A Historical Perspective and Rationale Behind the *Hruska Abduction Lift Test*

Webinar
November 10, 2023

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Postural Restoration Institute®

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Human postural patterns emerge as a function of ground support of mass and ground sense of pressure. To maintain upright balance, it is important to control the position of the trunk and the center of mass, that is located in the trunk, and the steer the trunk as a platform for the visual and vestibular sensory organs.

(Buchanan J. and Horak F. Emergence of Postural Patterns as a Function of Vision and Translation Frequency. J of Neurophysiol. 1999;81(5):2325-2339.)

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Our central nervous system (CNS) coordinates our joints and muscles and regulates our sensory information from our visual, somatosensory, and vestibular systems, to maintain balance and postural orientation during standing, walking or running.

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Translation of our trunk from side to side on ground surfaces that move toward or away from our center of our body also moves the sensory systems, within and outside of their optimal operating ranges.

Our CNS controls our position of our center of mass through recognizing this transitory, unfamiliar platform of movement, proprioceptively and mechanically, and reacts to gravitational forces by holding, slowing, or dampening trunk descension.

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Losing the ability to descend our body, or our diaphragms of our thorax and pelvis, restricts our ability to lift ourselves, raise our arms, and ascend on the other side. This alternation of descension and ascension, or abduction and adduction, allows us to move ourselves forward.

The abductors of the hip are the first muscle groups that become restricted, passive and yes, even dormant if this alternation is lost.

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Upright function on two legs, involves continuous compensatory adjustments of the musculature through feed back and feed forward control to stay balanced.

This is done through proprioceptor receptors in the vestibular canals, ankles and hips.

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The primary force that regulates and tunes us to the evolving ground oscillation is provided by our trunk, hip and ankle abductors. Abductors should descend us on the ipsilateral side, as they ascend our contralateral side, as we shift from side to side.

This webinar is designed to help one identify and assess these sites of abductor control descension activity of our body as our center of mass is elevated on the other side.

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Designing programs to reduce undesirable upright disorientation and intersegmental unstable coordination of the trunk's center of mass requires an understanding of how the hip abductors work when in single leg stance or double leg stance, as arms hang by the side of the body or when they are above the shoulder.

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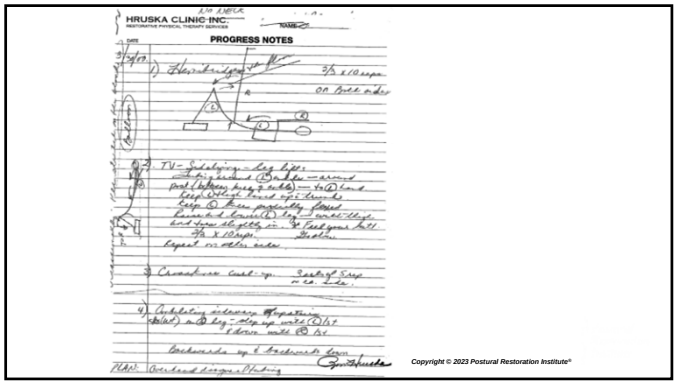
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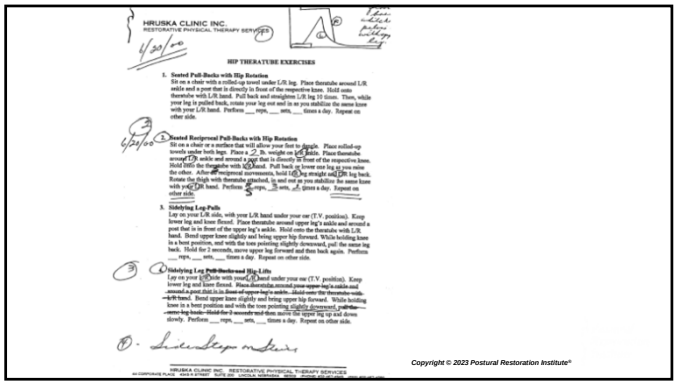
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3. Sidelying Leg Pulls
4. Sidelying Leg Pull-Backward Hip Lifts
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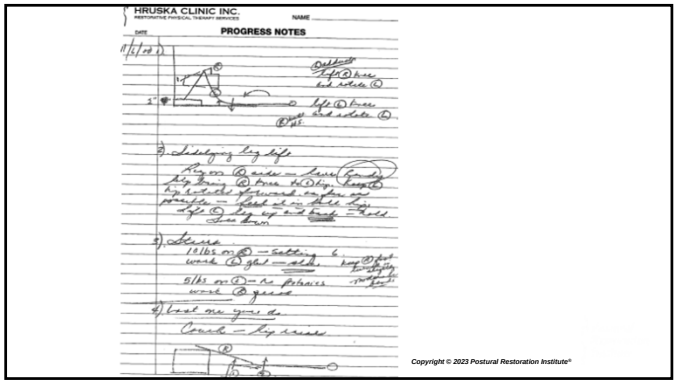
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PATTERNED MECHANORECPTORS

