

**NSCA COACHES CONFERENCE**  
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 NSCA NATIONAL STRENGTH AND CONDITIONING ASSOCIATION

**Push, Pull, & Propulsion**  
**The 10-20-30-40 Concept**

**HRUSKA CLINIC**  
 Restorative Physical Therapy Services

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**Conflict of Interest Statement**

- I have no actual or potential conflict of interest in relation to this presentation.

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**What we will cover**

- Assess structural influences and dysfunctional movement patterns across the ankle, knee, and pelvis that predispose injury.
- Identify positional interrelationships involving lower extremity push and pull patterns and their effects on function, posture, and performance.
- Learn how to optimize movement patterns and athletic performance by using objective evaluations/screening findings and corrective guidelines.

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**Push, Pull, & Propulsion**

A **PUSH** or a **PULL** is simply a force that changes the motion of a body segment

**PUSH**- The act of exerting force on something in order to move it away

**PULL**- The act of exerting force on something in order to draw it towards

**PROPULSION** (Lat. *pro-pellere*, push forward) – The force pushing a body to move against natural forces. Can be any driving force, whether it be a **PUSH** or a **PULL**.

A similarity is made from propulsion (**PUSHING**) to traction (**PULLING**)

**PUSH** and **PULL** motions produce the same effect : making a body move against natural forces.

[wikipedia.org](http://wikipedia.org)

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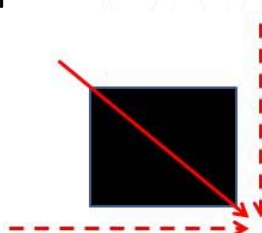
**Push, Pull, & Propulsion**

- A force is something that can make an object change speed, shape or direction
- Gravity is a force the **PULLS** objects down on earth throwing a ball up in the air.
- The forces of **PUSH** and **PULL** can do all three of these things
- Skateboard, yo-yo

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## PUSH

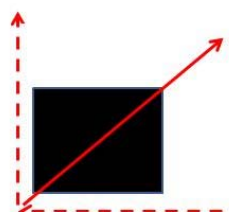
- When you push at an angle, you are providing two forces :
  - Horizontal force acting along the plane.
  - Vertical force downward perpendicular to the surface.
- Downward force acts as an additional weight. In case of pushing, it puts on additional weight on the object, which results in increasing drag or friction. This is similar to increase in difficulty in pushing heavier objects on the same surface.



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## PULL

- When you pull at an angle, you are providing two forces :
  - Horizontal force acting along the plane.
  - Vertical force upward perpendicular to the surface In case of pulling,
- The upward perpendicular force, sort of, tries to lift the object and cancels the weight partially. Hence it is easier to move



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## PROPULSION

Propulsion requires a force (thrust) to cause motion to advance forward which implies a second system being pushed backwards ( the environment)

Propulsion requires an energy source able to do some mechanical work the thrust is needed to push the body forwards (or what is the same, to push the environment backwards) but there is no propulsion without the forward advancement motion

<http://webserver.dmt.upm.es/~isidoro/bk3/c17/Propulsion%20fundamentals.pdf>

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## HOW DOES THIS APPLY TO THE HUMAN BODY?

In the body:

Each bone is a lever and each joint is a fulcrum, and muscles apply the applied forces.

Movement of the skeleton occurs at joints, so there has to be sufficient muscle power to move all the bones at these joints whether it be a pushing or pulling force.

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## PROPULSION

- Propulsive force generation comprises two primary factors: ankle moment and the position of the center of pressure relative to the body's center of mass. (Hsiao, et. al., 2015)
- These in turn encompass a variety of other complex biomechanical considerations including ankle dorsiflexion and plantar flexion, knee extension and flexion moments and the timing and magnitude of action of plantar flexors and energy consumption. (Groner, 2016)

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## MID-STANCE

Stance phase of gait is the most important portion of gait cycle as it is when the foot becomes fixed to the ground.

Body weight is passing over the foot as the tibia and the rest of the body are moving forward. Undergoing a change of a mobile adapter to a rigid lever to propel the body forward during the final portion of stance propulsion

During mid-stance of gait, while the leg moves over the foot if there is less than 10° of dorsiflexion there will be early heel off, Pronation like forces will be created, because pronation is a compensatory motion for limited dorsiflexion.

