Task Complexity and Jump Landings in Injury Prevention for Basketball Players

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Task Complexity and Jump Landings in Injury Prevention for Basketball Players

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SUMMARY

THE PREVALENCE OF INJURY PREVENTION PROGRAMS CONTINUES TO INCREASE, BUT THE INJURY RATES REMAIN CONSTANT. THESE PROGRAMS USE A BLOCK PRACTICE SCHEDULE AND CLOSED-SKILL EXERCISES, BUT GAMES ARE RANDOM AND INVOLVE OPEN SKILLS. TO IMPROVE THE EFFICACY OF THE NEUROMUSCULAR TRAINING PROGRAMS AND TREND THE INJURY RATE DOWNWARD, THESE PROGRAMS SHOULD INCORPORATE MOTOR LEARNING THEORY. BY INCORPORATING MORE RANDOM VARIABLE PRACTICE, ADDING COMPLEXITY TO EXERCISES, AND LESSENING THE RELIANCE ON THE VISUAL SYSTEM FOR FEED-FORWARD MOTOR CONTROL, ATHLETES WOULD BE PREPARED BETTER TO HANDLE THE STRESSES OF GAME ACTIVITIES.

The last decade has seen the development and implementation of neuromuscular training programs, which have demonstrated positive results for anterior cruciate ligament (ACL) injury prevention (10,11,15,17,19). These programs are designed to elicit measurable adaptations in neuromuscular control (9). However, the national injury rate has not declined (1), likely because the demands of the game activities exceed those of the training exercises. These numbers are subject to many variables, such as adherence, increasing participation rates, and more, but the transference of learning cannot be discounted. The neuromuscular training programs use tests, often a depth jump, that are very similar or the same as exercises in the training program (9) and that differ from the game environment. Although the programs improve performance on the exercises, there is no guarantee that the improved performance transfers to different more complex situations (14,22,27).

Noncontact ACL injuries occur more frequently during games than in practices (12) potentially because of the game's increased intensity. A high percentage of injuries involve a jump landing (8,13), and a study showed that 22 of 28 noncontact injuries occurred with another player within 1 m (13). Rebounding is cited most often as the maneuver associated with ACL injuries in female basketball players (20). Although most injury prevention programs focus on the jump landings (9,10), most ignore the added task complexity because of the proximity of other players, the reaction to the ball, the visual tracking of the ball, the prejump movement, and other factors involved with pursuing a rebound.

From the motor learning perspective of transfer, these programs appear to suffer from 4 shortcomings: first, a preference for block practice; second, a reliance on closed-skill exercises; third, a reliance on an ideal landing technique; and finally, a reliance on the visual system in training exercises. Addressing these 4 issues by progressing the programs to more complex exercises and practice schedules may improve the transference of learning of the neuromuscular training programs.

BLOCK PRACTICE VERSUS RANDOM VARIABLE PRACTICE

Motor learning is concerned with the retention and transfer of learning. Retention is the ability to reproduce the skill after a period of no practice, whereas transfer is the ability to use the skill in new situations (28). Traditionally, strength coaches use block practice conditions. In block practice, the athlete practices 1 variation of 1 skill at a time (28): a set of box jumps involves 1 skill (jumping) under 1 condition (36-in. box).

KEY WORDS:
ACL injury prevention; jump landings; task complexity; random practice; variable practice

During variable practice, the athlete practices variations of a single class of skills in a setting that simulates the conditions found in a competition (28). Rather than using 1 box of 1 height, the coach sets up 5 boxes in a line, each of a different height. During random practice, the athlete learns to combine different classes of movements within settings that simulate the conditions found in competition (28). For example, the athlete runs and performs a box jump to combine 2 different classes of movements (running and jumping).

Most neuromuscular training programs, like the Prevent Injury and Enhance Performance (PEP) program or jump training programs (9), use a block practice schedule (10,15). Block practice has been shown to enhance acquisition but impede retention and transfer, so the athlete and coach misrepresent the amount of learning (14,24). The improvements that a coach sees in jump landings on a box jump do not transfer automatically to novel situations, like a game. Random variable practice has been shown to improve retention and transfer of learning (20,28) and enhance vertical jump performance (25).

TASK COMPLEXITY: CLOSED VERSUS OPEN SKILLS

These neuromuscular training programs use an assortment of closed-skill exercises like backward running, stretches, lunges, cone hops, and shuttle runs (15) or various jumps like tuck jumps, squat jumps, and bounding for distance (9,10). Closed skills are performed in stable predictable environments, and the execution is self-paced (14), whereas sports like basketball are open skills performed in a constantly changing environment and controlled externally (14).

