Participation in athletics presents an inherent risk for injury. In high school athletics, football has the highest severe injury rate per 1000 athlete exposures, followed by wrestling, girls’ basketball, and girls’ soccer. Among comparable sports, females sustain a higher severe injury rate than boys do, with the knee and ankle accounting for over 41% of the most common severely injured body sites. Decades of research has been devoted to identification of intrinsic and extrinsic factors that predispose athletes to injury. Intrinsic factors include lower extremity malalignment, ligament laxity, lower extremity muscle strength/endurance, neuromuscular control, hormonal influences, intercondylar notch width, and biomechanical technique of sport-specific performance. Some intrinsic risk factors can be modified through training, which will be the focus of this report.

Although the pathomechanics associated with some common injuries have been clearly documented, strength and conditioning programs remain much more focused on performance improvement than injury prevention. Can elimination of high-risk movement patterns simultaneously improve athletic performance and reduce the likelihood of injury? The purpose of this report is to provide an overview of the research that is relevant to the following:

1. The impact that abnormal movement patterns can have on the lower kinetic chain that increases injury risk.
2. Identification of modifiable injury risk factors.
3. The impact that correction of abnormal movement patterns can have on athletic performance.

Pathokinematics (i.e., abnormal movement patterns) can include one or more components of excessive hip adduction, hip internal rotation, genu valgum, and pes planus. Depending on the performance strategies utilized by individual athletes and the demands of specific sports, there may also be components of lumbar side-bending, lateral pelvic tilt, decreased hip extension, excessive trunk rotation, and scapular depression that may increase injury susceptibility. Research evidence supports the value of training for correction of pathokinematics as a means for reduction of athletic injury risk.
metrics in fundamental movement patterns can be identified through a systematic movement assessment test battery, such as the Functional Movement Screen (FMS). The FMS is a combination of seven movements that are evaluated and scored, which has predicted injuries in professional football players. The FMS has been advocated for identification of movement asymmetries during preparticipation screening of athletes. The Star Excursion Balance Test (SEBT) is another standardized method for assessment of lower extremity stability that can be used to identify athletes with elevated risk for lower extremity injury. The SEBT involves maintenance of single-leg balance while reaching a maximum distance with the contralateral lower extremity. However, are isolated movement patterns truly representative of the kinematics involved in high-demand sports activities as fatigue develops? Is there an even better way to evaluate movement patterns? If movement assessment was combined with a training protocol that induces fatigue, would the movements be more representative of that which occurs during competition?

During participation in sports, the magnitude of peak ground reaction force (GRF) can be up to 3–6 times body weight. Pathokinematics may increase peak GRF, which may produce greater risk for injury during participation in high-demand sports (e.g., basketball and volleyball). Fatigue may exacerbate pathokinematics, which may contribute to elevated injury risk during the latter portion of a game. Increased peak GRF may result from altered movement patterns, which may be related to altered length-tension relationships within the musculature of the lower kinetic chain. An impaired ability to attenuate the GRF changes the distribution of loading through the kinetic chain, which can subject tissues to excessive loads. When the GRF is combined with torsion, shear stress is imposed on the cartilage and ligaments. Because cartilage and ligaments are highly vulnerable to shear loading, the correction of pathokinematics may be particularly important for athletes who participate in sports that generate high peak GRF.

What Movement Tells Us and the Impact on Sport Performance

Research evidence supports the implementation of a strengthening program as a strategy to correct pathokinematics, which has been associated with increased tolerance for running among athletes with patella-femoral pain syndrome. There is also a correlation between a muscle’s length-tension relationship and its capacity to generate and sustain tension. When pathokinematics are observed in an athlete, an optimal length-tension relationship does not exist. Consequently, movement is not efficient, peak GRF is not effectively attenuated, and the ability to develop and sustain force is submaximal (Figure 1). There is research evidence that correction of pathokinematics can lead to an improvement in athletic performance.

Figure 1 Young female soccer player photographed at take-off during performance of a maximal vertical jump.
The neurologic literature supports the idea that training should be specific to the task for improvement of performance. Hence, to improve squat performance, the squatting motion should be optimized. So, are there specific movements in sports that should be assessed and optimized for improved performance?

The right extremity of the athlete in Figure 2 clearly has an alignment that differs from the contralateral side. Knowing that her right extremity is dominant and used for push-off during sprinting, correction of her pathokinematics may improve power generation. But exactly how should the apparent problem be addressed? Differentiating among the various factors that may contribute to an abnormal movement pattern can be difficult, which may include altered muscle recruitment patterns, poor hip muscle strength, poor hip muscle endurance, poor core muscle strength, and impaired proprioception. Identification of the “root cause” of a pathokinematic problem is essential. Therefore, a standardized battery of tests is needed to isolate the components of a complex movement pattern. Combining the findings of standard orthopedic clinical tests with the results of a functional movement assessment may help to identify the “root cause” of the abnormal movement pattern. For example, knowing that the gluteus medius is an external rotator of the hip, as well as a pelvic stabilizer in a closed kinetic chain, weakness will result in hip adduction and internal rotation during the stance phase of running or other single-leg support activities (Figure 2). If a hip adduction (i.e., Trendelenburg) and internal rotation movement pattern is identified during box jumps or single-leg squatting motions, isolated manual muscle testing of gluteus medius (hip abduction, slight extension, slight external rotation) may reveal a deficiency that guides development of a treatment strategy. However, if the gluteus medius appears to be strong, then focused assessment further down the kinetic chain may be indicated. Excessive pes planus (Figure 3) can also be associated with closed-chain hip adduction and internal rotation. Because the multifidus, quadratus lumborum, and abdominal oblique muscles assist in maintaining rotational stability of the lumbar spine, weakness in these muscles may affect lower extremity positioning during athletic activities. If excessive trunk rotation is observed during running gait or rotation to one side during performance of the plank test, weakness of the core musculature may be a contributing factor. On the other hand, excessive trunk rotation during running that is combined with excessive tightness of the iliosposas and weakness of the gluteus maximus may be indicative of the cross-pelvic syndrome described by Panjabi. For each of these examples, development of a treatment strategy to address the identified “root cause” of pathokinematics should result in an improved movement pattern.

Figure 2  Track athlete (sprinter) photographed during performance of a single-leg squat test.
Summary

Human movement involves a complex interaction of multiple systems. Deficient function of any component can result in pathokinematics that increase injury risk and an adverse effect on performance. Standardized movement assessment can identify dysfunctional patterns that should be addressed by an individualized training program. Although further research is needed to more clearly establish the influence of pathokinematics on injury risk and functional capabilities, inclusion of functional movement assessment as a part of the preparticipation physical examination could provide evidence of its value for injury prevention and performance enhancement.

References


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