Appendix

On ice test protocol and partial database

Construction of Slide board, Russian box, Plyotube

Mathematical manipulation of research data

'Normalizing' – multiplying, dividing, adding to original data can change its meaning and Impact on correlations and comparisons. Some examples show how this can mislead coaches and athletes.

Overspeed on-ice drills (Separate PDF file to make it easy to copy)

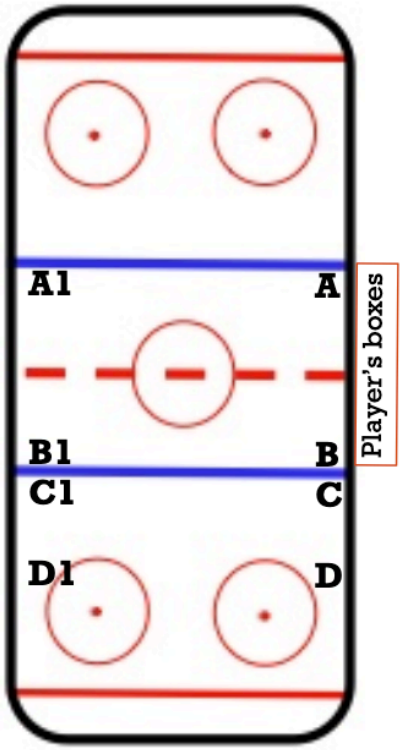
On-ice and Off-ice Testing

Take care in advance to prepare for accurate, repeatable results.

A pre-printed data-recording sheet, matching the order of names in the computer, will determine the order players line up for each test. Because you prepared in advance, data input to the computer is easier.

Setting up and marking the boards. Get to the rink an hour before testing.

1) Start: exact middle of the red line. Mark the top of boards. Use marker, no tape.
2) Measure 25' each way from X. Mark points A & B; then tape 6" vertically with duct tape.
3) Measure 40 feet from B and mark/tape point D.
4) Measure 60' from the goal line and mark/tape point C.
6) Measure and mark/tape the opposite side of the rink the same way A1, B1. D1, C1
7) Have 2 cones, an 8' board and a 5-gallon bucket of warm water ready for the S-test.



For every test !!!

You line the Photocells up accurately by getting your eye down close to the boards and site across to the tape on the other side. Example, to place A2 for Top Speed Test, your eye is at point A, so A2 is between A & A1.

For decades of electronic timing, the method of starting is problematic for most equipment. If it's an electronic starting block, players are taught to cheat – to lean back as far as they can to get a rolling start before their foot leaves the block. This is apparent at the NFL combine.

Or, if photocells are placed somewhere in front of the player to start the clock running, some players might step farther behind the starting line to get a running start. This is obvious for the world to see at the NHL All-Star game.

Having started tests with photocells for 50 years……

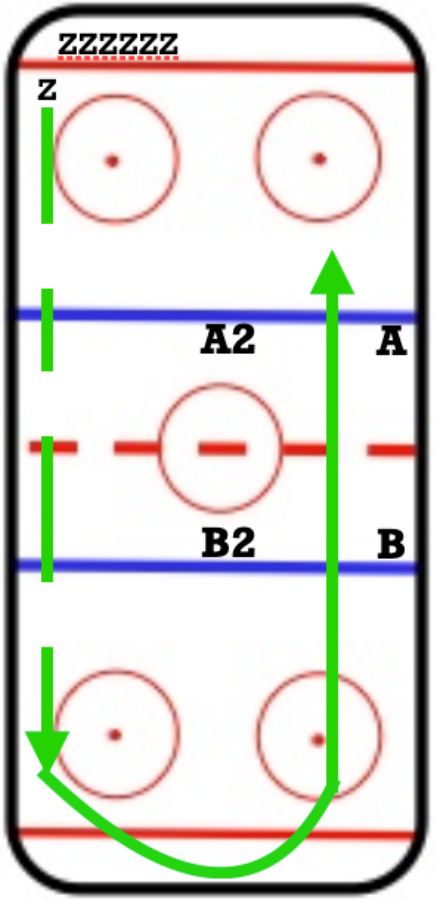
I now believe the best start is to hold the electronic timer in your hand,

instruct the player to start when your hand moves. Exaggerate pushing the button. The player focuses on speed, looking straight ahead, and will see your hand with peripheral vision.

