

HITTING BIOMECHANICS

(Revised 2018 - Simon Norton)

HITTING CONSIDERATIONS:

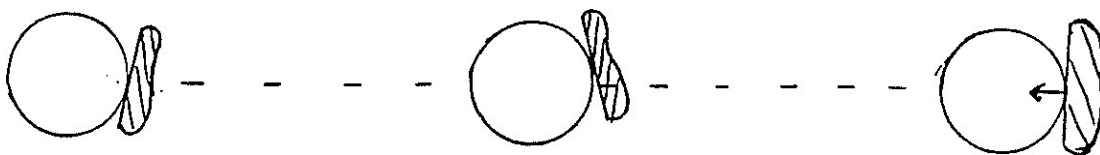
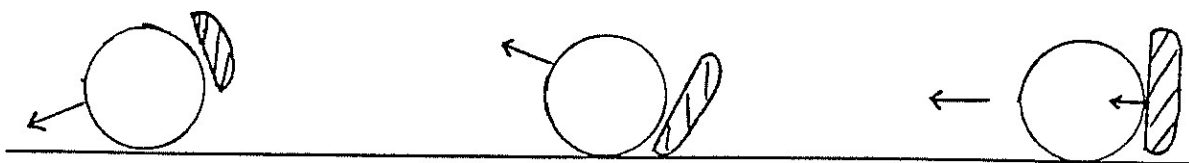
There are four factors that Hockey players should strive to attain when hitting the ball:

- Accuracy of the hit
- Speed of the hit
- A good ball roll
- Balance and keeping still at impact

ACCURACY OF THE HIT:

Accuracy of the hit will depend on various elements:

- Ball position in relation to body - ideally at impact it should be in line with the left heel, and with the head over the ball.
- Path of the swing - muscular forces should act to swing the hook of the stick in an arc that results in a tangent at the point of impact, that goes straight to the target (a team mate's stick or through a gap)
- The angle of the stick face at impact - the angle of the hook should be perpendicular to the desired path of the ball.



Open-Stick Face

Closed Stick Face

Square Stick Face

At impact the hands play a very important role in controlling the angle of the stick face. Poor grip at impact is the major cause of topping, chopping, lifting, slicing in hitting, along with poor ball and body position.

Many players have hitting problems because they fail to change from the dribbling grip, to a 'shake-hands' grip for hitting, and therefore have a 'strong' top hand at impact which closes the stick face, because of the natural rotation which occurs at wrist release.

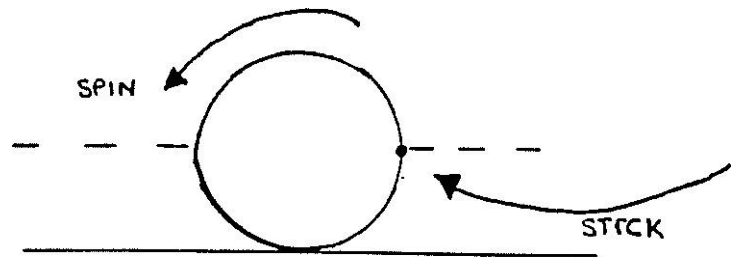
Poor grip also leads to other compensations with the hands to try and overcome the poor grip, which leads to hitting inconsistencies.

SPEED OF HIT:

The greater the club-head speed at impact, the greater the momentum transferred to the ball. Muscular forces, stride mass and stick length all contribute to imparting maximum momentum into the ball. Good timing ensures optimal summation of all the body levers to maximise club head speed.

A GOOD BALL ROLL:

A good hit imparts a top-spin on the ball which causes the ball to roll along the turf, rather than bounce across it, making it easier for the receiver to trap.



Some coaches say to hit the bottom half of the ball, or to hit the ball slightly on the up. Both these technique "hints" can help a poor hitter as it falls into line with the natural arc of the swing.

BALANCE:

At impact it is important for the hitter to have a wide base of support(feet), a low centre of gravity, and a good weight transfer. Keeping the head still at impact, lessens extraneous movements which cause a mishit. This allows the body to rotate around its axis. The swing should rotate around the knob at the

base of the back of the neck (C7 vertebra). Movements such as swaying and lifting up cause a mistimed or mishit shot.