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"The most sensitive mechanical proprioceptive information for standing is probably that from the mechanoreceptors in the ankle joints and associated muscles, and those in the soles of the feet."

(Lee DN, Aronson E. Visual proprioceptive control of standing in human infants. Perception and Psychophysics. 1974;15:529-532.)

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Abductors of the body are products of mechanoreceptivity of length and weight of body parts.

Our mechanorecptors are sensitive to the growth changes in lengths and weights of our body.

The group of muscles that are responsible for this anthropometric control of both the body and the extremities, is the abductors.

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They are our postural pressure influencers, and are closely associated with proprioceptors and mechanoreceptors, especially at the foot and ankle.

They are finely calibrated by means of continual practice in some controlled activity that utilizes them.

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Visual proprioception feedback from immature pre-standing activities and from mature novel function increases our dependency on abductors, that are usually embedded in developing patterned mechanoreception of the ankles and hips.

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Our vestibular ocular reflex (VOR) and our cervical ocular reflexes (COR) automatic postural responses are characterized by how well we respond to “off balance’ sensitivity with our hip abductors.

This response suppresses the adaptation of undesirable cervical stabilization for upright postural control.

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PELVIC RELATIONSHIPS

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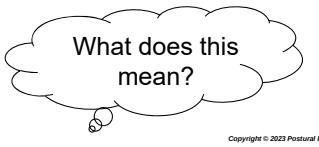
If your femur can abduct, your thoracic diaphragm and your pelvic diaphragm on the same side can also descend, upon inhalation, as the body, with respect to the dome of each central diaphragm of the thorax and the pelvis, ascends.



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Simply, we were designed to keep ourselves 'in check' or 'under control', as our center of mass moves with our vacillation of our trunk.

Abductors of the body are on the outer areas of both the appendicular and axial regions of our body, and provide the outer structural control for lung physiologic pressure rise during inhalation (thorax and pelvis diaphragm descension) and pressure relief during exhalation (thoracic and pelvis diaphragm ascension).

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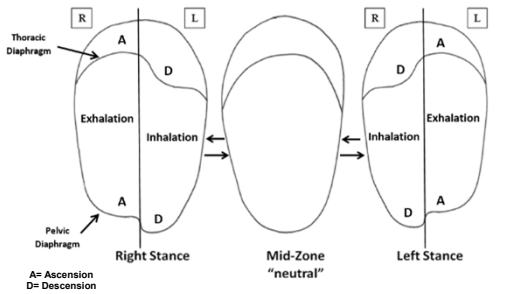
*Looking at the patient from the front



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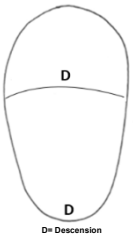
Those that hold their breath, or want more air in their lungs, are more than likely hyperventilating, to hold themselves upright, with accessory stabilization provided by the descent of the thoracic and pelvis diaphragms.



Front

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When we inhale, we pull ourselves together, against gravity, with muscles that connect to the middle or midline regions of our body.

The previous webinar in this series focused on adductor muscles that are more horizontal positioned to stabilize our foundations for hips, shoulders and ribs that expand or move away from the midline during inspiratory respiration.

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These adductors of our body pull the two sides of our body together as we inhale.

