

# Introduction of a Glide Phase in Skating Mechanics for Hockey Players

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I recently read some information from the Institute for Hockey Research, <http://www.hockeyinstitute.org>, about which I would like to comment. Some of the information presented on the site is quite valuable. The data helps the hockey coaching community to further our understanding of game specific behaviors. Some of the information suggests strategies for improving skating performance. This is the information I would like to comment on specifically.

There is a shortage of quality skating information for purposes of instruction. Some good science has been done, in both biomechanics and physics, to describe proper skating mechanics. The trouble is understanding just what the information means. For instance, how does the following phrase translate into teaching method: “An essential technical aspect of skating is the fact that the direction of the push off is perpendicular to the gliding direction of the skate (Van Ingen Schenau, et al, 1985)”? Making use of technically worded descriptions like this one has proven difficult for a great many skating practitioner. It is my endeavor, in this paper, to unravel some of those difficult concepts.

I would like to begin by discussing the following information posted by the Institute for Hockey Research at the following URL: [http://www.hockeyinstitute.org/x\\_skate1.htm](http://www.hockeyinstitute.org/x_skate1.htm)

Balance on one foot appears not to be an important performance skating factor for hockey players. A two foot glide position is an important performance characteristic and is the basis from which all other skating characteristics are derived.

I want to point out that the information as stated above is only an observation. It is assumed because professional hockey players are doing it that the behavior should be taught and emulated. Not long ago professional hockey players used straight wooden sticks, leather skates, and did not wear helmets too.

All skating characteristics evolve from a two foot glide position. The ability to move into other skating characteristics from a two foot glide position is important for hockey players as the nature of the game is stride - glide - stride - glide (Bracko, 1998).

The statement “all skating characteristics evolve from a two foot glide position” is not accurate. All skating acceleration must start with loading or putting pressure into one skate; a single-leg skating position. The scientific evidence in support of this statement is well documented. A single-legged glide, though not practiced by a majority of elite level hockey players, represents the most efficient transition from gliding to acceleration. This is because the athlete need not redistribute body mass to get the pressure required for acceleration. The athlete is already in the proper position to put pressure or force into the ice. In other words the single-leg skating position delivers the most pressure for the least amount of movement in the shortest amount of time and therefore is optimal.

Further information is provided at [http://www.hockeyinstitute.org/x\\_skate4.htm](http://www.hockeyinstitute.org/x_skate4.htm). Excerpts from this page include the following statements:

Velocity in speed skating is more dependent on stride length than stride frequency. This is the exact opposite of hockey skating.

Stride length needs to be defined in this statement. Dr. Braco has defined stride length as the distance measured laterally from the beginning to the end of the stroke. This definition was given by Dr. Braco at a lecture he gave at the International Skating Symposium in Detroit in 2003.

The physics of hockey skating and speedskating are no different. The physics state that speed in skating is generated from an applied force which is perpendicular to the skate blade. This fact is true for skating at all speeds. When a skating athlete starts from a dead stop the skate blade is not moving. The athlete turns the skate roughly ninety degrees and pushes off. Because there is no glide the acceleration is completely dependant on the stride length and the stride frequency. It is an impulse push; the more quickly the push is delivered the faster the athlete accelerates. I will refer to that stroke as the sprint stroke. As the athlete builds speed the skate is gliding through some part of the stroke. The gliding skate presents an opportunity to increase the amount of time putting pressure into the ice. The athlete can now deliver maximum pressure for a longer period of time. This is possible because pressure can and should be delivered while the skate is gliding. This pressure results in greater acceleration. The impulse push of the sprint stroke cannot deliver increasing acceleration at increasing speeds. The fastest skaters in hockey make use of this technique. These athletes have learned to apply pressure for a greater length of time per stroke than other athletes. I call this stroke the effective stroke.

The effective stroke and the sprint stroke are inversely related where acceleration is concerned.

