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Advancing Anterior Cruciate Ligament Injury Prevention Using Real-Time Biofeedback for Amplified Sensorimotor Integration

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A critical factor that may limit the efficacy of current injury-prevention strategies is the transferability of neuromuscular-training–induced, injury-resistant movement patterns (ie, coordinated biomechanics that decrease the injury risk) from the intervention to sport.[1–7] In addition, recent data indicated that deficits in sensorimotor neural activity underlie the risk of anterior cruciate ligament (ACL) injury,[8,9] but current interventions neither target this neural activity nor induce the neuroplasticity required for the transfer of injury-resistant movement patterns to sport.[7,10]

The failure of targeted injury-prevention strategies to induce the transfer of adaptations from injury-prevention training to sport likely contributes to the continued high incidence of sensorimotor errors during sport that cause noncontact ACL injuries.[10–12] For this reason, augmented neuromuscular training (aNMT) was designed to deliver real-time, interactive, augmented-reality biofeedback driven by select biomechanical variables that have been identified as contributing to the injury risk.[1,2,13–18]

The aNMT-biofeedback variables are calculated in real time and used to render a geometric shape (eg, a rectangle for a squat exercise that athletes view through an augmented-reality display, which provides a full view of, and engagement with, the actual environment). The feedback shape changes in real time according to the biomechanical variables as the athlete performs an exercise. The desired outcome for athletes is to move so that they produce a perfectly symmetric stimulus shape (eg, rectangle), which corresponds to a low risk of injury biomechanics.[18] Deviations of the biomechanical variables from the desired injury-resistant movement pattern values yield specific, systematic distortions of the feedback shape. Given only basic instruction related to performing the exercise, athletes must discover the movement pattern that produces a stimulus shape as close to the goal shape as possible.[18] No explicit directions are provided to athletes on their movements other than to achieve the goal shape, a process that engages implicit motor-control mechanisms by means of external perceptual control—a strategy known to improve sensorimotor learning.[18–24] Participants learn to move with optimal, low-risk movement strategies implicitly or without being able to explicitly describe how they are doing so; this is more likely to create effective and transferable sensorimotor adaptations than the typical clinical and coaching practice of providing explicit feedback that directs the individual's attention internally (eg, to joint positions that hinder motor learning).[7,25–31]

Removing barriers to feedback interventions (eg, instructors in current protocols who may provide less effective or uninterpretable feedback) through real-time automated techniques that supply implicit, analytic-driven biofeedback (eg, aNMT) could optimize current ACL injury-prevention strategies by leveraging sensorimotor processes for improved movement adaptations that transfer to the field of play.[7,18,32–34]

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