Often a Coach can pick up what a player is doing wrong, by watching what happens to the players body position after impact. Do they:

- fall backwards or step backwards
- step forwards
- lift (head or upper body) up

Coaching then begins to remedy these.

THEORETICAL FACTORS IN THE BIOMECHANICS OF HITTING

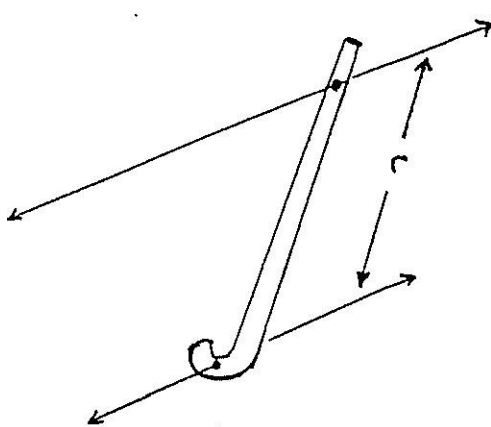
In hitting the body's musculature applies a force to the stick, resulting in stick head momentum. The stick in turn applies a force to the ball, resulting in a transfer of momentum.

Force is measured in:

- magnitude
- direction
- point of application
- line of action

MOMENT OF INERTIA:

Newton's first law of motion states that:



“A body (stick) will remain in a constant state (moving or still) unless acted upon by an external force”.

The body will resist the change in its state of motion, this being called the Moment of Inertia.

$$I = MR^2$$

As the mass of the stick is constant, the moment of inertia is directly proportional to the radius.

A hockey player can reduce the moment of inertia by decreasing the radius, or simply gripping the stick lower. (eg: to hit a fast ball in baseball, the batter chokes up the grip)

A hockey player can get a snap-shot away quicker by choking up the grip, thereby decreasing the moment of inertia and allowing the same muscular forces acting on the stick to overcome inertia quicker and result in stick head momentum. eg: spinning ice-skater with arms out, then bring the arms in, what happens? why?

CENTRE OF PERCUSSION:

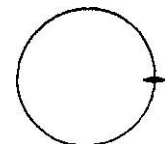
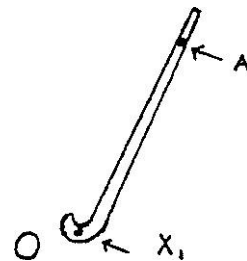
This is commonly called the 'sweet-spot'. The centre of percussion is the point where a blow must be struck (X) in order that no 'impulse' is felt at A, the centre of the grip.

If the ball strikes a long distance from X, the impulse will be transmitted to the hands at A, and the phenomenon of 'jarring' will occur. X is the 'sweet spot'.

Similarly, the ball has a centre of Percussion.

As we swing the stick through the ball, ideally the point X, will pass through the centre of percussion on the ball.

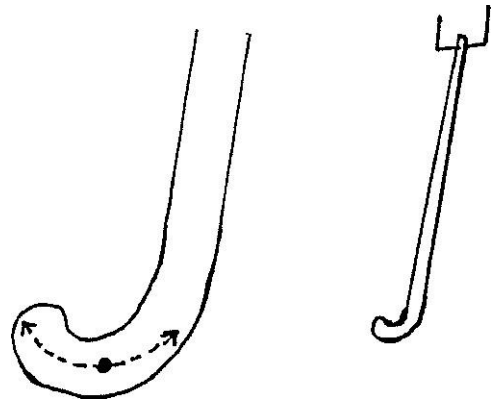
Studies indicate that by striking the ball precisely at X, up to 15kmph greater ball speed results in the hit.



TORQUE AND CENTRE OF MASS:

We can find the centre of Mass by tapping a suspended stick from the end of the toe of the stick and working our way in.

When we tap the stick outside the centre of mass, we feel a twisting (or torque) force. As we work our way in towards the shaft of the stick, there is a point where there is no twisting effect (or torque). If we go past that point further towards the stick shaft, we get a torque acting in the opposite direction.