As the effective stroke increases in it's ability to deliver acceleration the sprint stroke decreases. The sprint stroke delivers acceleration more



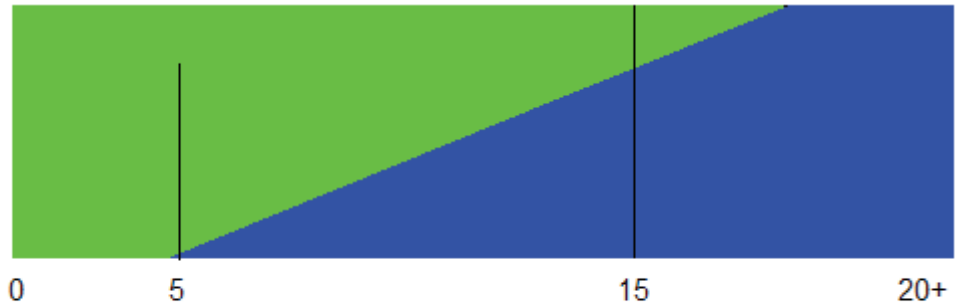
The top image shows the athlete beginning a left leg stride. When the stride is complete the lateral distance traveled is equal to three feet three inches (1 meter). This is Dr. Braco's method of stride length measurement. It is an important power component. Equally important, though overlooked, is stride length measured in distance traveled. This pressure, delivered during phase one of the stroke, is critical to efficient speed.



The skater above has traveled forward two feet and seven inches (.75 meters) on a left leg stride. Forward stride length increases with speed when using the effective stroke properly.

quickly at low speeds than the effective stroke but the effective stroke is required to build speed on top of the sprint stroke. As acceleration creates a gliding component the effective stroke plays an

Stroke used



Speed of athlete

increasing role in acceleration. While the amount of time spent gliding increases (i.e. the athlete's speed increases) the resulting force vector is directed from the transverse plane toward the frontal plane. Another way to say this is that generally the athlete's leg finishes rearward during the sprint stroke and finishes sideways during the effective stroke.

The graphic above represents the inverse nature of the sprint and effective stroke. The sprint is represented in green, the effective in blue. Up to five units of speed the sprint stroke provides all of the thrust. At seventeen units it is entirely the effective stroke providing the thrust. In this graphic, speeds beyond seventeen units can only be achieved using the effective stroke.

Force vector is an important concept so let me break rhythm now to describe what it means. There are times when a skater's body is directly over the top of the skate. When that is the case the force vector is straight down into the ice. There are times when the skater's body is not over the top of the skate. This happens when turning. While turning the force vector still must be directed into the ice. The force vector is now angled



Example of force vector directly into the ice.



Example of an angled force vector.

through the athlete's torso and into the ice through the skate. So the force vector will change based on the position of the athlete's torso, where the skate is in the stroke, the direction the athlete is traveling, and the athlete's speed. The force vector is the amount and direction of the force generated by an athlete into the ice.

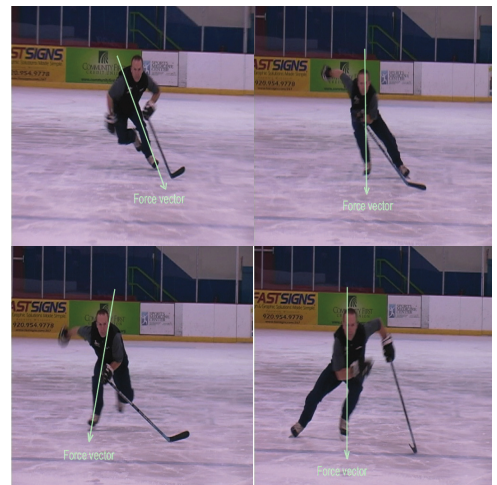
The "Railroad" skating style is a sprint stroke. The athlete does not take the time to glide with pressure. This is inefficient because of all the extra strokes required to maintain speed.



The effective stroke can build speed during the glide phase if the athlete produces early and continuous pressure. To get early and continuous pressure the athlete must recover the stroke so the torso is over the force vector into the ice. With the body weight over the force vector the athlete can deliver maximum pressure down into the ice and control the glide phase. These two details are very important. Many

hockey skating instructors, Dr. Braco included, have sacrificed this body position to increase the stroke count. Increasing the stroke count will do nothing to improve pressure during the glide phase. The glide phase, when weighted and timed properly, provides speed beyond the sprint stroke. To control the glide phase the athlete must position the torso over the force vector into the ice at the start of a new stroke. If the athlete does not get the torso completely over the force vector the stroke cannot be controlled; the stroke is cut short because the athlete is falling to the inside of the push. This is the cause of the familiar “railroad” skating style. The skater quickly puts the skates on the ice, the upper body does not transition over the force vector, and the glide phase is short or non-existent. The “railroad” skating style results in quick recovery, substandard pressure, and limited glide phase. A majority of hockey players at all levels could make improvements in their speed, power, and efficiency by improving their body position and glide phase.

