Press Statement Issued by Hammer Lacrosse

Natural Flex Is the Key to Ultimate Performance and Safety

Understanding the Bio-Mechanic Relationships of Energy and Performance

The Sports Medicine Importance of Weight and Flex Optimization

PLEASANTON, CA, August 5, 2008 – Hammer Sports Inc, a leading manufacturer of advanced composite sport shaft technology for lacrosse, the fastest growing sport in the Unites States, shares the science behind weight and flex optimization.

Hammer integrates the fundamentals of modern sports science into lacrosse handles to introduce next generation performance and safety. The highly engineered, biomechanically-correct, dynamic-flex of the Hammer PowerShaft enables the athlete to move naturally, improving physical speed, accuracy, and control. The PowerShaft design enables the athlete to achieve true kinetic linking, the perfect flow of energy through the entire body. This paradigm shift in performance is the complex result of components working together as a mechanical system. The PowerShaft's continuous-biaxial-weave aramid shell provides a protective flexible muscle layer powered by a vibration-damping foam core encasing a tuned internal carbon spar that's engineered to deliver a dynamic response that scales with athletic ability.

Alloy and composite tube shafts are still struggling with a 30 year old mechanical design, new materials but old technology. They are trapped in a design paradigm where performance and control are mutually exclusive and inherently at opposite ends of their technology performance continuum.

"To understand where lacrosse is headed, one only has to look at the performance based equipment advances of other sports such as hockey, golf, tennis, baseball and skiing" said Rene Meyer, Hammer's VP of Product Development and Manufacturing, "They all went through the same natural evolution to arrive where they are today, focused on performance, which is fundamentally based on bio-mechanic flex and shock-management technology. The science behind this evolution is well understood, the results are simple, but the technology is very complex. Studying the example sports, it took bio-mechanically correct flex to unite power and control in order to break the performance paradigm. Natural flex is the key. Flex is also required to isolate and conserve energy (less bio-mechanic energy absorbed by the athlete's body). Conservation of energy has two critical components, Vibration Damping (tuned energy dissipation) and Shock Prevention (impact absorption). Flex enables natural body motion (kinetic-linking) required for top athletic performance and also reduces the risk of long term shock and vibration joint damage. Rigid sticks, in their struggle for performance attributes, have been marketed as good for power, but in reality they are high on energy leakage which lowers power and contributes to long-term muscle joint damage like tennis elbow. For years, players have been wrapping their shafts with strategic applications of grip tape to reduce shock and vibration. It may take the sting out, but it does little to reduce the shock absorbed by the athlete's body, the shock that robs energy and damages joints. The indisputable fact is that **controlled flex absorbs torque providing maximum energy return and minimizing bio-mechanical energy leakage (into the athlete).**"

The fundamental starting point in studying bio-mechanic relationships in sports equipment is the "Sweet Spot". From this starting point you can study the physiological effects and relationships as you move through the body.

The **Sweet Spot** is known in sports science as the "center of percussion" or "center of oscillation." The sweet spot is a point, not an area, even though some refer to the "sweet spot" on a golf club, baseball bat or tennis racquet as being "large." The sweet spot is determinative of the force from impact: the higher

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the sweet spot (further from the hands), the lower the Impact Force acting at the stick's mass center, and the more positive the Impulse Reaction at the hands. Generally speaking, the higher the sweet spot on the stick (i.e. the longer the distance (q) from the hand to the sweet spot), the better. However, it's not that simple, it's true the Impact Force will be less due to the high sweet spot, but, the resulting Torque will be higher because the mass center where this force acts is far from the hand, giving the Impact Force a longer lever arm. This results in higher Torque and Shock, as well as Work, Shoulder Pull, Wrist Crunch, Shoulder Crunch, and Elbow Crunch. **What you want is a high sweet spot together with head-light balance, adequate mass and flex.** The formula for finding the center of percussion on a piece of sports equipment subject to oscillation is: $q = I / Mr$. [q is the distance in centimeters from the axis of rotation to the center of percussion; M is stick mass in kilograms; r is the distance in centimeters from the axis of rotation to the mass center, or balance point, of the stick; and I is the stick swing weight about the axis of rotation (also known as moment of inertia or rotational inertia or Second Moment].

Torque and Impulse Reaction are the two "resultant forces" from an "eccentric impact," such as the impact of a stick catching a ball. This is called an "eccentric impact" because the two mass centers (ball center and stick balance point) do not move along the same line to a point of collision. When you hit the Sweet Spot (tennis, golf, baseball, lacrosse, etc.), Impulse Reaction is zero, but there is still some Torque.