Propulsion begins after heel off and ends with toe off. This phase constitutes the final 35% of stance phase.

Remember the stance phase comprises 60% of gait cycle!!

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## GAIT & GRAVITY

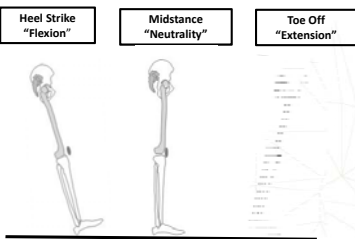
- Gait is maintained by a combination of muscular activity, momentum and gravity.
- The use of levers on land requires support against gravity, we have to contend with the pull of gravity to move efficiently in space, one must raise themselves off the ground.
- Gravity allows one to hit the ground without losing contact with it, however, because of gravity, work has to be done with each step to lift or propel the body forward.

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## THE THREE ROCKERS OF THE GAIT CYCLE (PERRY, 1992)

- Heel rocker-About the heel in contact with the floor, from the terminal part of the swing phase until the foot is flat on the ground, it controls the lowering of the foot to the floor.
- Ankle Rocker- About the ankle joint, during the period in which the foot remains flat on the ground and the shank advances, it controls the continued forward movement of the body.
- Toe Rocker- About the great toe, during the push-off phase, it allows the generation of power for progression of the relevant limb.

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Gait is the forward offsetting of the body's center of gravity, causing the mass to fall forward, at which time a limb is advanced to stop the forward fall (Perry, 1992)

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“Walking is the simple act of falling forward and catching oneself”  
(Perry 1992)

**Walking and running:**  
Involve forward propulsion  
Alternating and reciprocating balancing of the body on one limb  
Supporting the body in the upright position

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## 10-20-30-40 Concept

- Basic biomechanical principles that are dependent of posture:
  - Planes of motion
  - Length-tension relationships (Positional)
  - Force velocity relationships
- Joint alignment is crucial in movement; where the joints are in relation to one another determines the efficiency of the musculoskeletal system.
- Different joints and associated movements involve different lever systems and it is important to address multi-joint movements involved in multiple levers acting at once and interacting with each other.
- Manipulating variables such as length of the lever arm of the resistance force can help engage the appropriate muscle groups at their ideal position and length.

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## 10-20-30-40 Concept

- Reduced “push” from feet equates to compensatory pull from hip flexors and back extensors
- Want push from Hamstrings, glutes, and abdominals
- 10° Dorsiflexion (Knees don't bend)
- 20° Hip Extension (Forward lean with hip flexors)
- 30° Hip Adduction
- 40° of Hip Internal Rotation

Compensatory  
Passive MKD  
Knee Valgum  
Increased TFL Activity

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## The LEFT AIC Pattern


There are 2 anterior interior polyarticular muscular chains that have a significant influence on respiration, rotation of the trunk, rib cage, spine and lower extremities

One is on the left side of the interior thoraco-abdominal-pelvic cavity and one is on the right

Muscles include the diaphragm and the psoas

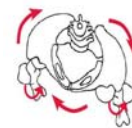
This chain provides the support and anchor for abdominal counter force, trunk rotation and flexion movement

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## The Left Side



With the tendency for anterior tilt and forward rotation of the left hemi-pelvis, the position of the pelvic girdle orients the pelvic girdle to the right causing a shift in one's centre of gravity to the right. The pelvic girdle is directed into a stance-like AF/IR position on the right and AF/ER position on the left. (J. Masek, 2014)

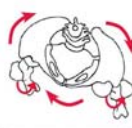
- Left innominate is positioned in a state of AF flexion, abduction, and ER with compensatory femoral activity.
- Efforts to restore correct AF position and rehabilitate FA activity on the left side should include extension, adduction and IR.