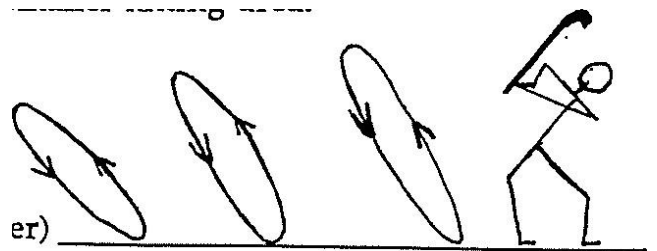


The greater the distance we hit from the centre of mass then the greater the twisting effect (torque) and the greater the loss of momentum impacted on the ball. Modern golf club shafts (boron and graphite shafts) are designed to reduce the torque in a mishit shot thus giving a bigger 'hitting' area.

Smaller hooks in modern sticks have resulted in a smaller hitting area.

ANGLE OF ROTATION:

Modern hitters are flattening the arc of the swing thus increasing stability and increasing rotational forces in the hit. Critical for this is maintaining the distance of ball to feet.



NEWTONS SECOND LAW OF MOTION:

The rate of change of momentum of a body is proportional to the force causing it, and it takes place in the direction the force acts.

$$\mathbf{F} = \mathbf{m} \times \mathbf{a}$$

So:

- The greater the force, the greater the acceleration (mass of the stick being constant)
- we want to exert the force through the line we want the ball to take.

This is very important for hitting power.

- we must use our muscular force to exert a force on the stick, through the line we want the ball to travel
- the force exerted on ball by the stick, should be in the direction we want the ball to travel. Not a closed or open stick face. This causes a torque (twisting effect) and results in power loss.

LAW OF CONSERVATION OF MOMENTUM:

This law states that: 'when two or more bodies collide with each other, momentum is conserved or transferred'

$$\text{Momentum} = \text{Mass} \times \text{Velocity}$$

Therefore, in hitting the greater the momentum we can create the greater the speed of the ball after impact. Note, the greater the mass of the stick, the greater the momentum transferred to the ball.

To attain a 'sweet hit' we still want the mass to be centred near to the hitting area, not up the handle.

LEVERS:

The body is virtually a system of third-class levers.

The principles of leverage state that *'the longer the arm of the lever, the greater the speed at the end of it'*

When hitting for power in hockey, we should

- hold the stick nearer the top
- fully extend our left arm at impact
- use a longer stick (with more mass in head)

The body uses leverage to exert forces, across a joint. The forces can be combined or added together to produce maximal force.

This is called "Summation of Forces".

SUMMATION OF FORCES:

Hitting does not just involve the hands and arms it involves feet, knees, thighs, hip, trunk, shoulders, arms, and hands. For maximal forces, as many body parts as possible should be used with:

- strongest heaviest, slowest body parts used first, followed by
- weaker, lighter, faster extremities.

Movement accelerates throughout.

In force summation, "TIMING" is vital.

For explosive force - all body parts contribute at the same time (Karate, hah!)

In hitting therefore, experiment with concentration on individual body parts

- feet, then knees, then hips, trunk, shoulders, arms and hands
- Reduce the time between use of each segment, one flows to the next.

Body parts should be sequentially accelerated, so that each preceding body part contributes optimally before the next body part comes into the action. Body parts should be sequentially stabilised so that each subsequent action may accelerate around a stable base.

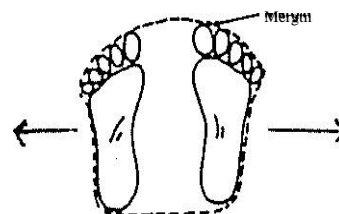
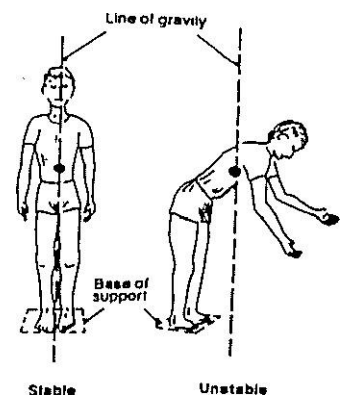
STABILITY AND BALANCE:

To maximise timing and summation of forces, a stable base is required.