Adding complexity to an exercise by introducing a static defender in cutting maneuvers (16) or an overhead goal in vertical jumps (6) significantly altered knee biomechanics. When athletes must respond to a cue like a flashing light, increased fatigue decreased the likelihood of reacting quickly and safely to the unexpected command (4). In an exercise like a lunge, shuttle run, or cone hop, the athlete initiates the performance, and the environment is unchanging. Pursuing a rebound adds complexity: the ball, 9 other players, the speed of play, possible foul trouble, the pressure of the game, court positioning, and more. The complexity changes the skill and alters the intensity and kinematics (6).

The taxonomy of motor learning by Gentile (7) classifies the complexity of a task based on object manipulation, intertrial variability, the stability of the environment, and the athlete's movement. The PEP exercises rate low on the complexity scale. Most do not involve an object; each repetition is the same; the environment is stable, and only some involve the body moving from its position (15). Pursuing a rebound rates as the most complex skill because it involves object manipulation; every repetition differs; the environment is variable, and the body is in motion. To prepare players for the more complex open skills in the game, training exercises must increase their complexity.

THE IDEAL LANDING

Most athletic trainers, strength coaches, and injury prevention programs focus on the teaching of an ideal landing. As explained to the *New York Times*, the ideal landing is for players "to bend at the hips and knees to softly absorb the load, keeping their knees behind the toes, striking the ground toe to heel" with "the knee in a neutral position; the center of the kneecap should be aligned with the second toe." Coaches give specific detailed instructions and immediate constant feedback with a very specific set of instructions or expectations for the proper landing technique. This instruction is problematic in 3 ways: first, there is no true ideal landing (23); second, game conditions often require stiff landings (26), and finally, the conscious control in training sessions may disrupt the automatic processing that is necessary during practice and games (3).

Movements always show fluctuations, and it seems almost impossible to produce the same movement twice (23). The constraints change the movement, whether from fatigue, jump height, or presence of another player. Between 30 and 60 different types of jumps have been identified in basketball games (5). One never performs the exact movement in the same way twice. If an expert cannot replicate a closed-skill movement over the course of a season (23), a nonexpert cannot be expected to replicate an open-skill movement, meaning that there is no single ideal to practice.

Furthermore, an ideal landing assumes that each athlete is built the same, but each athlete differs in size, strength, limb lengths, skill, experience, mobility, and more. "If we assume that world class athletes have found their instantaneous and very individual optima, and at the same time individuality can be identified in beginners, then we encounter the problem of teaching young athletes certain sport techniques that are no more adequate for their body or do not fit their mentality when they are grown up" (23) (p. 75). Rather than forcing each athlete to perform like everyone else, coaches should assist their athletes in discovering their individual optimal performance patterns for the given skill and to find an "individual way, including its effective variations, to control the forces that belong to those complex tasks" (3) (p. 624).

The ideal landing also assumes an absorptive landing, although many game situations require a stiff landing. During a landing or deceleration, energy must be absorbed, so muscle stiffness remains low (26), whereas in a stiff landing, like a jump stop into a jump shot, energy must be stored and released, requiring increased muscle stiffness (26). Focusing on an ideal absorptive landing may prohibit the development of the motor control required for a stiff landing.

Finally, the focus on the ideal increases explicit learning as opposed to implicit learning. Athletes engaged in explicit learning acquire skills with an internal focus and specific knowledge of how to perform the skill, whereas implicit learners acquire skill without the concurrent acquisition of explicit knowledge of how to perform the skill (3). Implicit learning is procedural, whereas explicit learning is declarative. Explicit instruction increases conscious control of movements and improves the immediate performance. However, explicit learning is less robust than implicit learning and is more subject to performance variables, such as fatigue and pressure (2), which are more prevalent in games than in training. Implicit learning is an unconscious process, and it yields abstract knowledge, which is more resilient (21).

Constant coach instruction takes away the player's responsibility in the learning process. Delayed and reduced feedback has been shown to improve the retention and transfer of skills (28). Rather than rely on coach feedback, visual feedback of one's own performance or the combination of one's own performance plus an expert model enables the athlete to explore his or her optimal skill execution rather than the coach's ideal (18).