Figure 2: Left AIC pattern. (J. Masek, created by sportEX, 2014)



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## The Right Side



With the tendency for anterior tilt and forward rotation of the left hemi-pelvis, the position of the pelvic girdle orients the pelvic girdle to the right causing a shift in one's centre of gravity to the right. The pelvic girdle is directed into a stance-like AF/IR position on the right and AF/ER position on the left. (J. Masek, 2014)

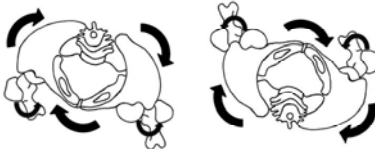

- Right innominate is positioned in a state of AF extension, adduction and IR with positional femoral activity.
- Efforts to restore correct AF position and rehabilitate FA activities on the right side should include flexion, abduction and ER.

Figure 2: Left AIC pattern. (J. Masek, created by sportEX, 2014)



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## THE PROBLEM

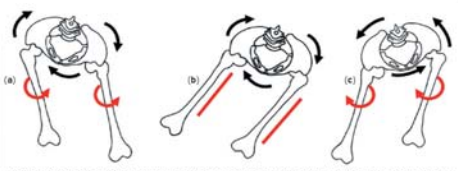



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## THE ULTIMATE GOAL!!





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(a) Right hemi-pelvis positioned posteriorly, adducted, and internally rotated with right compensatory femoral internal rotation. Left hemi-pelvis positioned anteriorly, abducted and externally rotated with left compensatory femoral external rotation. (b) Right hemi-pelvis positioned posteriorly, adducted, and internally rotated with right femur orientated outwardly. Left hemi-pelvis positioned anteriorly, abducted and externally rotated with left femur orientated inwardly. (c) Right hemi-pelvis positioned anteriorly, abducted and externally rotated with right compensatory femoral external rotation. Left hemi-pelvis positioned posteriorly, adducted, and internally rotated with left compensatory femoral internal rotation.

Figure 3: Left AIC and the effect on the pelvis and femur positioning. (J. Masek, 2015)



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**Figure 4:** (a) Right hemi-pelvis positioned posteriorly, adducted, and internally rotated with right compensatory femoral internal rotation. Left hemi-pelvis positioned anteriorly, abducted and externally rotated with left compensatory femoral external rotation. (b) Right hemi-pelvis positioned posteriorly, adducted, and internally rotated with right femur oriented outwardly. Left hemi-pelvis positioned anteriorly, abducted and externally rotated with left femur oriented inwardly. (c) Right hemi-pelvis positioned posteriorly, adducted and externally rotated with right compensatory femoral external rotation. Left hemi-pelvis positioned anteriorly, abducted, and internally rotated with left compensatory femoral internal rotation. (J. Masek, 2014)

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**ONE OR BOTH LEGS TURN OUT WHEN SITTING, STANDING AND LYING**

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**OVERDEVELOPMENT OF COMPENSATORY MUSCLES**

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**FEMORAL-ACETABULAR ROTATION**

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**ELEVATED ANTERIOR RIBS ON THE LEFT**

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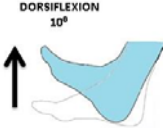
### LOWERED, DEPRESSED SHOULDER AND CHEST ON THE RIGHT



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### 10° ANKLE DORSIFLEXION



- The ankle joint contributes to 40-70% of forward propulsion during walking. (Chen et. al. 1997; Winter, 1983)
- With a loss of ankle function, hip flexors and extensors are more heavily utilized gait. (Cofre et. al., 2011)

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### DORSIFLEXION

- Root (1977) reports that 10° of ankle dorsiflexion is needed in normal ambulation
- If 10° of dorsiflexion is not available the subtalar joint will pronate excessively to obtain the needed motion
- Roche 2015, et al., if sufficient dorsiflexion is present, less hip flexion is required (distal strategy) whereas if dorsiflexion is reduced, it is compensated for by an increase in hip flexion (proximal strategy)
- Ankle dorsiflexion is a major factor affecting squat depth followed by hip flexion (Kim et. al., 2015)

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### LIMITED DORSIFLEXION

Ankle and hip movements during squatting are considered to have a certain relation, and it was found that the pronated group used different squat strategy. (Lee, et. al., 2015)

Pronated feet increased ankle mobility and internal rotation of lower limbs!!