Torque is a bending force resulting from impact, which causes the hand to bend back and then catapult forward. This torque is measured about the axis of rotation of the stick in the stroke. Note that Torque is not the screwdriver twist of the handle (which will be called Torsion, or Longitudinal Torque), but the bending back of the stick. Torque winds up a catapult in the wrist, which flings the stick forward after the ball is caught. The stronger this catapulting force, the worse the whipsawing stress cycle resulting from the stroke, and thus the worse for tennis elbow -- so high Torque is bad. There is also loss of energy from the conversion of Torque into the subsequent forward catapulting force, due to absorption of Torque by the player's arms, so it is difficult to quantify the catapult effect. Note, however, that a stiff stick will not absorb as much of this bending force, and therefore a stiff stick is a risk factor for tennis elbow.

Impulse Reaction is a push (positive) or pull (negative) on the axis of rotation (the hands) resulting from impact. Impacts above the center of percussion (Sweet Spot) result in a pull on the hand; below is a push. A positive Impulse Reaction is better because it means less Impact Force. Impulse Reaction is measured in units of force, because it is a translational force (straight ahead push or pull) on the axis of rotation (at the hand). The unit of measurement of force in the metric system is the Newton (1 Newton = 0.2248 pounds, or 3.6 ounces, of force). For impacts above the Sweet Spot (center of percussion), Impulse Reaction is a pull from the player to counter the yank on the hand (negative value). For impacts below the center of percussion, Impulse Reaction is a push against the hand (positive value). Right on the center of percussion (sweet spot), there is no Impulse Reaction at all (zero value).

Shock loading of the stick results from a sudden change in the stick's kinetic energy on contact, which produces an internal energy load on the stick. If the stick is stiff and light, the stick bending energy will not be absorbed by the material of the stick but rather transferred into the athlete's arms, wrists, and shoulders. Before impact, the athlete puts energy into the stick to prepare it for the contact, and during contact the athlete puts in a little more energy to catch and control the ball. After the ball is caught, the stick mass center (balance point) moves at a slower speed, and this means a loss of its kinetic energy (kinetic energy = 1/2 mass times velocity squared). The ball gets some of this energy and the rest becomes lost energy, absorbed by the athlete's body. A flexible shaft reduces energy loss (into the player) providing maximum energy return.

Shock becomes internal energy, which expresses itself as vibration. This vibration is transmitted to the arm holding on to the stick unless it is damped somehow. (The correct term is damped, not "dampened.") In the old wood shafts, vibration disappeared quickly because it was damped by the flex of the wood, but the new stiffer and lighter alloys and composite tubes do a poor job of damping, so they efficiently transfer the subtle shaking to the arm. Un-damped high frequency vibration can stealthily sabotage the elbow. Vibration of the stick shakes the extensor carpi radialis brevis muscle that attaches the middle of the hand to the elbow. This causes cyclic stressing of the tendons at the lateral epicondyle, where the fat half of this long teardrop-shaped muscle attaches. Cyclic stressing is how you break a coat hanger by bending it back and forth. Eventually, with enough stress cycles, fatigue can cause tissues to snap, even without any tremendous force.

Work is the energy required to produce a certain ball speed with the stick. Work measures the energy efficiency of the stick, so low Work is good. High Work is bad because the player has to swing harder to get the same result. Work quantifies a stick's power: the less work the player has to put in to get the required ball speed in the allotted time for the stroke, the more powerful the stick. Work, like Shock, is measured in terms of joules of energy, and the formula for Work (and kinetic energy) is 1/2 Mv2 (M is stick mass in kilograms and v is the linear velocity of the stick mass center (balance point) just before release, in meters per second). The principals of "conservation of energy" support the direct relationship of flex = efficiency = power.

Shoulder Pull is the force (in the metric unit of Newtons, 1 Newton = 0.225 lb. or 3.6 oz) exerted by the shoulder muscles in opposing the centrifugal force acting on the stick as it moves around the shoulder in the swing resulting from the player's Work. This opposing force is called a "centripetal" force because it acts toward the axis of rotation (here the shoulder socket); Shoulder Pull is equal and opposite to the centrifugal force while the stick is getting up to speed for the shot, and reaches its maximum the instant before release, which is where we measure it. After release, this centripetal force continues, but the offsetting centrifugal force is reduced because the stick has slowed down. The excess centripetal force becomes a radial compressive force known as **Shoulder Crunch**.

The formula for centripetal force is Mv2/R (where M is the stick mass in kilograms, v is the linear velocity of the mass center, in meters/second, and R is the distance, in meters, from the stick mass center to the axis of rotation, here the shoulder). Note that, in rotation, the mass center linear velocity (v) decreases as the balance gets more head-light, so head-light balance can mean low Shoulder Pull, even if the stick is heavy. The variable v is squared in the formula for centripetal force, so a light stick having a head-heavy balance may still have a large Shoulder Pull, despite its light weight, due to its distant mass center and consequent high mass center velocity in rotation. That's bad.