They check our outward expansion as our diaphragms are descending upon contraction.

The primary muscle that we use to position our unique and ubiquitous center of mass around our center of our body, are the hip adductors and abdominal muscles.

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The primary muscle that we use, to develop pressure to work around this center or mass, are our abductors.

The pressure under our feet, above our pelvic floor, under our thoracic diaphragm, and under the shoulder blades are all regulated by our ability to abduct without losing control of our center of mass, and pelvic floor descension.

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Therefore, someone who can lift their leg against gravity, in a sidelying position, without over extending their back to do so, more than likely can inhale as their thoracic and pelvis diaphragm's move down or descend into the respective thorax and pelvis cavities.

Additionally, they should be able to exhale as their thoracic and pelvis diaphragm's move up into their respective abdominal and pelvis cavities, without the need to lower their leg.

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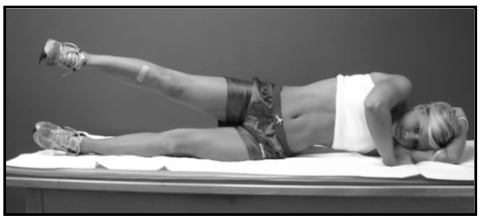

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If someone cannot lift their leg in a similar manner as shown on the previous two slides, there is a possibility that the abductors that are raising, or abducting the leg, are limited because of poor center of mass regulation, or poor breathing mechanics, secondary to thoracic or pelvic diaphragm internal pressure regulation, or both.

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Our hip abductors of our body are patterned off of internal pressure, that was developed and associated with respiratory function or dysfunction.

Our hip abductors are inherently also used for external rotational force to move our trunk to the opposite direction.

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Our hip adductors of our body are patterned off of cortical sense of midline associated with bipodal or single leg/foot pressure.

Our hip adductors are inherently used for internal rotational force to move our trunk to the same direction of the side they are located.

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CENTER OF MASS

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Our center of mass (COM) is a point on the body that moves as a representative of the body's reaction to external forces.

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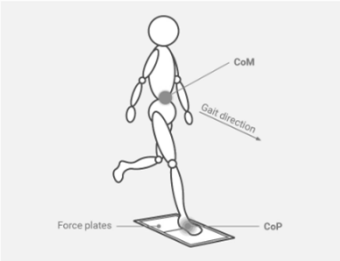

The location of Centre of Mass (CoM) and Centre of Pressure (CoP) on the human body when stepping on a force plate.
Figure from: VALD Health https://valdhealth.com/news/centre-of-pressure-centre-of-mass/
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[The major distinction between the center of gravity and the center of mass is that the center of gravity is the position at which the entire body weight is balanced, while the center of mass is the position at which the entire mass of the body is directed.]

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Our hip abductors, and contralateral pulling hip adductors, have the greatest influence on our center of mass direction.

When one stands on both legs, and shifts the hips to the right with the right hip adductors and left hip abductors, the center of mass will more than likely also shift to the right.

**Please note: This slide had a couple typos on it during the webinar recording, with respect to the underlined text. It was discussed at the end of the webinar and has been corrected here.*

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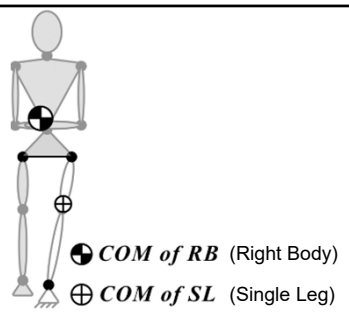

From Figure 1a: Mirshams Shahshahani P, Ashton-Miller JA (2020) On the importance of the hip abductors during a clinical one legged balance test: A theoretical study. PLOS ONE 15(11): e0242454. https://doi.org/10.1371/journal.pone.0242454 (Open Access)

Our ascension and descension of our center of mass and centers of diaphragms depend on this cooperative adduction and internal rotation of one side of the pelvis, with abduction and external rotation of the other side of the pelvis.