Justification: ***Every acceleration in a game begins with a visual cue, so players are not out of their com fort zone to wait for the hand held clock to move … a second or two after the investigator says 'set.'***

Top speed test: time to skate 50' with a flying start around one end

This extensive 'run-up' is necessary in order to get a 50' distance we would call "Top Speed." A straight ahead sprint does NOT do this, because of the distances needed to accelerate to full speed and to decelerate before the end.



Two pairs of photocells are placed 50 feet apart, at points (A,A2) and (B,B2).

Players start in line at 'Z.' Keep the same order for all tests.

Player 'Z accelerates gradually along the boards, then skates the corner deep and at full speed. S(he) is tested for 50 feet at top speed between photocells B and A. Second player can start when Z1 gets to B.

This is, in reality, a test of cornering ability, so tell players to take the corner as fast as they can – deep into the corner – and skate well past the last photocells.
Coaches may want to test in the opposite direction to expose weaknesses.
Most players we tested are faster and more comfortable counterclockwise.

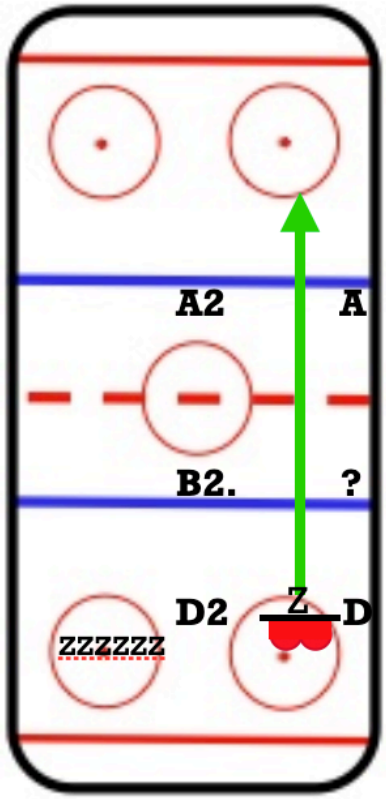
For all tests: for high school players and bantams, the photocells are 40" up from the ice. For older players, the photocells should be at 42" off the ice. For most players, their head will break the photo-beam at these heights, not the arms.

Record the average of two trials. If the two results are quite different, raise the lower score by no more than 0.03 seconds.

We have found it best to read results verbally to an assistant. If you try to input automatically to computer, the mistrials are a problem (z skates under the beam).

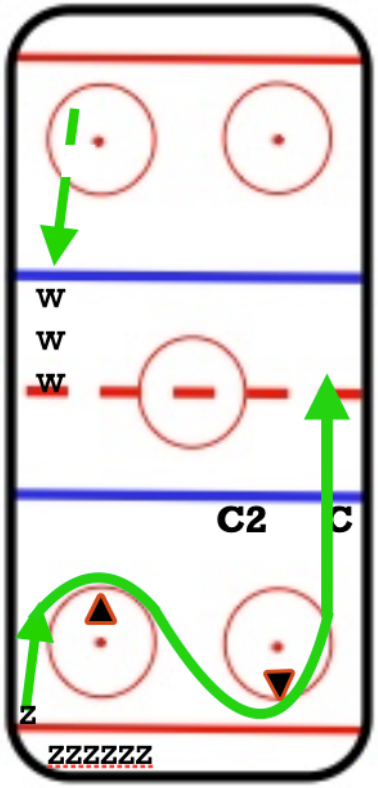
If a player breaks the photocell beam with a stick, (s)he goes again, but waits at the end of the line to rest.

Acceleration Test: time to skate 90 feet from a standstill



Photocells at (A,A2). Start with the hand-held timer. Secure one goal at D, so the back bottom pipe is exactly on the line between (D,D1). Or use a 2x4 board right on the line. Anchor the posts into the ice.