The effective stroke is defined by two phases. The phases are determined by the position of the athlete’s torso relative to the force vector. As long as the athlete’s torso is part of the force vector the stride length is in the first phase. As soon as the body weight shifts out of the force vector into the ice the stride length has entered the second phase. The second phase of stride length is nothing more than follow-through. The second phase of stride length should not be emphasized as an opportunity to generate speed during the effective stroke. A good example of this is the toe flick. Emphasis on the toe flick to generate power or speed during the effective stroke is misguided. The opportunity to deliver maximum accelerating force has long passed by the time the toe flick is an option. Follow through is still very important but it will occur naturally and should not receive focus from instructors as a power delivery component. The majority of power delivery occurs in the first phase. A skater like Paul Kariya has essentially completed power delivery with a fraction of the total stride length completed. This is true because the weight of his torso transitions to the next stroke before the previous stroke is complete. For example, I have a fictitious skater with a stride length of thirty inches. This athlete completes phase one when her torso has moved off of the current push and is now in a position to load the next push. The stride length has traveled twenty inches when the torso moves out of the force



Here we see four images of a single stroke in progress. By the fourth image the athlete has moved the torso out of the force vector. The torso is now ready to begin loading the next stroke.



Kariya has not finished the left leg stroke but his weight has transferred to the new push completely.



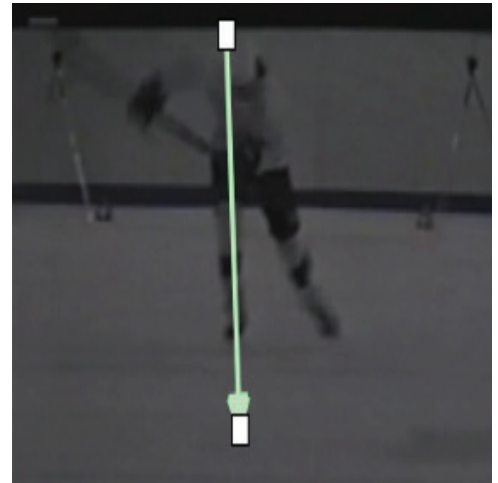
Kariya is so effective because he has a longer glide phase. He continues to push throughout the glide phase putting pressure down into the ice.

vector. That leaves a remaining ten inches to complete follow through of the stroke. She has transitioned her weight to maximize the pressure early in the next push. This concept, getting the pressure early in the stroke, is critical to fast, efficient skating.

Phasing of the stroke is a mental concept. It is not a physical concept that the skating athlete should feel. It is a tool for instructors to convey the movements and the focus of the effort for the athlete. It can also help the athlete by providing a visual for proprioception. Powerful and efficient skating requires that transitions from the sprint stroke to the effective stroke, and vice-versa, are fluid and controlled. The mechanics of the two strokes are different. The athlete will need to be patient and diligent while learning the effective stroke. First the athlete must learn the physical movements. When the physical movements are understood the athlete can learn timing of the stroke. Timing the stroke includes timing the exclusive movements of the effective stroke and timing the transitions from sprint to effective. Both of these timing tasks are detailed. Feel of the movements and feeling pressure cannot be over-emphasized when the athlete is learning. The instructor can help the athlete with cues regarding body position, pressure, and movement. The instructor cannot feel or time the movements for the athlete. Each athlete will have a unique experience and should be allowed to develop their own “style” while conforming to loosely defined rules of thumb.

What does this mean for hockey skaters? Current training techniques for hockey skaters based on measured stride length (the lateral distance measured from the beginning of the stroke to the end of the stroke) and stroke frequency needs to be augmented with a measured glide phase. The glide phase directs pressure into the ice using the mechanics of the effective stroke. Generally speaking higher speeds will require proportionally greater glide times during the stroke to maintain or increase speed. Plantar pressure distribution measurement systems have revealed hard numbers for both pressure distributions and timing to improve skating performance.

