



The Power Behind the Time and Room Shot

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Short Communication

A good understanding of the fundamentals and biomechanics of shooting a lacrosse ball will allow any coach or parent to help their young player achieve their potential.

There hasn't been the depth of biomechanical research in lacrosse shooting as some of the other athletic movements. There are striking similarities between the biomechanics of a baseball pitch, javelin throw, tennis serves, golf swing and the biomechanics of the lacrosse shot however. These similarities and the research into these other athletic movements helps deepen our understanding of what contributes to optimal lacrosse shot mechanics. Most of the interest in these other movements is in projectile velocity rather than accuracy and that applies also to the lacrosse shot. The time-and-room shot is just one of many shots in lacrosse, but the mechanics can be applied in part to the other shots (Figure 1).

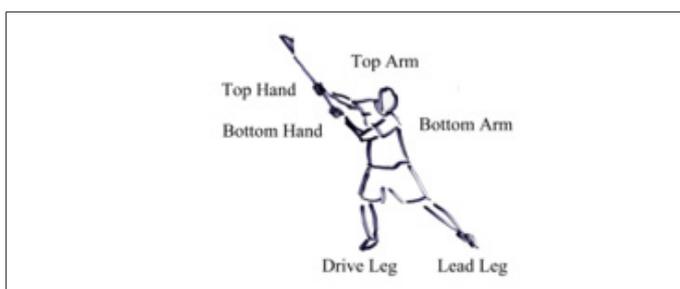


Figure 1: From Mercer J, Nielson J. Description of phases and discrete events of the lacrosse shot. Sport J, August 2012.

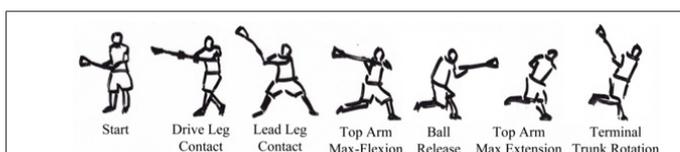


Figure 2: From Mercer J, Nielson J. Description of phases and discrete events of the lacrosse shot. Sport J, August 2012.

The foundation principle is the *kinetic chain*. The kinetic chain is the coordinated series of movements or 'chain' of events that transfer force through multiple segments of the body. It is involved in all 6 phases of the shooting motion described by Mercer and Nielsen in 2012 (Figures 1 & 2) [1]. The legs and core provide a base,

generating energy that is transferred up through the torso to the shoulder and arms culminating in the release of the ball from the stick (Figure 2) [2,3].

Breakdown in the kinetic chain leads to decreased performance. A good understanding of these coordinated mechanics allows a coach to assess and correct any breakdowns in the chain to optimize performance. The shooting motion requires coordination of the timing and angular velocities of the larger proximal muscle groups to the smaller distal ones to optimize shot velocity. Disruption in the timing or changes in movement velocity effects the coordinated movements of the kinetic chain and reduces performance [4].

The phases are intricately coupled. Each segment starts as the adjacent proximal segment reaches top speed. Ultimately this results in top speed of the distal most segment (the head of the lacrosse stick). It is analogous to a whip. The legs and trunk are the proximal segment or the base. They serve as the main force generators of the kinetic chain. The integrated motion of the entire body then culminates with rapid motion of the upper extremity [5-9].

The energy delivered from the ball is a combination of the energy transferred from the forward momentum of the player's body and the stored elastic energy from the stretched muscles of the chain (myotatic reflex or stretch reflex). The stretched muscles of the trunk and upper extremities generate more powerful concentric contractions than non-stretched muscles [10-12].

Increased stretch through improved flexibility has been shown to enhance the efficacy of the stretch-shortening cycle. Furthermore, the increased flexibility and pre-contraction elongation of the chain ultimately allows the athlete to apply force and accelerate the ball over a greater distance which enhances ball velocity at release [13].