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In summary, the human thorax and pelvis alignment in the frontal plane is influenced by the requirement to reach equilibrium around the hip joint, whereby the forces created by the lateral stabilizers, the abductor muscles, balance the loads imposed by body mass. These forces create the abductor internal moment that is essential to support the weight of the body, and maintain an upright posture during walking.

(Molina-Rueda F, et al. Thorax, pelvis and hip pattern in the frontal plane during walking in unilateral transtibial amputees: biomechanical analysis. Braz J Phys Ther. 2014 May-Jun;18(3):252-258.)

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CENTER OF PRESSURE

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Center of pressure (COP) is a temporally influenced measurement that is usually recorded by a force plate.

However, during quiet standing, the anterior and posterior movement of the COP is largely influenced by the ankle joint movements, not just the pressure under the foot.

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The medial and lateral movement of the COP is influenced primarily by the hip joint motion.

During forward locomotor movement, the COP reflects the body movements that occur as forces attempt to rebalance the position of the COM.

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Humans neurological systems and musculoskeletal systems may lead to severely inefficient movement as the body is constantly battling to maintain postural stability which may or may not lead to a balanced COM that is possibly positioned in a state of balanced asymmetry.

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Pronation of the lower extremity, internal rotation of the femur under the acetabulum, and plantar flexion using the abductor hallucis and flexor hallucis brevis at ‘push off’ all provide the center of pressure needed to maintain appropriate center of mass of the body during forward locomotor movement.

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"Since hip control is minimal during push off, there is greater activity in the right forefoot for pronation, postural stabilization and transverse plane control.

The foot complex is under active contraction, with supinators that are highly active in a 'pronated' state. When push off occurs too laterally, normal weight bearing and function at the first MP joint or first ray is impaired."

- Curt Johnson, PT, PRC, Impingement & Instability PRI Course Manual

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Therefore, over supination, or over external rotation of a femur under an acetabulum, reduces the ability to lateral move the body to the contralateral side.

Our vertical center of mass becomes localized over the homolateral center of pressure point, or the right forefoot, contributing to limited side to side lateralization.

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By demonstrating the ability to internally rotate the right femur under the acetabulum, without rotating the pelvis or torso in the same direction, prior to abducting the right femur on the acetabulum or the right acetabulum on the femur, indicates that the center of mass of the torso can shift to the left without losing the lateralized location of the ideal center of pressure reference provided by the right great toe and its internal rotational plantar flexion support for the proximal external rotation force on the leftward moving acetabulum.

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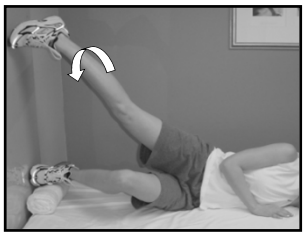
This is the reasoning behind level 3 of the HRUSKA ABDUCTION LIFT TEST.



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Level 3 requires the ability to rotate the top extremity inward without moving the top pelvis forward.

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Inability to do this, reflects poor strength or kinesthetic awareness of ipsilateral gluteus minimus and anterior gluteus medius, or impingement of the medial femoral head on the anterior medial cotyloid labral rim secondary to a forward, anteriorly rotated contralateral pelvis.

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Acceptance and acknowledgment of left center of mass movement or placement, requires homolateral, or in this case left ischial femoral adduction, concomitant homolateral thoracic ilium abduction, and contralateral, or in this case right, iliofemoral **abduction**, during center of pressure assurance from right plantar surface.

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In other words, the thoraco-abdominal abduction or lateral flexion on the left, is occurring because the center of mass is over to the left, as the result of a fixated left ischium that is located between the leftward center of mass and the rightward center of pressure.

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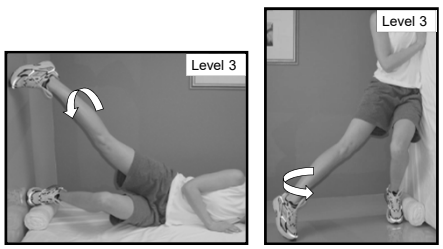

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INVERTED PENDULUM

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"All of the 'HRUSKA' functional test outcomes reflect the orientation of the individual's sense of location with respect to the spine, its sacral base and its sphenoid base."

