Arm Action in Hockey Skating- Is It Being Taught Incorrectly?

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Introduction

The arm movements in both speed skating and hockey are less understood than many of the lower body movements, as the majority of research focuses on variables pertaining to the trunk, hip, knee and ankle for both sports. However, coaches in sports such as high jumping and volleyball include equal emphasis on the movements of the upper body, as they teach their athletes to use a large arm swing beginning in shoulder hyperextension and flexing forward and upward in coordination with knee and hip extension. This forceful upward movement of the arms in jumping has been found to increase the ground reaction forces that the athlete can apply against the ground and therefore increase the force that the ground will apply back on the athlete due to Newton's 3rd Law of Motion, the Law of Reaction. The faster and more powerful the arm swing, the higher the jumper will jump {Feltner, 2004 #90;Lees, 2006 #91}. The arm swing will enhance the jump height considerably, by increasing the work done by the hip, knee and ankle joints during push off {Hara, 2005 #92}. This increase in work was produced by the additional load on the lower extremity due to the arm swing. This forceful arm swing should take on equal importance when performed by skilled skater, as it could also increase the ground reaction forces on the skates and increase the work done by the lower extremity joints while the athlete is pushing off. When skating athletes are able to use a vigorous arm swing as they are extending at the knee and hip, it will allow them to increase the force that they can apply against the ice, therefore increasing the force applied by the ice on the athlete.

The hockey stride being referred to here is used in the all out sprint in the game of hockey, such as seen in icing or back checking when the skater has to attain top speed for several seconds of play. There are times in hockey when fast changes of direction are required and shorter

strides and a more upright position are necessary, so the optimal sprint technique may not be needed.

Speed skating coaches have long known that the most effective arm action in speed skating is to swing the arms wide of the body, in a sideways direction rather than in a forward backward direction. As the right skate pushes out to the side of the body, the left arm also drives out towards the left, in order the increase the sideways ground reaction forces on the driving skate. Speed skaters are always taught to swing the arms sideways, out to the side of the body, to correspond with the sideways direction of the push off of the skates.

Hockey coaches almost invariably teach the arm swing in skating to occur in the forward backward direction, similar to that seen in running directly forward {Glantz, 2010 #83;Nauman, 2009 #80;Rhoads, 2010 #82;Stamm, 2010 #81}. Most coaches and skating instructors will have hockey players practice flexion-extension of the shoulders and hips when striding {Bracko, 1999 #76}. Their reasoning is that since a hockey player is primarily moving forward, their movements should be forward (flexion and extension of the hip and shoulder). As one author recently noted "Swinging your arms forward and backward while skating creates momentum in the same way that swinging your arms does while running"{Nauman, 2009 #80}. However, it is clear that flexion-extension of the shoulders and hips while skating hinders the coordination pattern required for effective skating, and in fact is almost impossible in hockey skating. The coordination pattern required to drive the arms forward and backward while the legs are driving out to the sides is difficult and counter productive in that the momentum of the arms is in a forward backward direction while the legs are driving the body from side to side.

Since momentum is the amount of motion that an object has in a certain direction, because it is a vector, the momentum contributed by the arms should be in the same direction as that produced by the leg drive. The correct movement of the shoulders and hips during skating is abduction and adduction- movements to the sides. This paper will provide an examination of the role of the arms in skating in general, and in hockey skating in particular, with a view to attempting to explain why a sideways arm swing should be taught to maximize skating effectiveness.