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### Limited Dorsiflexion Macrum et. al. 2012

- Altering ankle DF starting position during double leg squat resulted in increased knee valgus and MKD as well and decreased quadriceps activation and increased soleus activation
- Decreased DF during weight bearing tasks limits ones ability to lower the body's center of mass, encouraging increased subtalar joint pronation and tibial internal rotation to gain additional motion
- As the body's COM is lowered during the squat, increased levels of knee flexion and quadriceps activation are required. When the participants were on the wedge they could not increase the knee flexion any farther, so greater quadriceps activation was not required.

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### Dorsiflexion & Medial Knee displacement

- Restricting the forward movement of the knee (Dorsiflexion) can place more loads on the hip and lower back because the reduced knee loads can be improperly transferred to the hip and lower back (Fry et. Al., 2003) Resulted in a more inclined torso!!



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### Limited Dorsiflexion Macrum et. al. 2012

- Increased tibial IR requires concomitant increase in femoral IR and has been linked to knee valgus position
  - Decreased sagittal plane motion at the ankle leads to the following kinematic changes
  - Decreased knee flexion and excursion
  - Increased knee valgus
  - Increased medial knee displacement

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### Limited Dorsiflexion

- Greater ankle-dorsiflexion ROM during a weight bearing lunge resulted in greater sagittal plane motion at the knee and ankle during squatting tasks (Dill et. al., 2014)
- Compared with nonweight-bearing passive measures, ankle dorsiflexion range of motion during weight-bearing lunge may be a more sensitive measure for identifying those with high-risk movement patterns. (Dill et. al., 2014)
- Ankle dorsiflexion can be increased by knee flexion ,however, significant differences of ankle dorsiflexion were only found between full extension and 20° of knee flexion, Further knee flexion did not increase ankle dorsiflexion (Baumbach et. al., 2014)

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### Limited Dorsiflexion

- Limitation of ankle dorsiflexion makes it impossible to adopt the squatting knee flexion posture. (Jali et. al., 2010)
- Greater dorsiflexion ROM is associated with greater knee-flexion displacement and smaller ground reaction forces during landing ( Fong et. al., 2011)
- The ankle is responsible for support throughout stance. Thus a loss of ankle function impairs support and alters propulsion, requiring compensations at other joints. (Riley et. al., 2001)

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### Screening of Dorsiflexion

- The reported normal distance between the wall and the longest toes is 9-10 cm
- 35-38 angle of the tibia

Variability due to anthropometric factors!

Figure 1. Diagram depicting the two methods of measuring dorsiflexion lunge.  
K. Bennell et.al., 1998

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### 20° HIP EXTENSION

Extension Drop Test

Left: Positive Test      Right: Negative Test

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### 30° HIP ADDUCTION

- Reduced ankle dorsiflexion is associated with increased hip adduction during step down test. Ankle dorsiflexion should be taken into account when assessing frontal plane lower limb alignment. (Bell-Jenje et.al., 2016)


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### Adduction Drop Test

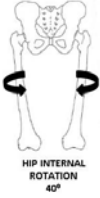
Left: Positive Test      Right: Negative Test

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### 40° HIP INTERNAL ROTATION




HIP INTERNAL ROTATION  
40°

- The hip contributes to medial knee displacement through a combination of femoral adduction and internal rotation (Bell et. al., 2012)
- The presence of MKD during squatting may indicate a lack of neuromuscular control of the hip external rotators or abductors (Bell et. al., 2012)
- MKD and limited ankle dorsiflexion requires a compensatory mechanism for the participant to complete the squat task (Bell et. al., 2012)



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### 40° HIP INTERNAL ROTATION



HIP INTERNAL ROTATION  
40°


- (Bagwell et al. 2016)
- For every 5° of anterior pelvic tilt there was a 1.2°-1.6° increase in internal rotation.
- For every 5° of posterior tilt there was 1.2°-1.6° increase in external rotation.

**Conclusion**  
Altered pelvic control or positioning in the sagittal plane has the potential to influence transverse plane motion of the femur.