Players start with their back foot touching the board on the goal (ie. they are not behind the starting line (C,C1). Sprint straight ahead through (A2,A). Add extra photo cells at (B2, B) if you want an intermediate time for shorter acceleration.



S-Test

Photocells at (C,C2). Place cones (lying down)

Pour warm water outside the circles for 20 feet near the cones – slightly before, and well past them. This reduces deep cuts in the ice.

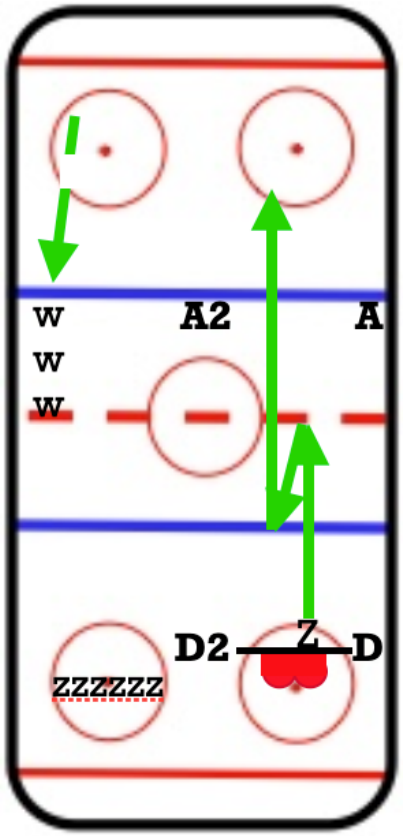
Skaters (Z) line up behind the goal line. Z1 starts with his back foot on the line, butt near the boards.
Timer hand held. Timing stops at (C,C2), 60' from the goal line. Use the same visual start.

Note: after one trial, players line up at W, instead of skating through the course.

Note2: The path they skate will be close to the one drawn, not skating a straight line from the first cone to the second. That would force them too wide, and they'd be slowed down by the boards. They might skate near the crease to accelerate out of the turn.

Stop-Start Test:

You will need to move, because the ice will get cut cut up very fast. Be sure to line up the photo cells accurately when you move.



For all tests

If (for photocell timing) you measure the course accurately, and eyeball the alignment of photocells carefully, your distance errors will be less than one inch (0.083 feet out of the 50' test represents only 1/6th of 1%). On the other hand, an error of 0.2 seconds using a stopwatch (13%) gives no meaningful information.

When each player of a professional team does the top speed test twice, the average difference between the two trials is less than 0.01 seconds.

If you also do the top speed test clockwise, the correlations to counterclockwise are high, but most players are more comfortable and faster counterclockwise.

OFF-ICE TESTING

Short Sprint: *correlation to on-ice acceleration 0.70 < r <0.90*

We have found the shorter the sprint, the greater correlation to on-ice acceleration. However, shorter sprints have an error potential that becomes a higher percentage of the overall time as the distance is shortened.

Stop watch timing over distances this short are totally unreliable, considering that the expected error of timing is around 0.2-0.3 seconds, five times the standard deviation of the subject variation between individuals.

Starting protocol is problematic with photocell timing. The hand pad starter (or foot pad) can introduce great error. If they keep the hand starter depressed while they accelerate (athletes' intention or not) this error can be ten times the standard deviation.

(a) Hold the timing clock in your hands. It communicates with finisah line cells. b) the photocell height at the finish should be mid-thigh, so it is below the hands and above the knee. (c) standardize the starting stance among all subjects.

Vertical Jump: *correlation to on-ice acceleration 0.65 < r <0.85*

Timing mats have ridiculous error. Athletes bend their knees, and the best cheaters bend more. Landing with flat feet, rather than toe extended introduces a wide variation.

Vertec testing introduces an error when some athletes fail to move the markers at the very top of their jump, sometimes well below their highest reach. We've studied this error with video tape, and it is in the order of 1-2 inches.

I prefer a simple board on the wall, marked every inch. The evaluator gets up on a small step ladder to reduce parallax error, and sites horizontally. After a couple trial jumps, the evaluator is focused on the probable top point, and will see the actual top point within a half inch. Don't use chalk for the same reasons mentioned for Vertec testing. The real inaccuracy here is in the independent 'reach' by the subjects, who can come up with the most creative ways to fail to stretch out during the reach. I'd recommend doing the reach, at a different time than the jump. Make it part of anthropometric testing (like wing span, body fat, etc).