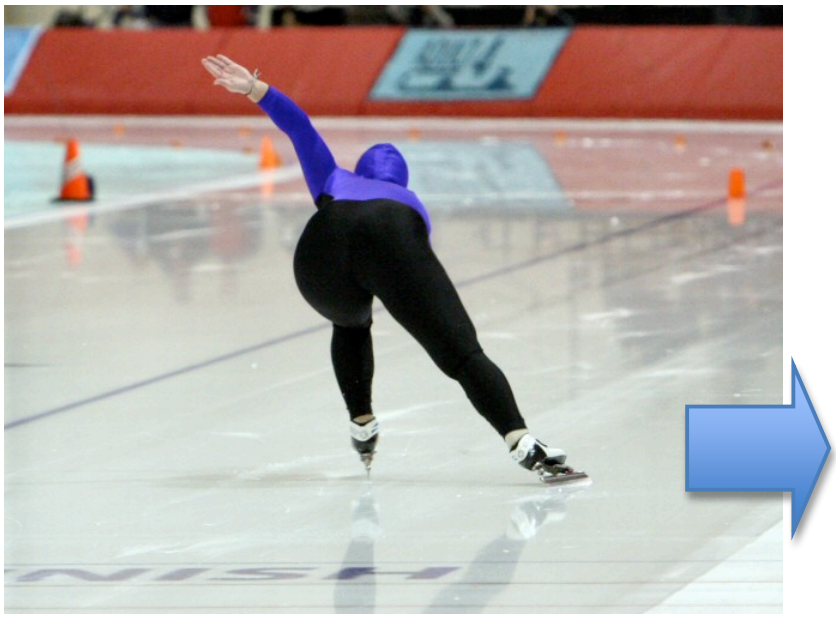

Figure 1. A skilled speed skater drives sideways with the right leg while the left arm swings out to the left. The swinging arm increases the sideways forces on the skate and increases skating velocity.

Figure 2. A skilled sprinter drives down the track with the arms moving directly forward and backwards. The arm swing increases the Ground Reaction Forces on the driving leg

Ground Reaction Forces

According to Newton's Third Law of Motion, for every action force there is an equal and opposite reaction force {Hay, 1993 #84}. When a person is standing motionless on the ground the body weight produces a force

acting directly downward toward the middle of the earth. In order for the system to be balanced, the ground must provide an equal and opposite reaction force acting upward to balance the weight. This equal and opposite upward force provided by the ground is known as the ground reaction force (GRF). The GRF can be increased by the acceleration of body parts in the direction of the desired movement. Often a jumper will want to maximize the downward forces against the ground so that the resulting GRF will be maximal in the upward direction.

For example, when performing a vertical jump the jump height can be increased by swinging the arms forcefully upward using shoulder flexion during takeoff. As the arms are driving upwards, the upward arm motion produces a downward force on the shoulders, which produces a downward force on the hips, which increases the downward force on the feet and increases the upward GRF on the body {Dapena, 1988 #85}. This increased upward GRF will increase the height of the jump by increasing vertical velocity at takeoff. The Impulse-momentum relationship suggests that a greater Force x time will produce a greater change in velocity ($Ft = Mv_f - mv_i$). Also, Newton's Second Law of Motion states that force is proportional to the acceleration ($F = m \times a$). A faster and more forceful upward arm swing will increase the ground reaction forces at takeoff, and increase the upward acceleration of the body.

The ground reaction forces that act upward and forward on the sprinter are increased by the use of forceful arm actions in the upward and forward direction. As the support foot is placed on the ground slightly in front of the runner, the support leg will flex slightly to help in decelerating downward motion at foot strike. This support flexion will produce a slight decrease in ground reaction forces prior to the concentric contraction during push off. Following maximum support flexion in mid support, the sprinter will push off forcefully from the support foot to drive the body upward and forward into the next stride. This push off comes primarily from the contraction of the sprinting muscles of the support leg, the hip extensors, knee extensors and the plantarflexors. Both hip extension and knee extension are also important movements in the push off phase of the skating stride {Lafontaine, 2007 #87}. The greater the range of knee and hip extension from a position of

support flexion, the more forceful the push off. Fast hockey skaters were found to have more knee flexion immediately prior to the propulsion phase, and slow skaters did not flex their knees as much during fast skating {Page, 1975 #72}. A forceful push off will occur as these muscles are powerfully contracted to drive the body off the ground.

Figure 3. This skilled sprinter keeps the arms in the sagittal plane to avoid unnecessary rotations of the trunk and hips during the stride. All movements should be in a forward backward direction through an optimal range of motion.

Role of the Arms in Sprinting

Sprint coaches have long emphasized the role of the arms in helping their athletes in sprinting faster and more effectively. Top sprinters are seen to perform a very defined and deliberate pattern of ideal arm motions that are used to improve sprint speed. Sprinters try to maximize the range of motion of the arms, the direction of the arms, and the speed of the arms, in order to maximize the ground reaction forces that are propelling them forwards and upwards. The arms are driven directly forward and backwards during the sprint stride, in unison with the leg drive. As the left leg is pushing from the blocks, both arms are driven directly forwards and upwards, producing a downward force on

the body and increasing the ground reaction forces on the driving foot (Figure 2).