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### 40° HIP INTERNAL ROTATION



HIP INTERNAL ROTATION  
40°


With regards to an anterior pelvic tilt, there was a significant loss of 6-9° of hip internal rotation and subsequently an increase in femoroacetabular impingement. (Ross et. al., 2014)

Changes in anterior and posterior pelvic tilt as well as pelvic rotation suggest that the two innominate bones are rotated differently with sacroiliac dysfunction (Cibulka, 2014)




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### 40° HIP INTERNAL ROTATION

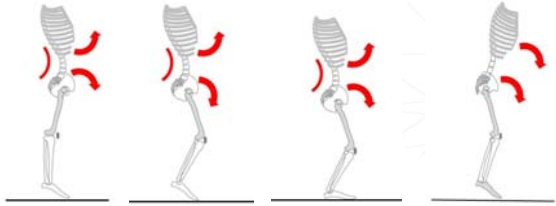



HIP INTERNAL ROTATION  
40°

- Hip IR greater than 35 was considered a successful outcome with individuals with chronic low back pain (Roach et. al., 2015)
- Altered sagittal plane loading in those with hip impingement, more specifically hip flexion and ankle dorsiflexion may be important biomechanical parameters to be targeted (Zhang, et. al., 2016)



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### TOE WALKING GAIT

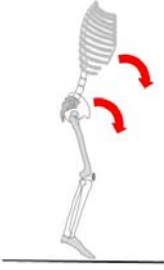
- If the GRF is anterior to the knee joint, it will generate an extensor moment. This is often the case in plantar flexion tightness causing forefoot loading (toe walking) this causes the GRF to displace forward and generating and excessive knee extensor moment and knee hyperextension.



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### CROUCHED GAIT

- Crouched gait is obtained increased knee flexion, resulting in the GRF posteriorly causing an increased flexor moment at the knee. Individuals often lean their trunk forward to displace the center of gravity and GRF anteriorly, thus reducing the flexor moment. (Theologis, 2013)



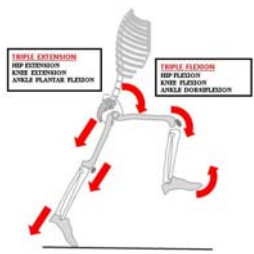
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You can flex your knee while on toes however it will require you to go into more lordosis to keep you from falling forward



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### PROPULSION



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### Ribs Up "Ankle Plantar Flexion"

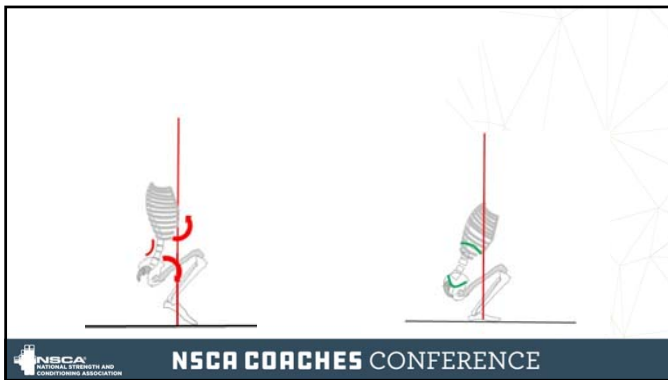
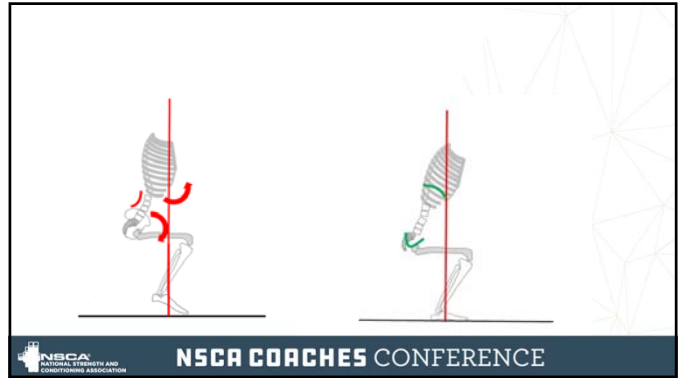
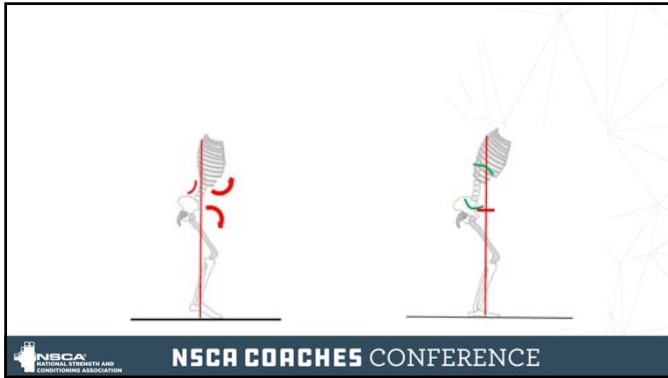


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### Ribs Down "Ankle Dorsiflexion"



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### Knees over toes controversy?