Shoulder Crunch is the change in the centrifugal force acting on the stick, a change that occurs due to the impact changing the velocity of the stick, thus creating a sudden excess in centripetal force at the shoulder. Before, the centripetal force and centrifugal force were in equilibrium, but suddenly there is an excess in centripetal force. This is effectively a muscle spasm in the shoulder muscles. So Shoulder Crunch is a radial compressive force, and is measured in units of force (Newtons, 1 Newton = 0.225 lb. or 3.6 oz.). Once the Shock is known, Shoulder Crunch follows by a simple calculation: Shoulder Crunch = (2/R)(Shock) (where R = distance of the stick's mass center from the axis of reference, here the shoulder (i.e. the distance from the player's hand to his shoulder plus the distance from the hand to the balance point of the stick)).

Elbow Crunch is the excess centripetal force acting at the elbow, an excess that occurs because on impact the stick slows down, so its centrifugal force drops. The centripetal force of the muscles attaching to the elbow and the centrifugal force of the stick in its swing had been balanced before the impact, but the sudden slowdown creates what is effectively a muscle spasm. The muscle continues to contract as if it still had a full load, so it suddenly shortens and yanks on the tendons that attach it to the elbow. This yank (Elbow Crunch) is a cyclic stress which, repeated over time, may be a contributing cause to tissue failure. Like Shoulder Crunch, it is calculated by multiplying Shock by 2/R' (where R' is the distance of the stick's mass center from the elbow, and is equal to the distance from the hand to the elbow plus the distance from the hand to the balance point). Elbow Crunch is larger than Shoulder Crunch because the elbow is closer than the shoulder to the mass center of the stick.

Wrist Crunch is derived the same as Elbow Crunch, only the new distance R" is measured from the mass center to the wrist, not the elbow. R" is equal to the distance from the wrist to the stick axis of rotation plus the distance from the axis of rotation to the balance point.

Impact Force is the change in the stick's momentum on impact, divided by the time it occurs (the dwell time). It is the force (measured in Newtons) appearing at the mass center (balance point) upon impact with the ball. Note, the higher the sweet spot, the lower the Impact Force If we multiply the Impact Force by the lever arm on which it operates (i.e. the distance from the hand to the balance point), we get exactly the same Torque as calculated by the formula for Torque. So the benefit of a high sweet spot will be offset by a head-heavy balance, because a head-heavy balance means a long lever arm for the Impact Force to operate on, and thus a severe bending of the hand on impact, with additional damage to the elbow from the whiplash mechanism.

Power
In science, power is measured in watts. A watt is one joule of energy/work/heat/effort per second, and one horsepower is 746 watts. Power is the rate of doing work. Of course, a stick cannot be given a horsepower rating. The player/stick system has power, with the player providing the effort and the stick providing the interface with the ball to deliver that player effort. So if, consistent with this scientific meaning, we consider a powerful stick to be one can achieve a certain ball speed with the least player effort per unit time, and we limit the time of the stroke, what power then becomes is the inverse of Work: low Work means high power. A more accurate term would be "Efficiency."

Control -- everybody wants it, but nobody knows how to measure it. Just what is "control," exactly? It is generally thought that power and control are two ends of a continuum, so high power is low control, and vice versa. This inverse linear relationship is true with contemporary alloy and composite tube shafts, but this paradigm is broken with modern material systems like the Hammer Ultraflex. The Ultraflex is not a simple tube; it's a complex system of components working together providing scalable performance of both power and control.

Weight – Is lighter better?
No, contrary to popular marketing, light weight is not the key. Balance is more important than weight in maneuverability and control. Also a medium weight flexible shaft is more power efficient (with less energy lost to player), and responds better to advanced play through conservation of momentum. Aside from the foregoing performance considerations, there is the even more important question of safety. Light sticks are bad for muscle joint damage like tennis elbow.

The Effect of Stiffness
Flexible sticks absorb more of the Torque from impact, with the energy going into bending the material thus reducing the risk of injuries. Players at all levels report that flexible sticks perform better, and feel better. It therefore appears that the present popularity of stiffer, lighter shafts is motivated not by safety or performance considerations, but rather by manufacturers trapped in the materials paradigm unable to produce a stick with engineered flex without compromising strength.

Dedicated to performance innovation, Hammer has made a breakthrough in the quest to dramatically reduce the shock and vibration without compromising performance or weight.

The Hammer shaft, unlike alloy and composite tube shafts, provides controlled flex. Flex is the complex result of dynamically related components working together as a system. A system that utilizes the tuned performance of an impact-absorbing, vibration-damping, laminated carbon-fiber reinforced core, encased in a highly flexible composite shell. The system produces scalable controlled flex that, for the first time, unites power and control, enabling performance to increase with athletic ability. It not only breaks the performance paradigm, it does it with unmatched scalable performance and safety.

HAMMER LACROSSE is a division of Hammer Sports Inc., a leading developer, marketer and distributor of branded performance sports equipment and accessories. Through an unwavering commitment to innovation, Hammer creates products designed to make every athlete a better athlete. Hammer's products are used primarily in team and individual sports activities such as lacrosse, ice hockey, field hockey, baseball, softball, and water sports. Headquartered in California's high-tech corridor, Hammer has dedicated R&D and manufacturing facilities with focus on global competition. For more information, visit www.hammerlacrosse.com.