Lead Leg Contact

During this phase, there are several important parts to understand particularly with the trunk and lower extremity. The amount of energy that can be transferred from the bodies momentum is dependent upon a stable base [14]. It is akin to

slamming on the brakes. The more abruptly that you decelerate the higher the impulse of energy. This is power. Power equals work over time. The shorter the amount of time it takes to 'stop the car', the more power can be captured and transferred up the chain. When the athlete plants his foot, the force that he plants his foot with causes an 'equal and opposite' force from the ground. This ground reaction force is the power that is transferred up the chain. In other throwing sports, this has been measured and proven [15]. When the lead foot is planted, the angle of the knee that affords the most torque through mechanical advantage and thus allows the leg to become rigid the easiest is roughly a 45 degree angle [16].

The quadriceps in the stride leg contract to decelerate the flexed knee, stabilize the stride leg, and provide a stable base. It is critical to minimize any lead knee flexion at the front foot strike. This quickly dumps valued energy from moving up the body. Comparing high velocity throwers and low velocity throwers revealed that the high velocity throwers had stronger quadriceps and were able to stop more abruptly without any 'give' in their knee [17]. Furthermore, it was shown that the highest velocity throwers actually 'push off' a little and slightly extend their knee to increase the energy even more [18]. In critiquing your athlete, a 45-degree angle of the leading knee at foot plant should be the target [19].

Just prior to foot plant, the trunk is rotated away from the shooting side, the shoulder of the lower arm is maximally internally rotated, and the shoulder of the upper arm is maximally externally rotated in a slight amount of abduction. This is frequently described as 'coiling'. It is important for the distal part of the chain to remain rigid through the initial acceleration phase. Bracing the arm against the torso or minimizing abduction of the arm in this phase offers the most mechanically advantageous position. Maintaining the rigid position avoids 'dumping' energy prior to the distal segments of the chain moving. Furthermore, the wrist of the upper arm is roughly 90 degrees to the shaft which is the position of maximum mechanical advantage and grip strength.

The lead foot when planted should be in line with the target. Although this may seem awkward, this allows for the most mechanically advantageous rotation of the pelvis. If the foot is over rotated then the hip is 'too open'. This leads to decreased trunk rotation and release of the ball toward the target before the maximum angular velocity of the trunk can be achieved. If the foot is under rotated, then the hip is 'closed' and the elastic energy of the stretch is not optimized and the shooter shoots across his body [20,21]. Regardless, these alterations to hip rotation will lead to a disruption of the kinetic chain and ultimately a loss of energy production. Studies have also shown that fatigue and breakdown of the leg kinematics correlated with velocity drop in baseball [22].

Top Arm Max Flexion

The lumbar spine and associated musculature of the abdominal wall transfer energy of the throwing motion from the lower to the upper body via rapid trunk rotation and tilt, and these structures are involved with the acceleration and deceleration of the upper body during a shot [23]. As the trunk muscles contract to rotate

the trunk, they also cause the trunk to bend forward [24-26]. This motion is also aided by contraction of the rectus femoris muscle of the quadriceps which is both a knee extender and a hip flexor. The slight knee extension in high velocity throwers and shooters made be a concomitant movement with the contraction of the quad that is trying to tilt the trunk forward [27-29]. This suggests that strengthening the knee extensor muscles may be important for the athlete since a braced lead leg creates angular momentum of the trunk about the trunk's mediolateral and longitudinal axes [30].

As the trunk muscles contract to the shortened position, reaching maximum angular velocity the shoulder rotators then contract, followed by the triceps extending the elbow, while the wrist remains rigid in its position of maximum grip strength. Following shoulder rotation and then elbow extension, the wrist then flexes, and the ball is released. If the stick is held so that the upper wrist is not in a neutral position with the forearm perpendicular to the shaft, the amount of power in the wrist snap is diminished.

Understanding where the power comes from and how it is transferred through the kinetic chain will allow the coach to optimize his athlete's shooting power [31]. Efficient transfer of power also means that there is less force required from the distal segments of the chain, more vulnerable to injury [32]. A 20% decrease in kinetic energy delivered from the hip and trunk to the arm requires a 34% increase in the rotational velocity of the shoulder to impart the same amount of force to the hand [33].

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