This forceful drive upward and forward of the legs from the ground can be increased by the use of the arms. A forceful forward and upward motion of the arms will increase the downward forces on the ground, and increase the upward forces on the athlete. The technique of the top sprinters of today are characterized by a large range of motion of the arms, as well as by keeping the arms moving in the sagittal (forward-backward) plane rather than moving sideways or rotating around the trunk. The direction of the arm swing is important as it determines the effectiveness of the arm movement in increasing the GRF in the correct direction. Forward upward movements will increase the downward forces in the downward backward direction to maximize leg drive, while if the arms cross in front of the body this rotation will increase the magnitude of the undesirable sideways forces on the ground.

The timing of the arm action in sprinting will also determine the effectiveness of the arms in increasing the GRF. The peak velocity of the arm swing should occur in mid push off phase of the driving leg, so that the ground reaction forces produced by the arm swing can be effectively applied to the sprinter during push off. Peak upward velocity of the arms will occur near the middle of the upward range of motion of the arm swing, which should occur at a point just past the vertical, when the arms pass the body and are moving upward to their highest point. The point of peak angular velocity of the arms will be determined by how large the range of motion of the arms is, or how high each arm is raised during the arm action.

The optimal position of the arms in sprinting is with the elbows flexed to ninety degrees (Figure 3), as this will minimize the moment of inertia of the arms about the shoulder joint and decrease the torque required to move them. This position will conserve the sprinter's energy and increase their angular velocity about the shoulder with any applied torque. More highly skilled, faster sprinters will have a greater range of motion of the arms. Optimal range of motion for skilled sprinters appears to be with the hand reaching the level of the eyes on the forward swing and with the upper arm reaching the horizontal behind the body on

the backswing (Figure 3). However, sprinters differ from skaters in that their stride frequency is much faster. Sprinters may attain a stride frequency of 4.3 strides/sec during the top speed portion of the race {Mann, 1988 #86}, while skaters attain a much lower 1.3 strides/sec during their top speed portion of the sprint races {Bedingfield, 1983 #89}.

Trunk Rotation in Sprinting and Skating

Trunk rotation in sprinting is generally undesirable, as it is caused by angular momentum in the transverse plane around the vertical axis that is usually created by the arms. This movement is wasteful of energy as it does not contribute directly to the sprinter's velocity down the track. Sprinters try to keep the shoulders facing down the track as much as possible, and trunk rotation is kept to a minimum. Excessive trunk rotation is often produced by driving the arms across in front of the midline of the body, so their rotational angular momentum is transferred to that of the trunk. If the arm motions are primarily in a forward backward direction, their angular momentum can aid in the forward and upward movement of the trunk. These forward backward movements of the arms also increase the vertical and forward ground reaction forces, as previously suggested (Figure 3). Sprinters who are very muscular and have exceptionally large shoulders and arms will often produce too much trunk rotation from the arm swing during the sprinting stride. The greater the angular momentum produced by the arms crossing in front of the trunk, the more trunk rotation that is produced (Figure 4) and the greater the detraction from the forward movement that can cost precious hundredths of a second.

Figure 4. This muscular sprinter exhibits considerable rotation of the shoulders, likely due to the angular momentum produced by the arm swing around the vertical axis.

Trunk rotation in skating is generally desirable, as it increases the range of motion of the shoulder girdle in the transverse plane. The further the shoulder girdle rotates to the left and right during the stride, the greater the range of motion of the arms in abduction and adduction. This greater range of arm motion will also eventually produce increased ground reaction forces, since the longer the shoulder range of motion and the faster the arm moves, the greater the forces on the shoulder girdle and the opposite skate. The hockey skater in Figure 5 has a wide arm swing that increases the forces on the driving skate. The left arm appears to be left behind the trunk due to the rotation of the shoulder girdle, although it is actually swinging out to the side of the body.

Figure 5. This skilled hockey player exhibits a wide left arm swing out to the sides of the body. This arm swing has increased the forces on the right skate.