Average Times for On-Ice Testing – Male Hockey Players
Notes (4 & 5) below refer to testing of elite females.

Top Speed Test

	Average	Std.Dev
	seconds	*seconds*
NHL Teams (n=3; 1978-1990)	1.53	0.035
NHL Teams (n=2; 1991-2025)	1.49	0.030
US Olympic Teams (n=4)	1.50	0.034
Division 1 College Teams (n=4)	1.52	0.055
Division 3 College Teams (n=3)	1.60	0.066
US Junior Team (1993)	1.53	0.054
High School Varsity Teams (n=7)	1.62	0.059
Bantam *(A or highest designation)* (n=5)	1.65	0.080
Bantam B (n=3)	1.93	0.099

Acceleration Test

	Average	Std.Dev
	seconds	*seconds*
NHL Teams (n=3; 1978-1990)	3.35	0.069
NHL Teams (n=2; 1991-2025)	3.29	0.056
US Olympic Teams (n=4)	3.32	0.059
Division 1 College Teams (n=4)	3.35	0.076
Division 3 College Teams (n=3)	3.48	0.095
US Junior Team (1993)	3.37	0.090
High School Varsity Teams (n=7)	3.55	0.110
Bantam *(A or highest designation)* (n=5)	3.61	0.141
Bantam B (n=3)	4.00	0.193

S-Test

	Average	Std.Dev
	seconds	*seconds*
NHL Teams (n=3)	5.83	0.135
US Olympic Teams (n=2)	5.81	0.128
US Junior Team (1993)	5.94	0.150
High School Varsity Teams (n=7)	6.08	0.154
Bantam *(A or highest designation)* (n=3)	6.25	0.182

Note 1: On the Top Speed Test, the retest consistency with professional and college players is remarkable (r=0.99). With 14 year-old youth players, this is slightly lower (r=0.93).

Note 2: For 45 years the acceleration test and S-test were both started with photocells 8 in front of the player. Since I recommend a different start now with a handheld timer (and movement the player sees) these times will be different. They are included to stir up questions.

Note 3: The 'n' values shown here represent the number of teams. But, for statistical comparison of early years timing compared to later, I used much larger 'n' values – hundreds of players.

Note 4: Comparing the 2018 Gold medal Olympic women to NHL teams: men were 9% faster on the top speed test, 7% faster on the acceleration test, and only 5% faster on the S test. Why?

Note 5: It is not surprising that Track & Field world record 100m dash results are similar to elite men and women in Hockey: Usain Bolt's world record is 9% faster than Florence Griffith Joyner's.

Unfortunately, in moving from old generations of computers to new ones, I lost much of the data. This chart represents only a small fraction.

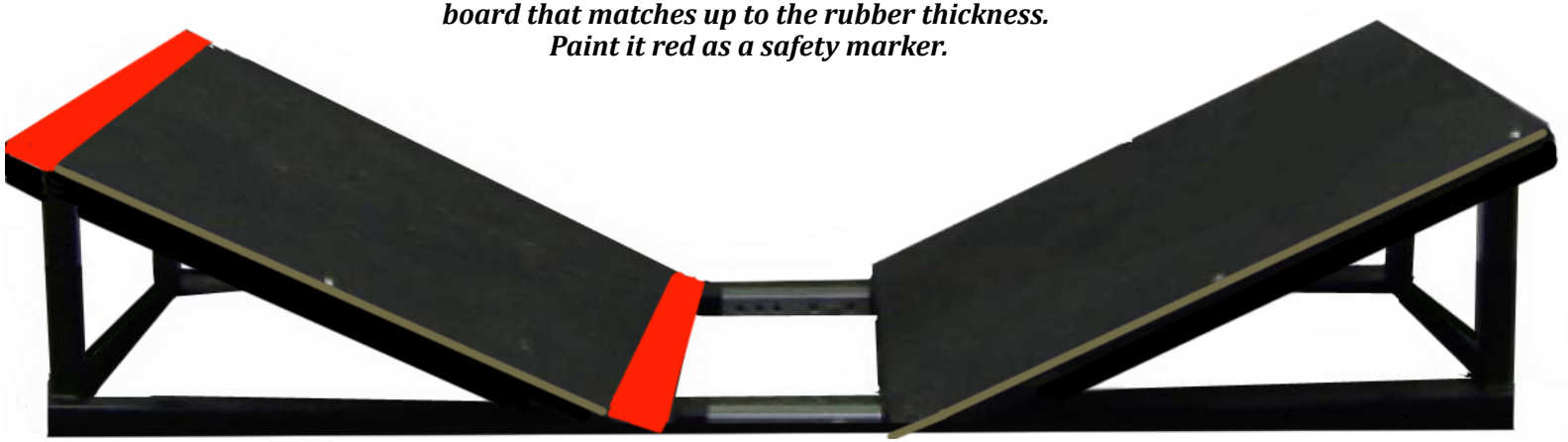
Construction of three pieces of equipment that are very useful for dryland skating practices