After push-off, speed skaters bring their recovery skate back under their body, and when they put it back on the ice, they land on their outside edge, roll onto their inside edge, then push-off.



At the beginning of this push the athlete is not getting the body over the top of the push.



Midway through the same stride and the athlete is not taking advantage of a glide phase by getting the torso over the force vector into the ice.



Stride is now completed and transition has been made to the new push. Athlete is not getting body over the force vector into the ice on the new push.

I do teach hockey skating athletes to bring the knee of the recovery leg to the calf of the skating leg. This has benefits. It is a good way to augment injury prevention strategies in hockey athletes. Hockey athletes tend to have very strong abducting complexes in the hip which are often not properly balanced by adducting complexes. Recovering the leg back to center requires and eventually builds great strength in the adductors and hip extensors. This technical requirement, full knee recovery, is difficult for



Samponov using an outside edge to start a left leg stride.

seasoned hockey athletes. This is because the act of returning the recovery knee all the way to the pushing leg creates timing issues for athletes that skate exclusively with the sprinting stroke. The reason it creates timing issues is because the skater must wait just a bit longer to transition to the next stroke. Waiting, which is an

opportunity to get early pressure and keep it, is where improved acceleration can occur. Additionally, a full knee recovery aids in positioning the torso over the force vector into the ice. Maximum pressure can be achieved when the athlete has the torso over the force vector into the ice. I do not instruct hockey athletes to place the recovery foot on the outside edge at the beginning of the new stroke, though it may have benefits.

**Forward hockey skating is consistently pushing off with the inside edge and landing on the inside edge.**

Once again this viewpoint is limited to the sprinting stroke. It does not apply to the effective stroke. There are numerous examples of skaters in the NHL where this observation is not accurate. Athletes who have pronounced glide phases in their strokes and place their bodies directly over top of the force vector into the ice while gliding include Paul Coffey, Bret Hedican, Scott Niedermayer, Marian Hossa, Paul Kariya, Sami Kapanen, Sergei Federov, and Brian Rafalski. I teach hockey athletes that there are two skating strokes and both are equally important. The first stroke is the sprint stroke. The sprint stroke delivers the most acceleration at low to moderate speeds. It is characterized by quick and



This is a pronounced outside edge placement which is typical of speedskaters. Note how close the other skate is. Speedskaters get their blades on the ice very early in the push.



Sprint stroke characterized by rearward thrust, rearward extension, and inside edge pushes.



Kariya's skate position is neither on the inside or outside edge. Part of the glide phase occurs with both edges on the ice. This position early in the stroke allows for a longer glide phase.

powerful movements in the hip extensors and quadriceps. The sprint stroke delivers impulse pressure rearward to drive the body forward. Acceleration using the sprint stroke is a function of stride length and stride frequency. The sprint stroke makes exclusive use of inside edges during linear acceleration. As an athlete's speed increases the rearward focused sprint stroke has diminishing returns. To accelerate further the resultant force vector must move in an increasingly lateral direction. As the skating stroke delivers pressure in an increasingly lateral direction a gliding force component is added to the stride length and stride frequency force components. To continue accelerating the athlete must properly time the recovery, glide, and lateral force components. The management and timing of the recovery, glide, and lateral force components are what I call the effective stroke. The effective stroke is the second stroke I teach hockey athletes. The acceleration improvements when the effective stroke is mastered, particularly during non-linear acceleration, can be dramatic. The efficiencies gained from effectively using a glide phase are also dramatic. I teach all hockey athletes with an equal emphasis on both the sprint stroke and the effective stroke.

Seasoned hockey athletes who endeavor to learn the effective stroke can be guaranteed a performance decrement before they show an improvement. The time to learn the new stroke will be based on many factors including musculature, proprioception, flexibility, timing the new force component, and athleticism. The performance improvements, which can be significant, are not limited to increased speed. The effective stroke is significantly more efficient as well.

The mechanics of the effective stroke deliver the most powerful, most efficient, high speed cross-over turns possible. High speed turning is where poor skating mechanics are easy to see in hockey athletes. Since the effective stroke is not taught most hockey athletes sprint through cross-over turns. Two critical mechanical errors occur when an athlete sprints through a turn; the glide phase is significantly reduced and the body weight is not positioned to deliver maximum force into the ice. The athlete still experiences good acceleration because the centrifugal force component increases the resultant force into the ice. A great deal of potential speed, power, and efficiency is lost, however, when the glide



This skater is turning the upper body into the turn. An upper body turned in unloads the stroke early. The upper body's role in the push is finished resulting in a short glide phase.