The ideal soft landing with knee flexion and a toe-to-heel strike should not be abandoned. However, it is not the end goal, and an environment dependent on conscious control of movements may inhibit the subconscious learning of proper motor control for a variety of situations. The absorptive landing is only a type of landing, and the stiff landing is more prevalent in game situations because of the speed requirements of skills like shooting or an offensive rebound put-back attempt.

FEED-FORWARD MOTOR CONTROL

Ballistic movements depend on feed-forward motor control, not feedback. Feedback is information about the actual state of the system (22), whereas feed-forward information is anticipatory (26). Feed-forward motor control uses advance information about a task, usually from experience, to preprogram muscle activity (26). In a stiff landing, there is no time for feedback (26). The muscle activation before landing is preprogrammed, and the increase in muscle activation increases muscle stiffness properties, which provides dynamic support for functional stability (26) and allows for a stiff landing.

Wikstrom et al (29) showed that even in a controlled jumping exercise, there were failed jump landings, as determined by the inability to maintain balance for 3 seconds postlanding. Successful jump landings required earlier muscle activation (29), which depends on the feed-forward motor control (26). The subjects touched an overhead target, which directs the vision upward and changes the body posture from the ideal absorptive landing (6). Wikstrom et al (29) suggested that vision is more important in the learning of a task, so with the novel jumping task performed in the study, some of the failure may be explained by the lack of vision because compensations were "negatively affected when vision was impaired" (p. 60).

When training focuses on controlled closed-skill exercises, athletes tend to depend on visual information to prepare for the landing. They can anticipate the landing in a way that is not always possible in a game. Visual perturbations affect muscle activation with randomized heights (27). Game landings vary, and a player often lands blind as her eyes focus on the ball or the basket. The player depends on her experience and practice to increase muscle stiffness and neuromuscular control (26). When players train with visually dependent exercises, they may not develop the feed-forward motor control to anticipate the landing without visual information, especially in uncontrolled situations (27,29). More randomization, overhead targets, and visual perturbations in training may improve the player's ability to handle the open-skill game environment.

CONCLUSIONS

Basketball coaches are not movement experts; they are unconcerned with the kinematics of a jump landing unless the poor technique leads to a traveling violation or missed shot. Therefore, the strength and conditioning coach must bridge the gap between the traditional closed-skill training environment and the open-skill conditions of basketball practices and games.

In the ACL injury studies (12,13,20), nearly all of the incidents involved the ball (attack, rebound, and turnover) or an overhead goal (rebound). These objects and orientations change the task complexity and affect posture (6,16). Training must progress from simple closed skills to more complex random and variable exercises as a means of closing the gap between the off-court training activities and the game actions.

These adjustments or progressions are not solely for ACL injury prevention; these concepts of complexity, variability, and randomness enhance transfer of a skill from one situation to a novel situation. Strength and conditioning is skill development, and these concepts can be applied to other areas beyond jump landings, like speed training, agility, and more. Ultimately, training is measured by game performance, and incorporating motor learning theory into the planning of an off-season training program will enhance the athletes' preparation for the open-skill, random, variable conditions of their sport practices and games.

PRACTICAL APPLICATION

To enhance transfer and add complexity, the strength and conditioning coach can adjust the same exercises in the current neuromuscular programs or add progressions to the exercises because the athletes demonstrate improvement with the simple tasks. For example, a common exercise is a lateral hop, either over a line or over a cone. To challenge proprioception and enhance the feed-forward motor control, the athlete could perform the same lateral hop with eyes closed. To add complexity, the athlete could perform a transverse cone hop rather than a simple lateral hop (see Video, Supplemental Digital Content 1, http://links.lww.com/SCJ/A11). To add variability, the athlete could perform a multicone lateral hop over cones of varying heights (see Video, Supplemental Digital Content 2, http://links.lww.com/SCJ/A12). To add randomness to the training, the athlete could perform the lateral hop and change directions based on the coach's visual or verbal cues. To create random and variable training, the athlete could perform the lateral hop over cones of different heights based on the coach's verbal or visual cues (see Video, Supplemental Digital Content 3, http://links.lww.com/SCJ/A13). Finally, to add complexity through manipulation and change the role of the visual system, the athlete could perform the lateral hop while holding a basketball. Next, the coach could toss the ball for the athlete to catch in the air and hop back to the starting position before passing back to the coach (see Video, Supplemental Digital Content 4, http://links.lww.com/SCJ/A14).

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