Trunk flexion in sprinting and skating

Following the start of the sprint race, sprinters do not want to have excessive trunk flexion as they attain top sprinting speed. The trunk gradually rises up to the vertical position during the first 20 m of the race. The trunk should be kept upright, with no more than 5° of forward trunk lean, as vertical forces are important to project the body upward and forward into the next stride. In speed skating, however, the skater should have as much trunk flexion as possible. Ideally, the skater should have the trunk in a horizontal position parallel to the track, with up to 90 degrees of trunk flexion (Figure 6). The reasons for this horizontal position are primarily to minimize air resistance acting against the skater by decreasing the cross sectional area of the skater in the direction of motion. Air resistance can cost the elite speed skater up to 15% of their energy cost for the skate, so to minimize their cross sectional area would increase efficiency of the skater. As well, the flexed trunk will help to place the hip extensors in an optimal position from which to push off. As the skater flexes the trunk forward the gluteal muscles are placed on a stretch, so they will have a longer effective range through which to push off strongly in hip extension and lateral rotation.

Ice hockey skating has slightly different skill requirements than speed skating in terms of trunk position. A greater trunk flexion position is also desirable in hockey, to decrease air resistance and to place the hip extensor muscles on a greater stretch for the subsequent contraction.

However, the hockey player must be able to see a wide field of view in front of him, and this wide field requires a more upright trunk position. Hockey players should try to flex forward as much as possible when skating near top speed in open ice, in order to maximally engage the hip extensor muscles. Trunk flexion also helps the hockey player to line up his trunk with the driving skate so that more of the force can be used to propel the player forward and sideways (Figure 7). It has been reported that faster hockey skaters had greater trunk flexion and more forward lean, whereas slower skaters were more upright with less trunk flexion during fast skating {Page, 1975 #72}.

Trunk rotation is desirable during fast hockey skating, as the trunk rotation away from the driving skate moves the trunk more in line with the force from the skate. As the player is driving from the right skate, the trunk is rotated toward the left side and is leaning toward the left side (Figure 5). These movements line up the trunk more directly with the force vector of the pushing skate and increase the effectiveness of the push off. To increase skating speed, skilled skaters should engage the trunk with slight trunk rotation and slight lateral flexion away from the driving skate.

Role of the Arms in Speed Skating

The role of the arms in skating is similar to that seen in sprinting- to increase the magnitude of the ground reaction forces in the direction of the desired motion. As well, the arms in sprinting will help to balance the driving motions of the legs around the vertical axis of the body. As the right leg drives forward into a stride, it tends to rotate the body to the left around the longitudinal axis since it is acting lateral to the long axis of the trunk. The driving left arm will help to take up these unwanted rotations and keep the trunk balanced and minimize unwanted rotations. However, the movements in skating are quite different from those seen in sprinting. The movements in skating are oriented much more in the sideways direction, using hip abduction-adduction movements and not flexion-extension movements. Fast skaters have wide strides because they push to the side, abducting while extending the hip during propulsion and adducting while flexing the hip during recovery. The

equal and opposite reaction of the body to hip abduction and adduction is shoulder abduction and adduction. The shoulders have to adduct and abduct in unison with the hip movements to maintain balance, momentum and increased velocity, whether the player has one or two hands on the stick {Bracko, 2004 #73}. The vigorous arm movements should be maintained in the arm with the stick as well, as this arm swing can also assist with the driving forces of the skate.

The use of the sideways action of the arms in skating is to increase the sideways forces on the ice applied by the skate blade. This increased force is required due to the low coefficient of friction seen between skate blade and the ice surface. If the skater were to push directly backward with their skate blade while gliding forward down the ice, the blade would simply slip backwards and forwards on the ice as it is not possible for the skate to grip the ice when driven directly forward and backward. Since the legs clearly move sideways during the skating stride, the arms should follow this pattern. Skating therefore consists of a sideways directed force in which the skater will move sideways away from the pushing skate with each stride. The movement in the pushing leg is primarily hip abduction (leg moves outwards sideways) accompanied by forceful hip extension (leg moves back behind the body) and hip lateral rotation (the toe of the pushing foot rotates to point to the outside). The latter two movements occur at a slight angle to the side of the body so that the leg push off is not perfectly sideways but diagonally to the side. The drive of the arms should be in the same plane as the drive of the legs, which is primarily sideways and only slightly backwards.