- If you limit your knees to pass over your toes, you are more likely than not experience compensation elsewhere.
- Hemmerich et al. 2006 reported that the average ankle dorsiflexion angle required was  $38.5 \pm 5.9^\circ$  during a squat. (Past  $90^\circ$ )
- Early movement of the knee supports the concept of the knee being the lead joint in the squat movement. (McKean & Burkett, 2012)
- Restricting movement of the knee during the squat will alter the movement sequence and hence place undue stress on segmental joints. (McKean & Burkett, 2012)
- During downward squatting, activation of the tibialis anterior is needed to initiate squatting in the upright position (Robertson et al., 2008, Kim et al., 2015)

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### 10-20-30-40 CONCEPTS

- TFL compensatory TFL for IR and out-flaring of innominates to stabilize SI Joints.
- Increases psoas and iliacus activity.
- Limited Dorsiflexion results in medial knee displacement or back extension.
- Increases frontal and transverse plane compensatory activity throughout the kinetic chain.
- Increases the need for over-activity from the lats to transition the upper body forward.

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Heel pushes down into floor as knees move forward.  
Requires one to pull with hamstring to stand up without extending low back.

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Need hamstring and tibialis anterior to work concomitantly to control the forward translation of the tibia as your come off wall

If you don't engage hamstring you will most likely extend lower back, tibialis anterior will pull you off the wall and propel you forward (thrust)

When knee joint angle increases in a plantar flexed position, the tibialis anterior muscle activity increases (Lee, et al., 2015) if knees move forward excessively, the angle of the ankle joint decreases, thus increasing the tibialis anterior activity during the squat.

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**Left Anterior Interior Chain (Left AIC)**

Left	Right
Tensor Fascia Latae (TFL)	Gluteus Maximus
Rectus Femoris	Hamstrings
Psoas	
Iliacus	
Gastrocnemius/Soleus	Anterior Tibialis

Classifications:  
 Pullers: TFL, Rectus Femoris, Psoas, Iliacus  
 Pushers: Gluteus Maximus, Hamstrings, Gastrocnemius/Soleus  
 Pullers: Quadratus Lumborum, Latissimus Dorsi  
 Puller: Anterior Tibialis

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**Bilateral Posterior Exterior Chain (PEC)**

Left	Right
Tensor Fascia Latae (TFL)	Tensor Fascia Latae (TFL)
Rectus Femoris	Rectus Femoris
Psoas	Psoas
Iliacus	Iliacus
Anterior Tibialis	Anterior Tibialis
Gastrocnemius/Soleus	Gastrocnemius/Soleus

Classifications:  
 Pullers: TFL, Rectus Femoris, Psoas, Iliacus  
 Pushers: Gastrocnemius/Soleus  
 Puller: Anterior Tibialis

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# Management Considerations

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**90-90 hip lift with hip shift**

1. Lie on your back with your feet flat on a wall and your knees and hips bent at a 90° angle.
2. Place a 10-15cm ball between your knees.
3. Inhale through your nose and exhale through your mouth, performing a pelvic tilt so that your tailbone is raised slightly off the mat. Keep your back flat on the mat.
4. As you maintain a hip lift, shift your left hip down and your right hip up so that your right knee is slightly above the left.
5. Slowly take your bent right leg on and off the wall so that your right thigh comes toward your chest. You should feel the muscles behind your left thigh and left inner thigh engage.
6. Perform 3 sets of 10 repetitions, 1-2 times a day.