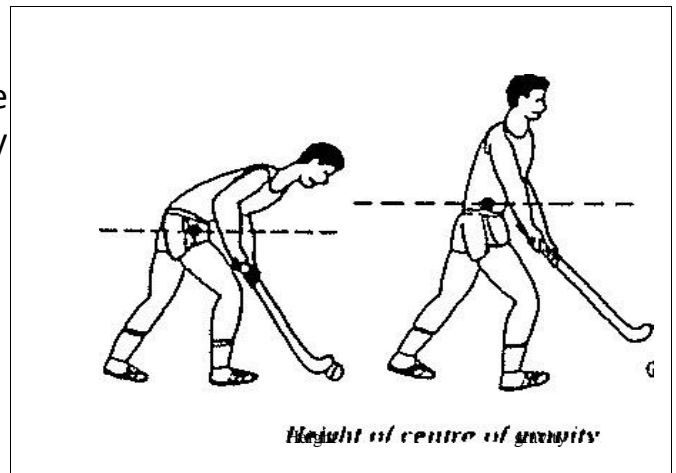
Principles of Balance ...

The nearer the line of gravity falls to the centre of the base of support. The greater the probability of maintaining balance

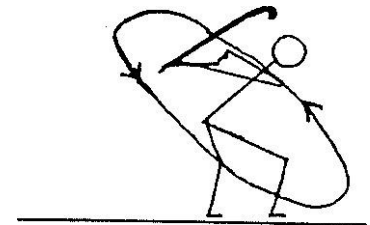
The broader the base of support, generally the better probability of maintaining balance.



- The probability of maintaining balance is increased when the centre of gravity is lowered in relation to the base



- Rotating movement increases stability eg: spinning ice-skater as opposed to stationary skater in same position. It is much more difficult to balance on a still bike than one with rotating wheels



SUMMARY OF STABILITY:

To achieve greater stability you need:

- to maintain a wide supporting base in line with the oncoming force
- a lower centre of gravity
- a line of centre of gravity close to the centre of the base of support
- to increase rotation (especially hips, trunk and shoulder).
- to lean into the oncoming force (action vs reaction)

The last point highlights the need for Transfer of Weight. Increased accuracy and momentum can be achieved by transferring the body weight from the back foot (right) to the front foot at impact.

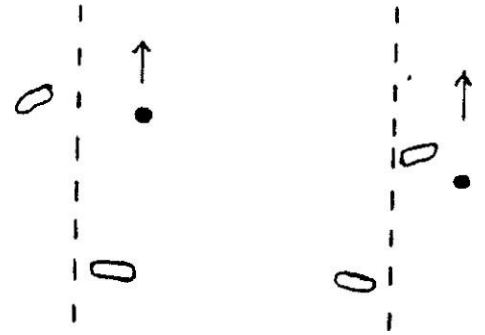
The final 'planting' step in the approach to hit is crucial in developing

- balance
- transfer of weight, thus increasing momentum
- a low centre of gravity and correct posture (straight body segments)
- increasing accuracy

Experiment with planting the left foot in

- (1) open position
- (2) closed position

Which allows greater rotation?



Planting the foot with the toes pointing slightly outwards allows for greater rotation, especially the hips.

Much practice has to be done to perfect the footwork and angle of approach, to coincide with the 'bump' into the circle by the PC stopper in order to maximise momentum, and to cut down the stop/ hit time lag.

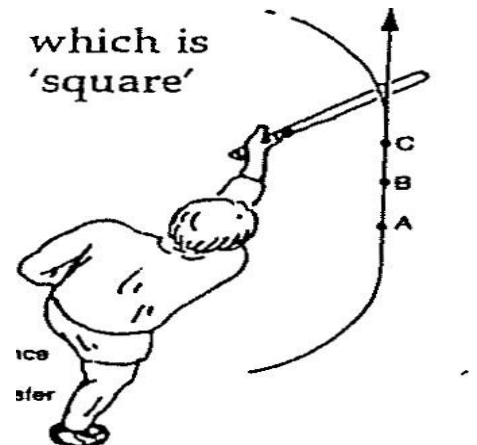
ACCURACY COMPONENT:

As the stick is travelling in an arc, the ball after impact moves in a line which tangential to impact point, assuming that the stick face is in the desired 'square' position.