An essential technical aspect of skating is that the direction of the push off is perpendicular to the gliding direction of the skate {de Boer, 1988 #77}. The skater therefore has to tilt the skate blade to grip the ice with the inside edge of the blade, and use the blade edge to push sideways against the ice. This sideways push occurs while the skater is skating diagonally forward on the ice, so the push is actually directed diagonally sideways and backward as the skater is moving away from the skate.

It should be noted that some speed skating authors advocate the forward backward arm swing even in speed skating {Watts, 2002

#93}{United States, 2002 #94}, where it is seldom observed. These authors appear to be incorrect in their assessment of the correct pattern of arm movements in speed skating.

Role of the Arms in Hockey Skating

The role of the arms in hockey skating is the same as it is in sprinting and speed skating- the increase the ground reaction forces from push off to increase speed down the ice. The arms should swing forcefully and rapidly along the same line as the push off from the skate, in order to maximize the drive from the ice. If the skating leg is pushing directly sideways on the ice, the arms should also move sideways. Since the hockey player is moving rapidly down the ice with each stride, the push off is actually somewhat diagonal- the leg is moving sideways as well as slightly backward. The movements of the driving leg include hip extension, knee extension and some lateral rotation of the hip to maximize the driving force of the push off leg.

Hockey skating coaches are incorrect when they advocate forward and backward movement of the arms during the stride {Nauman, 2009 #80;Rhoads, 2010 #82;Stamm, 2010 #81}. It has been suggested that the arms should move forward and backward in such a way that the elbows stay close to the ribs as they move {Glantz, 2010 #96;Stamm, 2010 #81}. {Stamm, 2010 #81} suggested that the skater finish each forward and backward swing of the arms with the elbows straight and with the palms of the hands facing upwards. As stated by a hockey coach {Glantz, 2010 #96}: The importance of correct arm swing when skating cannot be minimized either. Make every attempt to have your arms swing to the front, with one hand on the stick, in the direction you are going, not passing the mid-section of your body because that can take your momentum from side to side and throw off your balance, all resulting in a loss of speed.

Another hockey coach has suggested:

Keep your arms tight to your side. One of the biggest mistakes that a lot of people make skating is that they let their arms move loosely, often from side to side. Any motion that isn't in the direction that you're skating is just bleeding off energy and causing your balance to lower. Keep your arms tight at your side, and pump them in the direction of your motion, not from side to side {Rhoads, 2010 #82}.

A further suggestion follows {Roy, 2010 #95}: We teach players off and on the ice to exaggerate the arm swing. I want the arms thrown directly forward and

back, with an elbow bend on the way back and a full extension of the arm on the way forward. The elbows should be kept in. If the elbows go out to the side then the arms invariably start to move side to side again. The arms when thrown forward should come from underneath and up, like a typical arm swing, i.e. not straight out from the shoulder. The arm thrust forward should not come up above the chin.

The previous authors are in error in their description of the direction of motion in skating being directly down the ice. The hockey skater does not move directly forward down the ice, but they move from side to side in response to the sideways push off of the skates. The arms need to move in this sideways direction as well, and help increase the forces on the skate rather than trying to generate momentum in the direction of the skater. The arms will make a greater contribution to skating speed when directed sideways with the legs, rather than in a forward backward direction in conflict with the motion of the legs.

Figure 6. Speed skater exhibits ninety degrees of forward trunk flexion, with a sideways leg drive and a wide lateral arm drive. Note that both arms are swinging in a direction away from the driving skate, to maximize the ground forces.

{Bracko, 1996 #74} studied the effect of different shoulder movements on acceleration in high school hockey players. Each subject was randomly instructed to accelerate with one of two shoulder movements, either abduction/adduction or flexion/extension. No significant differences were found between acceleration techniques, but the researchers did find differences between groups that approached statistical significance. The athletes who performed shoulder

adduction/abduction were faster than those who performed flexion extension {Bracko, 1996 #74}. It was further reported that 13 subjects were eliminated from the data analysis due to an inability to perform the flexion/extension actions of the arms in hockey skating. They suggested that this finding may be an indication that natural movements of the shoulders during acceleration are abduction and adduction, or "side to side" shoulder movements {Edwards, 2004 #75}.