Russian Box Construction: *for explosive abduction-extension*

The important components are just two pieces of plywood 4'x4', covered by rubber 3/4" thick at most, braced underneath by steel or (2x6) wood.

To support the platforms at about 20°, you could just use a couple cement blocks, or you can get more elaborate with steel or wood. You don't need very strong members to keep them from sliding apart. You can also buy these at *TPFitness.com*

Option: The rubber often comes 3'x4', in which case you can fill in the top and bottom with a board that matches up to the rubber thickness. Paint it red as a safety marker.



Slide Board: *for skating stride habits, knee bend, muscular endurance, abduction-extension, and 'slippery' adduction & stabilization, Knee bend. Explosive stride. Arms assist, actually lead.*



Use three 2x10s ..... only the straightest boards ..... 10 feet long. First, use clamps to ensure the 2x10s are sandwiched together and flush on top. Bolt the three boards together at the ends with 4x4's and hex or carriage bolts. Then turn the slide board over and work on the bottom. Use 2x4s perpendicular every 3-5 feet, and after clamping them, glue and screw the 2x4s to the 2x10s. Three coats of poly: 24-48 hours each coat to dry. Sand lightly between coats. After the last coat allow three days to cure so it isn't sticky. Spray silicone before use. Let silicone sit a few minutes and gently wipe most of it off. Another 4x4, with large heavy-duty C-clamps is used to adjust the length. 8'6" clear distance is plenty. Sand bags (or be creative) for protective bumpers needed on each end.

Plyotube: *for creative strength and weighted jump exercises.*

Cut a pickup truck inner-tube in half, and cut out the stem. Wood dowels 1" diameter are cut 12" long. Stick one dowel in halfway, and duct tape twice around to protect the rubber when you apply a hose clamp.

Be sure the clamp covers the rubber completely; then close the clamp super tight. Fill about 90% of the tube with sand. A little slack is good. Use 20–70 pounds for various age, gender, and strength level of the athletes.

No weighted one legged jumps until athletes are mature, are very strong and have done plenty of two legged squat jumps with perfect landings. Land quietly with less knee bend than deep squats – not quite to parallel.



‘Arithmetized’ Data

Manipulated data: Mathematical tricks.

'Arithmetized' data can be misleading; yet it's done all the time.

1) Tricky Division = "Normalizing" data by body weight

The overly-common practice of 'normalizing' data (dividing by body weight) is NOT justified by elementary physics, physiology, or geometry *(Hill,1950; Jaric,2005);* nor is it justified by empirical evidence when the test data represents a performance of explosive **strength** *(Knudson,2009)* or **endurance** *(Tanner,1949)* **or energy expense** *(Issa,2006)*.

'Normalizing' by surface area rather than weight would make more sense. If two people are similar shape and density (approximately, of course), but different height, h, their muscular strength (force) is proportional to the cross-section area of the muscle, because that determines the number of contractile elements. To a great extent, endurance is dependent on surface areas: Lung surface in contact with blood vessels (total surface area of alveoli is about the same as a tennis court!)**;** Blood capillaries-to-muscle fiber area**;** and inside the cell (mitochondria surface area).

