly related to specific patterns and task conditions. Their recorded latencies are approximately 85-95 msec and activity for those movements is related to areas of brain stem and subcortical centers. For sports performance development of these reactions is critical for optimal movement coordination and speed. As we know in sports, dynamic situations when space and time of reaction is limited we often rely on automated movements mastered in the process of training. Usually available information input from visual, somatosensory and vestibular systems may be compromised and in such circumstances automated reactions play a deciding role in win-loose situations.

Highest level responsible influencing control of stability and balance involves conscious decision and acts to change position of body segments. This is used when a subject decides for some reason to move the body in a specific way, for example when sportsman consciously bends his knees or moves to one side. In normal situation this is how a basketball player reacts to a changing situation on the court and decides to act accordingly, in this place it is worth to mention that this mechanism of conscious act is used for learning purposes. At the initial stage of learning one starts to acquire specific skills by a purposeful act and attention influences this process significantly. In later stages the purpose is to follow this process with more automated reactions and responses that require less conscious attention (Riemann and Lephart 2002).

Stability of body is affected by various biomechanical (body height, feet position, body segment lever), physiological (arousal level, fatigue), environmental (amount of light, BOS size, external disturbances) conditions. Other important factors that influence stability of sportsman are: level of acquired

individual skills, actual level of motor skills (available range of motion of affected segments, strength level) just to name few.



Scheme representing basic processes responsible for maintaining dynamic stability of body segments (Lephart and Fu 2000).

The mentioned aspects affecting stability are important as they directly decide on balance strategy used for sports movements. A basketball player who has no sufficient range of motion in his ankles is not able to guard efficiently, and must compensate this deficit with body segment adjustment for example trunk flexion, and this changes the biomechanical alignment and body position. This adjustment varies from movement pattern he learned as he was growing up, and CNS under this condition will eventually change this pattern. A problem might arise when this new pattern starts to overload other soft tissues and that inevitably can lead to overuse injury. From sports performance aspect this situation should be addressed during training process as element of prevention that has two goals: avoiding injury and optimizing sports performance technique (Riemann and Lephart 2002).

Another mentioned previously factor that affects stability and balance skills is fatigue. There are several research projects done confirming that when fatigue arises stability is compromised. That fact has serious implications for a player who when game progresses becomes "less stable" i.e. less efficient in sports technique. This could directly affect for example a basketball player's shooting percentage, ability to effectively drive to the basket, rebound etc. By the same token, less stability increases risk of injury as this affects control how body moves. When control becomes less accurate there is a better chance for an "error" in function of muscles acting on body segments. This "error" can lead to

strain or sprain of ligaments, tendons or muscles (Andrews and Harrelson 2004).

As motor control process is complex and takes place in many body systems simultaneously, it is very difficult to evaluate it thoroughly with current technology. In best situation we are capable of assessing certain aspects of motor behavior and some components of motor control.

Today in scientific and sport's world that requires more and more objective indications of training efficiency, as well as close monitoring of an athletes condition to perform optimally, objective evaluation of stability and balance is essential.

Below is a list of purposes of such objective assessment:

- determination of current stability and balance skills,
- verification of training efficiency directed to improve stability
- evaluation of risk of injury due to balance and stability deficits
- identification of postural strategies used to maintain balance
- evaluation of other motor skills related to stability and balance i.e. endurance, strength, muscle coordination, muscle force development rate etc.)

In general evaluation of stability can assesses movement parameters as: angles, acceleration of body segments (kinematic evaluation), activity of muscle groups involved in movement (electromyography evaluation – dynamic EMG), ground reaction forces recorded during various activities like for example standing on one leg. For various reasons (availability of equipment, measurement field conditions etc.) measurement of balance and stability has been usually performed with use of variety of dynamographic force plates. These force plates offer capability of testing on stable (stabilography) and unstable surface. Former and later has its advocates, most important these instruments provide objective evaluation of selected aspects related to stability, balance and motor control (Wilkstrom et al 2006).

In a series of experiments related to assessment of balance the authors decided to use both conditions to evaluate stability and balance skills.

Assessment of stability on stable surface (stabilometry) allows to observe ground reaction forces in 3 planes Fx, Fy, Fz and its derivatives (for example: moments of force, center of foot pressure COP, COP length, area covered by COP, COP frequency). This type of evaluation gives very precise indication of how balance is maintained during various conditions (standing on both legs, standing on one leg, standing with eyes open or closed) and allows to assess selected aspects of balance for both extremities separately. Observation of all three planes (Fx, Fy, Fz) gives another dimension to evaluation, providing detailed information how balance and stability is maintained in separate planes of

movement. Some authors found that after injury to lower extremity one uses different strategy of accepting load during dynamic movement as cutting. An objective assessment of this strategy helps to determine if the retraining stability and balance process has been effective (Weber and Cass 1993).

Another form of postural control assessment includes the use of unstable surface platform. This kind of instrument measures the degree of tilt about each axis of movement during dynamic (unstable) conditions. Used by authors Biodex Balance SD System device has been verified by many authors as reliable measure of balance. Biodex Balance SD system consists of circular platform that is free to move in anterior – posterior (A-P) and medial-lateral (M-L) axes simultaneously up to 20°. M-L stability index, A-P stability index and over-all stability index are provided after evaluation. Difficulty level of unstable surface is adjustable due to electronically controlled springs. Subject in set position is given various tasks related to stability and balance. In this way one can evaluate efficiency in controlling of unstable surface for given task or test (Cachupe et al. 2001, Wilkstrom et al 2006).

On-field and clinical stability and balance objective evaluation is important measure for both sports and rehabilitation purposes. Providing accurate information about current stability, balance and motor skills, verifying neuromuscular training effectiveness, identifying risk for injury – objective balance assessment playing important role in modern training process.

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