- Hruska Adduction Lift Test webinar (Sep 2023)

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Humans move on three inverted pendulums:

1) The sacral base

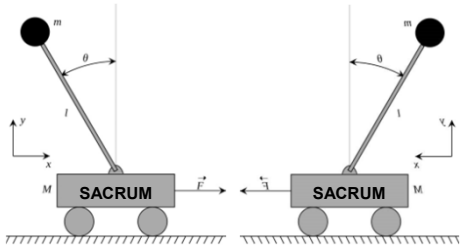

Figure modified from: https://en.wikipedia.org/wiki/File:Cart-pendulum.svg (Open Access)

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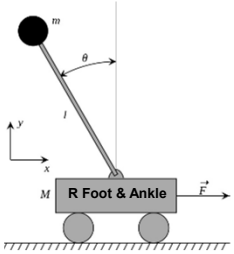
2) The foot and ankle on the right when in single leg balance.



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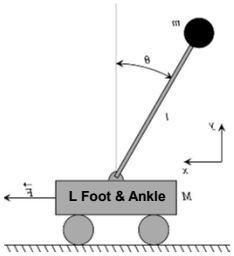
3) The foot and ankle on the left when in single leg balance.



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These inverted pendulums are constantly seeking resolution to guide the body and head and neck toward the unstable fixed point at the top of the pendulum.

Since the fixed point is unstable, the body or the 'bob' must be balanced relentlessly to keep it upright.

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Our cortical function is built around the control of our pendulum or a body, that hopefully will not fall over, when the cart, (sacrum or feet) moves.

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This self-regulation of balance is accomplished through experimentation of different appendicular lengths, weights, amplitudes of oscillation and strengths, in order to discover what determines the necessary frequency of oscillation of their pendular movement for acceptable balance behavior.

Balance is maintained over a range of angles and not just at one angle.

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Any resting equilibrium position of the pendulum is unstable, and in practice, temporary. Movement to a different resting equilibrium position can only be accomplished by a biphasic 'throw and catch' pattern of torque and not necessarily by an elastic mechanism.

(Loram ID, Lakie M. Human balancing of an inverted pendulum: position control by small, ballistic-like, throw and catch movement. J Physiol. 2002 May;540(Pt3):1111-1124.)

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Maintaining quasistatic or control when on one leg for balance requires 50 to 100% of the maximum hip abduction strength in both young and older adults. Effectiveness of a 'hip strategy' in recovering one leg balance, heavily depends on the maximum hip abduction strength, and for healthy older women, hip abduction is as important as ankle strength.

(Mirshams Shahshahahani P, et al. On the importance of the hip abductors during a clinical one legged balance test: A theoretical study. PLOS ONE, Nov. 2020.)

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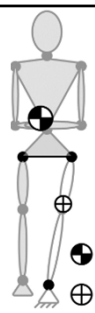

⊖ *COM of RB* (Right Body)

⊕ *COM of SL* (Single Leg)

From Figure 1a: Mirshams Shahshahani P, Ashton-Miller JA (2020) On the importance of the hip abductors during a clinical one legged balance test: A theoretical study. PLOS ONE 15(11): e0242454. https://doi.org/10.1371/journal.pone.0242454 (Open Access)

Much of this one leg control of balance is provided by the standing hip abductor 'eccentric' strength and by the 'concentric' strength of the non-stance hip.

Standing Left AF IR with Passive Right FA Abduction (Standing Integration #76)

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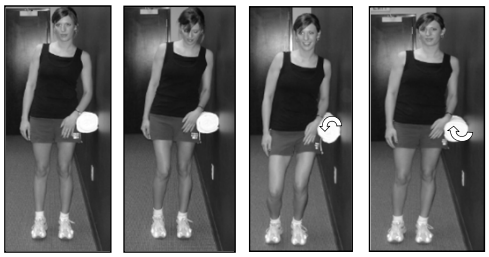

Standing Wall Shift (Standing Integration #6)

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Upright Thoracic Abduction with Contralateral FA Abduction (Standing Integration #17)

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To develop hip abductor concentric strength as seen in level 3, level 4 and level 5 of the Hruska Abduction Lift Test, one would have to therefore, acquire the ability to move the hips to the side where 'eccentric' hip adductors become stabilizers for the center of mass, so that the contralateral 'concentric' hip abductors can improve the ground support kinesthetic awareness and the center of pressure sense, provided by level 2.