Figure 7. A skilled hockey skater showing the stick in one hand and the right arm swing out to the right side to oppose the left leg drive. Note that both arms are swinging in a direction away from the driving skate, to maximize the ground forces away from the skate.

The arm movements of skilled hockey players are subject to some interference from the stick, and the extent of the interference depends on whether there are two hands on the stick or only one. When carrying the stick in one hand, the arm movements should still occur in a sideways direction, with the free hand taking a full swing and the hand with the stick taking a somewhat modified swing. The direction should remain constant but the range of motion with the stick is modified. The hockey skater driving from the right leg should drive the left arm out to the side in a direction opposite to that of the leg drive (Figure 7).

When the stick is carried in two hands, it is essential that the arm swing occur in a sideways direction in order for the stick to clear the

body. The stick moves sideways across the front of the body while the arms drive directly sideways with the stick. It is not possible to move the arms in a forward backward direction when there are two hands on the stick.

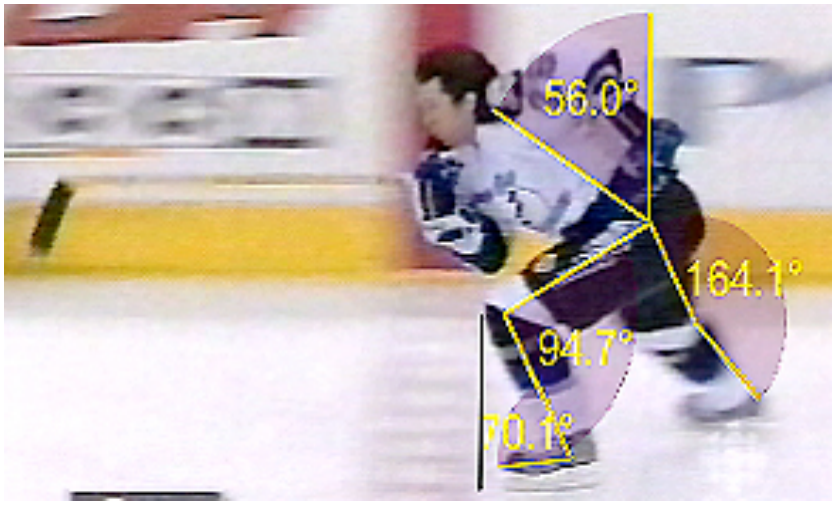

Figure 8. Hockey skater showing good technique with right leg drive out to the side, and left arm swing out to the opposite side to increase forces on the driving skate. Note the right arm is also moving away from the driving skate. Good position of trunk flexion and trunk rotation to the left in this skilled skater.

Sideways Arm Action

As previously noted, the primary direction of the push off in skating is sideways, due to the necessity of edging the skate blade to produce the sideways push. The driving skate drives outward against the ice so the ground reaction forces drive the skater inwards. The ground reaction forces should therefore be directed primarily sideways, in order to maximize the GRF to propel the athlete away from the pushing skate. The leg drive is therefore directed primarily out to the side, with a slight diagonal component due to the forward progression of the skater.
Since the objective is to maximize the outward forces on the skate blade, these forces can be increased by the use of a forceful arm swing. If the skater drives the arms outwards in a sideways direction, the arm will push inward on the shoulder joint, which will push inward on the pushing hip, which will increase the downward outward force on the hip and the GRF in the direction of the inward movement of the body. The larger the

range of motion of the arm swing and the greater the angular velocity of the arm, the larger the increase in the GRF of the pushing skate.

Figure 9. A skilled hockey skater exhibiting a wide arm swing to the right side, in opposition to the leg drive from the left skate.

Figure 10. Skilled speed skater with a wide arm swing to the right side coordinated with the sideways drive of the left skate.