- (1) to increase the accuracy of direction, the arc is flattened by moving the centre of the arc in the desired direction

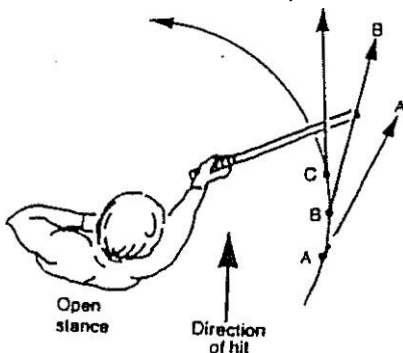
This is aided by transfer of weight, trunk movement towards the goal and most especially the right shoulder and hand coming into play.

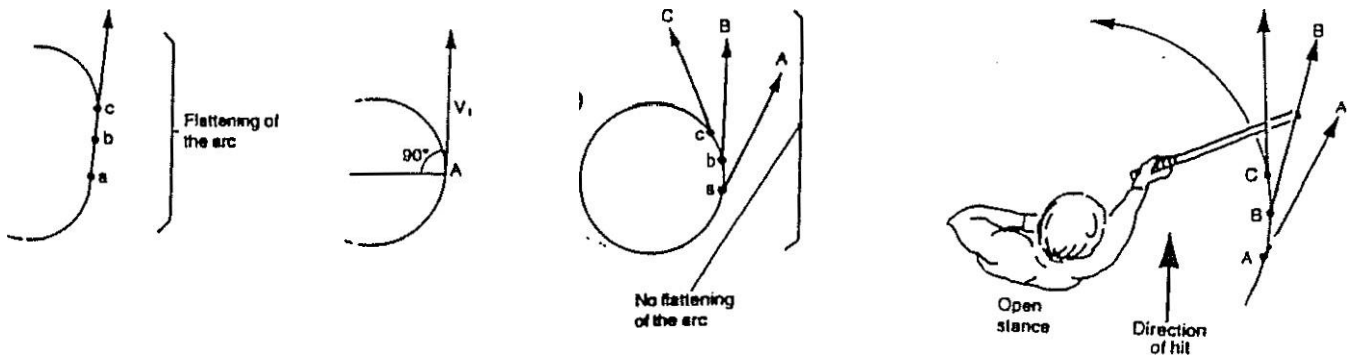
- (2) There must be a balance between producing speed yet maintaining accuracy.



Arc is flattened, contact at either A B or C will result in a straight hit.

Arc not flattened, contact at B.





Arc is not flattened only contact at B will result in straight hit.

CANING ACTION FOR POWER:

A knowledge of Biomechanical techniques can greatly improve club-head speed, balance, body position and foot position.

At impact, if the right shoulder can be brought into play, via a good shoulder rotation and strong right hand, the player can produce a powerful 'caning' action similar to top hitters. There are also similarities to the action of skipping a stone across the top of the river.

Many, many hundreds of balls must be hit to develop the hitting muscles, to develop timing, correct footwork, posture and balance.

Players must be motivated towards becoming competent hitters. Understanding the principles and being able to self-evaluate is the first step, following this up with hours of dedicated practice will ensure perfection under pressure.

Great hitters should generally:

- be tall
- be strong
- be able to develop power (strength x speed)
- have good flexibility in hips trunk and shoulders
- have a strong grip and use a longer stick.
- use a bigger stick hook

- use a stick with the weight primarily in the head
- practice long and hard with the 'PC corner-bracket' to develop a smooth functional unit with fast accurate injection, perfect stop and bump, and a short time lag between the ball crossing the circle line and when the stick makes impact.

COMMON FAULTS AND REMEDIES IN JUNIORS PLAYERS:

When addressing the ball, the player moves their hands away before moving the head of the stick and gets too much swing rotation.

When addressing the ball, the player moves the stick head before moving the hands and gets too much “wrist break” at the top of the back swing.

From the stationary ball position with the head of the stick addressing the ball, ideally the player should move the hands at the same time as the head of the stick.

When stepping into the ball to hit, the player steps too close to the ball without maintaining the desired distance to achieve a flattened swing arc.

Ensure players maintain a “distance” between their feet and the ball allowing the “swing plane” to be flattened (swing around the body rather than up and down). Some coaches teach stepping to the ball with a “box” technique.

Player tries to “club” the ball with an aggressive jerky back swing.

Coach players to “stroke” the ball focussing on a quality strike ahead of power in early stages of player development. I liken this to delivering it nicely and efficiently to the target. Slow down the backswing to achieve rhythm.

PERFORMANCE = LEARNING + MOTIVATION