This skater is leaning into the turn with the torso. Leaning is another common technical problem resulting in a shortened glide phase.



This skater is loading the push with the torso over the force vector into the ice. This position allows the athlete to deliver maximum force through a prolonged glide phase.



phase and proper loading of the stroke with the torso do not occur.

Cross-over turns are a great example of the speed that can be generated from gliding. Hockey athlete's can feel the speed boost during a cross-over turn. This speed boost is caused by increased pressure. The cross-over turn increases the amount of force the athlete is able to generate through centrifugal force. The increased centrifugal force results in more pressure into the ice and therefore more acceleration. A terrific amount of speed can be developed even when an athlete incorrectly sprints through a cross-over turn. The perception becomes that sprinting through the turn is effective because acceleration is achieved. Unfortunately the result is less than the potential of a properly skated cross-over turn using the effective stroke. Acceleration in cross-over turns requires a glide phase which is cut short when using the sprint stroke. The increased force during a cross-over turn is a great opportunity to glide with pressure. Effectively using the glide phase requires less strokes than sprinting and so is more efficient as well. Most hockey athletes could improve their cross-over turning by incorporating the effective stroke.

Misinformation is common when teaching cross-over turns. Athletes are instructed to twist their upper bodies while turning. Another mistake is encouraging athletes to "run" through the turn as if to get off of a stroke as quickly as possible. These technical deficiencies result in lost opportunities for maximum pressure early and throughout the stroke. Arguments for twisting the body into the turn include seeing the ice or looking to where the athlete is going, or the phrases "where the torso goes the legs will follow", and, "to control the puck on the inside of a turn the torso needs to be inside." Let me be clear about something. I don't mean to suggest that the hockey athlete is pure skater. No. The hockey athlete



The above nine frames show a single crossover stroke. Note the slight shoulder rotation as the skater transitions through the stroke. This rotation allows pressure consistent with the perpendicular force requirement while the torso remains over the top of the force vector into the ice.

must be able to skate and handle a puck, give or take a pass, take a shot, give or take a check, all while watching play develop. But, as Dr. Braco has discovered, a great deal of time is spent skating without the puck. This is when maximum power with efficiency can make a real difference. If the best players in the world only control the puck two minutes out of twenty minutes total playing time, the opportunities for efficiency are obvious. It is possible for a trained skater to maintain excellent pressure into the ice during a cross-over turn while handling a puck, but it must be learned. It will be learned with practice using proper mechanics and training muscle strength and memory.

Skate setups can have a dramatic effect on an athlete's technique. There is one popular skate manufacturer that designs their skates to put athletes "back on their heels". This forces the athlete to push from the heel when completing a stroke. There are skaters who have the strength to make this skate setup work. But, even for those athletes, the resulting position reduces control and therefore affects quickness and agility. Most skaters on those setups do not have the strength or anatomy to use that setup properly. Those skaters appear flat and slow and have developed a supporting style and muscle memory. Skate setup issues of all kinds are common. I worked with a player in the AHL who played for Milwaukee. He had a contract with a specific skate manufacturer. He had been told by the organization that his skating was keeping him from playing in Nashville. He was actually quite a good skater but was on the wrong skate setup. He had two options. He could change manufacturers or he could have the skates modified to fit his anatomy, strength, and skating style. In my experience little attention is paid to skate geometry. An athlete's skates are his interface with the ice and improper geometry can create real problems. If an athlete is having skate issues a skating professional should be consulted and skate blade and boot geometries should be understood. Consistency is the name of the game and the right skate setup is an important component.

There is much to be improved with regard to teaching powerful and efficient skating technique. Using the effective stroke has repercussions for off-ice training, a topic not discussed in this brief paper. Young athletes should be encouraged to get out and skate and when they do to skate low. More experienced athletes will need to focus on mundane and sometimes painful detail. Skating instructors should spend time learning the movements of the effective stroke and incorporating those movements into their training regimens. This new information will provide strong skating fundamentals for future hockey players at all levels.

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