Arm Action in Hockey Skating

Hockey skating is currently taught by most coaches as a pure forward backward motion of the arms {Glantz, 2010 #83;Nauman, 2009 #80;Rhoads, 2010 #82;Stamm, 2010 #81}. Although no valid rationale is usually given for the selection of this technique, it has been universally

accepted by almost all hockey coaches, and by default by ringette coaches as well, as the ideal technique for fast skating. The players are told to move the arms in the forward backward direction only, much like that seen in running. Emphasis is on keeping the arms in the sagittal plane and not moving them sideways, and to move them as fast and vigorously as possible. This technique is sometimes explained in terms of keeping the momentum of the arms moving in the same direction down the ice as the momentum of the skater, but this is a false assumption. The skater is actually moving from side to side down the ice, so the forward backward arm swing may actually be detrimental to skating performance.

The basic premise of this paper is that hockey coaches teaching the forward backward action of the arms in hockey skating are incorrect. If the skate push off is primarily in the sideways direction, and increased speed is attained primarily by increasing the force of the push off, then a sideways arm swing should be used by all hockey players. Skilled hockey players should resemble skilled speed skaters when skating at top speed, with the arms swinging wide out to the sides of the body using the movements of shoulder abduction and adduction.

Why use shoulder abduction?

Recall that the skilled skater must push the skate out to the side of the body, in order to drive the body away from the pushing foot. For a drive from the right foot, the inside skate edge digs into the ice beside the skater, and the hip is forcefully abducted to drive the body sideways toward the swing leg. As the right leg is driving the athlete, the arms are swung towards the left side, creating a greater force on the pushing foot. The wider the arm swing, and the faster the arms move, the greater the GRF are produced on the driving skate. Since most of the force on the support skate is directed sideways, the arm swing should also be directed sideways. Since the support skate is unable to push backward on the ice due to lack of friction in the backward direction when the skate blade is aligned forward, a forward backward arm swing would not assist the skating stroke. It has been reported that more highly skilled skaters have

greater lateral excursion of the body during the power stroke, due to a longer and more forceful push off {Upjohn, 2008 #88}.

Figure 11. Skilled hockey player with a wide arm swing out to the side and good trunk rotation. Trunk rotation and trunk lean helps the skater drive the body sideways.

Forward backward arm swing is incorrect in hockey

Hockey coaches invariably advocate the forward backward arm swing technique when teaching skating to beginners, and when practicing technique at all levels {Nauman, 2009 #80;Rhoads, 2010 #82;Stamm, 2010 #81}. It is unclear why this forward backward technique has been adopted, since the sideways arm action would produce larger ground reaction forces in the direction of the sideways skate movement and produce a more powerful stride. Skilled speed skaters all use the sideways arm swing in their skating stride because it produces a more powerful stride. Hockey players who choose to use this technique could gain the same advantage. An interesting point here is that skilled hockey players skating at top speed usually use the sideways arm swing regardless of what they have been taught. It is more natural and leads to increased speeds, so good players revert to the most mechanically sound technique. The most efficient technique is often used at top speeds regardless of what is being taught by coaches.

Figure 12. Skilled hockey player with a wide arm swing out to the side, and good trunk lean forward and trunk rotation to the left. Maximum arm velocity occurred at peak angular velocity of leg abduction.

For maximum performance of hockey skating, smooth, coordinated abduction and adduction movements of the shoulders and hips are required for high performance {Edwards, 2004 #75}.

Figure 10. Mid push off of a skilled speed skater, showing mid arm swing to the right as skate is pushing to the left.

Summary

Skilled and fast skating is essential for a young player to be successful at ice sports such as hockey and ringette. Fast skaters are

characterized by a long sideways push off, forward trunk flexion, greater knee flexion and hip flexion during push off, faster recovery following the push off and a sideways arm swing. A wide skating stride using a large range of hip abduction should be accompanied by a wide arm swing using sideways arm movements. The shoulders should rapidly abduct and adduct in a smooth movement pattern coordinated with the abduction and adduction of the hips. Hockey coaches should teach the arm swing in a sideways direction rather than in the forward backward direction, in order to produce more skilled and faster skaters. The arm swing sideways produces higher ground reaction forces on the driving skate so the push off will produce higher ground reaction forces. Coaches will also find that this sideways motion is a more natural movement for most skaters, this arm swing will be easier to learn and that it will improve the power and smoothness of the skating stride.

REFERENCES