Therefore, based on the geometry of similar objects, **strength** and **endurance** should be roughly proportional to height^2, (h^2 or Areas not body mass). If we feel the urge to normalize for different size subjects, we would divide the data by M^x, where M is body mass or weight and x is the exponent 2/3. It isn't perfect, but would be more justifiable than using an exponent of one, and arbitrarily choosing to divide by M^1 , which is the common default with no justification.
For more on this topic, see *(Hill,1950; Astrand,1977; Jaric,2005).*

Example1: $Vo_{2\ peak\ or\ max}$ (ml O_2/minute/kg body mass) has become a common expression for aerobic fitness. The justification for using maximum volume of oxygen that can be consumed per minute, rather than other variables like anaerobic threshold is debatable; yet it is universally accepted. There are several issues that could be discussed, but one we will focus on is this: if the group being tested is much heavier than marathoners of the original studies, or has **a** wide range of body weights (football, basketball, or hockey teams) **...**

the fraction is dominated as much by body weight as oxygen uptake and utilization.

Any third grade student would tell us that the value of a fraction (A/B) is just as representative of the denominator (B) as the numerator (A). We cannot simply call this fraction "A," as is common with $Vo_{2\ max.}$ It represents "A divided by B." Period.

In other words, the fraction should never be thought of simply as $Vo_{2\ max}$, (oxygen consumption) because body mass is just as significant as O_2 consumption when discussing the fraction. If a subject loses 10% body weight, the fraction, $Vo_{2\ max}$ (ml/kg/minute) is elevated 10%.

When we divide by body weight we change the meaning of the data!

Dividing by body mass is called normalizing the data, and it is highly suspect unless division is justified by empirical studies. Even then, the numbers should not be used to interpret the fitness of athletes who are not similar in weight to the population in the original studies. For a football, hockey, or basketball team relationships of the fraction to other variables (like endurance) might be more about body weight than oxygen consumption: 'The lighter the runner, the greater the endurance.'

Example2, normalizing strength by body weight can lead to unjustified conclusions: In 2009, McBride et.al, investigated, "The relationship between maximal squat strength and five, ten, and forty yard sprint times." That title and final conclusion (next sentence) omitted the critical fact that squat strength was divided by body mass. The article concluded, "a substantial commitment to increased squat strength has a high likelihood of contributing to increased on-field sprinting ability."

That's a powerful statement, and will influence strength coaches to use heavy squats for years to come. It may be true but it's not justified by the published data. No fraction can EVER be identified by just the numerator. The abstract and some other statements in the article correctly include the fact that data was normalized, so this was not meant to deceive. Nonetheless, the title is deceptive.

Players on a division 1AA college football team were tested to compare one-repetition maximum squats to sprint times. It's possible that the smaller players (wide receivers) would generally be the faster sprinters, but might squat **less** than their larger team-mates. If that were the case it would have led to the conclusion:

Maximum squat strength is related to slower sprint times.

If one-rep max squats could be done safely 100% of the time, they might be building blocks for speed. But this article did *NOT* provide "additional evidence" to substantiate this, because it ignores the impact of the denominator on correlations. These authors have done a lot of great research in the past. **This is not an attempt to disguise the realities; they are just doing a common (accepted) manipulation.**

The problem is the universal acceptance of normalizing by body weight.

2) Multiplying by (or adding) body weight

For some reason coaches and researchers have not been satisfied to use the word **Acceleration** (from kinematics) to describe the major objective: moving your body quickly in all directions (accelerating, decelerating, changing directions). Instead, it's been a popular fad for 50 years to use the words **Force** and **Power** (kinetics) – often incorrectly.

Am I against fads? No. I'm against communications that mislead coaches who must analyze how to train athletes in the most effective way.

Example1: **Moving your body quickly and efficiently is the goal for hockey training**. For the past 50 years it would have been more productive if we'd kept it simple when describing this goal to researchers. But it became popular to use colloquial thoughts about **'Power'** when we really meant 'explosiveness' or 'explosive acceleration.' So, for many years, force platform studies have concluded that certain heavy strength movements produce great Power or result in high rates of Force development. Okay, but …

most of these studies did *NOT* find that the subject moved quickly for a distance – the objective.