Figure 4: Exercise for left AF IR with concomitant left FA IR. (Postural Restoration Institute, 2015. Image used with permission)

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**Side-lying respiratory scissor slides**

1. Lie on your right side with your hips and knees bent at a 90° angle, and place a ball between your knees.
2. Press your right foot slightly into the wall.
3. Inhale through your nose and gently slide your left leg back without letting your trunk rotate back.
4. Exhale through your mouth as you gently push your left knee down into the ball.
5. Inhale again and slide your left leg back further.
6. Exhale and squeeze into the ball again.
7. Repeat this sequence until you have taken a total of 4-5 breaths, in through your nose and out through your mouth.
8. Relax and repeat 4 more times.

Figure 5: Exercise for left AF IR with concomitant left FA IR. (Postural Restoration Institute, 2015. Image used with permission)

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**Right side-lying supported left gluteus medius exercise**

1. Lie on your right side with your feet on a wall, hips and knees at a 90° angle and your back rounded.
2. Place your lower arm or a pillow under your head and upper hand on the floor in front of you to help stabilize your trunk.
3. Place a 10-15cm ball between your knees.
4. Push your right foot into the wall.
5. Slide or shift your left hip back as far as you can without arching your back.
6. Press your left knee down into the ball. You should feel your left inner thigh engage.
7. Rotate your left thigh 'W' by lifting your left lower leg towards the ceiling. You should feel your left outside hip (buttock) engage.
8. Hold this position for 4-5 deep breaths, inhaling through your nose and exhaling through your mouth.
9. Relax and repeat 4 more times.

Figure 6: Exercise for left AF IR with concomitant left FA IR. (Postural Restoration Institute, 2015; image used with permission)

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**Retro stairs exercise**

1. Stand with your heels placed in front of 15cm stairs and point your toes forward.
2. Advance your left foot on the first step keeping your feet neutral or parallel with each other.
3. Shift your hip back and to the left as you place your weight through your left mid-foot/heel. Your zipper line should be lined up over your left great toe. Keep your left knee pulled in slightly.
4. Keep your back rounded.
5. Begin lifting your right leg to the step keeping your weight shifted over to the left. You should be using your left leg to advance yourself to the next step by pushing slowly through your left mid-foot/heel.
6. Continue to advance up the stairs until you have completed 1 flight always leading with your left foot. You should feel your left outer hip (buttock) engage.
7. Relax and perform 1-2 more flights (10-12 steps).

Figure 8: Single-leg dynamic stance with left AF IR and concomitant left FA IR. (Postural Restoration Institute, 2015; image used with permission)

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**Standing supported right gluteus maximus exercise with resisted left proximal hamstring and left knee flexion**

1. Anchor taping around a stable structure and place the other end around your left thigh.
2. Place a 6-8 lb (2-3 kg) shoe weight around your left ankle.
3. Place your right side on the surface in front of you and round your back.
4. Tilt your right foot in at 45° angle. MAINTAINING CONTACT with your right outer arch, shift your weight onto your right leg. Do not back your right knee (collapse, tuck) away or straighten it.
5. Rise your left leg up as if you were pushing your left foot out of mud. You should feel your left inner thigh and your right outside hip (buttock) engage.
6. Slightly lean back your left leg without using your back.
7. Keeping your left thigh pulled back, slightly bend your left knee. This should feel the back of your left thigh engage.
8. Hold this position while you take 4-5 breaths and repeat 4 more times.

Figure 9: Exercise for right AF with left AF IR (Postural Restoration Institute, 2015; image used with permission)

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## The Power of a Pattern

Maximizing performance while maintaining mechanical health requires one to minimize the development of positional patterned imbalanced forces. Therefore the athlete can maintain non-limiting movement and can develop their athletic skills and talent to the fullest.


Bone position and muscle orientation minimizes poor performance and negative pattern development.

The human foot was intended to **"PUSH"** through the ground/floor to **"PROPEL"** one forward. Often times due to sub-optimal position throughout the kinetic chain **"PULLING"** occurs as a compensatory mechanism for forward **"PROPULSION"**. In reality one should be alternating and reciprocating both **"PUSHING"** and **"PULLING"** on either side of their body to minimize patterning of **"PULLING"** one forward.

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**THANK YOU!!**  
**QUESTIONS?**

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