After conducting a vertical jump test, it is popular to estimate power from a regression equation in which body mass is added *(Sayers, 1999; and others not cited)*. Should we then conclude that the best vertical jump training should follow the path of the heaviest athlete who doesn't jump high but who's estimated power is high because of greater body mass?

Note: In decades of testing, for each team we have found a high correlation between vertical jump **height** and times for the skating acceleration test (straight-ahead sprint). But, when we change the data, by using Sayers regression equation or others, the so-called 'peak power' has little or no correlation to the skating test.

In other words jump ability is related to skating acceleration. Estimated power is not.

Do calculations of Power mislead us in training? Keep in mind vertical jump height is determined by **Impulse** (I= Force•time), **not by Power** (P=Force•distance/time). It is the final takeoff velocity that determines jump height, so the goal in a jump is to **increase time, which increases Impulse and momentum (mv) and therefore velocity**.

Note: Impulse = $\int(Force)dt = \int(m \bullet a)dt = \int(m \bullet dv/dt)dt = \Delta(mv)$ or change in momentum.

Bottom Line from the two equations: To increase Impulse we should *increase* time (t) we are applying the force. To increase Power we should *decrease* the time … meaning 'execute quickly.'

High jumpers, shot putters, and discus throwers use strategies that evolved over centuries to **INCREASE** the **TIME** they take to develop momentum (this is not a conscious thought of course. It just worked better). Picture a shot putter or discus thrower building up momentum in their unique ways. Then the momentum is transferred to the object they're throwing. They do NOT try to REDUCE this time. That would look silly.

The same physics applies to skating: Train for increased Impulse on each stride. This is one of the many reasons knee bend is important – it increases the time for force to be applied into the ice. All this is said recognizing that a quick stride rate is also important. So, you don't try to apply force slowly, just as a discus thrower doesn't try to move slowly; you just get as much out of every skating stride as you can.

What about Jump-Training for Skating? Train for Impulse, not quick, abbreviated touch.

Skater's Plyometrics' should NOT reduce contact time with the surface, as is the goal for sprinter's plyos that are universally (and mistakenly) advocated for EVERY sport and every training purpose. Each skating-specific jump should be done with good knee bend, taking much more time than a sprinter does at full speed. They have to reduce contact time at high speed, because friction would slow them down if they bent their knees and stayed in contact with the track.

Why all this math/physics? I'm not a 'word cop,' out to correct semantics. I am concerned with decades of miscommunication between the lab scientists and the coach and athlete. I am also concerned that when mistakes slip by peer-reviewers for scientific journals, it is in the database forever, and future readers are misled.

Example: In 2004, Carlock and co-workers concluded, **"Vertical jumping peak power is strongly associated with (Olympic) weightlifting ability."** The conclusion might be true, but the published correlations do little to verify it. The subjects (64 national-level weightlifters) included 15 year-old girls as light as 103 pounds and elite men up to 373 pounds, as well as elite boys, girls, men, and women between these extremes – **all in one subject pool!**

With a group of subjects this heterogeneous, it is a no-brainer to find significant correlations that may or may not be helpful. Elite men on the national team will lift more than 15 year-old girls, so the dice are loaded for a high correlation before testing begins. But then the original data was ***arithmetized*** (adding in body mass) using Sayers' regression equation for power. The final conclusion now included the words "strongly" associated, because the heavyweights who had impressive cleans and snatches, also tipped the teeter totter completely because they weighed so much more.

Body mass was just as "strongly associated" with weightlifting ability as vertical jump 'power' was.

Beware: Conclusions drawn from heterogeneous groups, and mathematical manipulation of data can be very misleading.

Example: over four decades we've tested thousands of skaters on the ice and off. The athletes ranged in age from 11 year-old peewees to 35 year-old NHL players. If we lump data for all the athletes together in one group, bench press max would be highly related to on-ice skating speed and acceleration. In other words NHL'ers bench press more and skate faster than peewees. Profound?

Then, if we stretch the limits of objectivity even further, and multiply skating acceleration by body mass, the relationship would be even stronger between "skating force or power" and bench press max. Note that the physics and math are legitimate, but if we published this, coaches and athletes might conclude that bench press is a good training exercise to improve skating power – unless they use logic. **Or … how about this? "Obesity helps you skate with more power." Huh???**

Children and world-class athletes don't belong in the same subject pool. In fact, heterogeneous grouping of male and female subjects often leads to conclusions that are misleading and counterproductive.

So, this is another box that research has put us in: Arithmetic manipulation of data, such as adding, multiplying, or dividing (normalizing) data by body weight. It might be justified at times, but arithmetic tricks have led folks to tell us we should train for Force and Power, rather than simply accelerating our bodies in all directions.

Lesson for every coach and athlete: Be suspicious when arithmetic tricks are used in research, especially when original data is not reported. Trusting research without challenge can lead your training philosophy into a distorted box, one that has become very popular and intimidating, because, "EVERYONE'S DOING IT."

If research conclusions conflict with your own gut feeling it pays to investigate in more depth.

I don't apologize for fighting upstream when everyone's doing the opposite. I repeat my purpose in writing:

to challenge dogma that confines our training philosophy to a box.

Do I lose sleep about the claim: **"Everyone's training this way?"**

No. First, because I've tried heavy strength training and Olympic lifts with many athletes and found it better to add a lot of ***Move-the-Body*** exercises combined with strength training to improve skating speed, strength, agility, and acceleration.

"Everyone's doing it," should turn our heads, of course, and we should investigate what everyone's doing. But, the validity should also be questioned. Durell, Pujol, and Barnes *(2003)* published the results of a survey of 321 Division-1 college strength coaches. The survey asked where the strength coaches got information for the programs they used with their athletes. 93% of the 137 respondents answered, **"<u>From other strength coaches</u>."**

In other words, 'Everyone's doing it.'

The claim that *"everyone's doing it"* is not justification.
It's Thinking in a Box.

Trust the cheetah

Sports-scientists make careless mistakes

In a previous book, I tried to elevate an imaginary centrifugal force into a real one, acknowledging Isaac Newton's statement that for every action (centripetal force in this case) there is an equal and opposite reaction (centrifugal force). I was wrong.

With that in mind, let me explain a widespread careless mistake – an incorrect conclusion that has universal impact on training for Hockey.

Unfortunately, this is typical: the research team does a thorough job to show that the fraction, maximum squat strength divided by body mass is somewhat related to skating speed (r-values less than 0.5). The mistake is to leave the denominator out of the title, abstract, and discussion. It is incorrectly stated that the numerator, maximum squat strength, is related to skating speed. But, the data does not show this.

It's a very influential mistake, and it's 100% wrong. Strength coaches around the world will plan training programs based on false conclusions.

Years of our data (I won't identify the years) – shows the reality that the denominator, body mass, is inversely related to skating speed. In other words, smaller, shorter players are, on average, faster in tests of agility, speed and acceleration. That biases the entire fraction, of course; it was never established that squat strength among professional or college players has any relationship to skating parameters.

Similar manipulation of the fraction $V0_{2\ max}$ has biased testing–training for endurance on heterogeneous teams with respect to body mass – teams like football, basketball, hockey.

We investigators, coaches, and peer-reviewers must do better.

Hockey players need as much aerobic capacity as they can acquire, and strength training is constructive at EVERY age.

But, long, slow aerobic workouts are not the best way for young players to increase aerobic capacity. To play at higher levels, they need a lifetime of high quality intervals for speed, quickness, agility, and explosive strength … plus stick skills, hockey sense and competitive toughness.

Fortunately, the ability to transport and utilize oxygen is enhanced by high intensity interval training (HIIT), plus the sum of all on-ice and off-ice activities, especially competition in a wide variety of sports.

Practicing slowness, inherent in long 'aerobic training,' is not advisable until players get to the NHL, where aerobic training is needed for recovery.

A similar fact is important in strength training. Lifting weights is part of the development process at older ages, but *explosive strength* for children and adolescents is best developed by moving the body.