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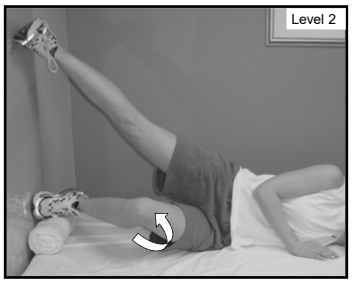

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This horizontal activity and techniques like it, have a direct influence on the vertical activity that requires it.

Left Sidelying Left Flexed FA Adduction with Right Extended FA Abduction and Left Abdominal Co-Activation *(Sidelying Integration #47)*

Left Sidelying Supported Left Ischial Femoral Ligamentous Stretch with Right Extended FA Abduction *(Sidelying Integration #48)*

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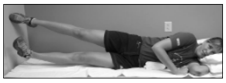
Left Sidelying Supported Left Flexed FA Adduction with Right Extended FA Abduction *(Sidelying Integration #49)*

Left Sidelying Left Flexed FA Adduction with Right Lowered Extended FA Abduction *(Sidelying Integration #50)*



Left Sidelying Left FA Adduction with Right Extended FA Abduction *(Sidelying Integration #54)*

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Right Sidelying Supported Left FA IR with Left Extended FA Abduction
(Sidelying Left Gluteus Medius #31)

Right Sidelying Supported Left Glute 45's
(Sidelying Left Gluteus Medius #32)

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UPRIGHT ABDUCTION RELATIONSHIP TO STANCE ACTIVITY OF SHOULDERS AND HIPS

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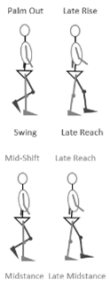
Midstance gluteal abduction activity requires concomitant contralateral posterior and middle deltoid abduction activity to move the arm away from the body so it can clear the body 'palm out' and 'late rise'.



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Gluteal abduction (femur abducting on ilium, or ilium abducting on femur), requires concomitant ipsilateral abdominal abduction (lateral ribcage abduction on ilium, or ilium abduction on lateral rib cage) to maintain the center of pressure on the stance side and the center of mass in front of the sacrum, as the contralateral shoulder is abducted on the trunk.

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Therefore, shoulder abduction requires contralateral hip and lateral trunk abduction (glutes and abs), when the center of mass of the pelvis remains neutral and centered between the hips and shoulders (non-trendelenburg position).

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PRI Right AIC Single Leg Stance (Standing Integration #110)

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In essence, good shoulder abduction, flexion and extension relies on stabilization of the spine and trunk from contralateral hip abductors and abdominals when in standing.

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Single Leg Right Apical Overhead Reach (Standing Integration #88)

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Standing on one leg, or with one foot off the floor, and reaching with the contralateral arm and hand above the head requires concentric abdominal work from the side one is standing with.

These abdominal ‘concentric to concentric’ muscles will need to work with ‘eccentric to concentric’ hip abductors from the side one is standing with.

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All scapula trapezius muscles on the overhead arm/shoulder side and all gluteal muscles on the stance side will become co-activated.

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Arm abduction on one side, along with leg abduction effort on the other side, provide the upright stability for small medio-lateral shifts of the body's center of mass, and if timed correctly may be sufficient to maintain balance under extreme rotation inertia of the upright body axis.

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Our arms, are the human hips abductors best reference, and our ankles, best allies. When we raise or abduct our arm or arms, we create a horizontal human balance pole for effective hip abduction to manage our center of mass inertia, especially when limited center of pressure force exists.

(Morasso P. Centre of pressure versus centre of mass stabilization strategies: The tightrope balancing case. R Soc Open Sci. 2020 Sep 9;7(9):200111.)

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TRENDELENBURG CONSIDERATIONS

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The most universal identified indicator of weakness in the hip abductor muscles is the Trendelenburg sign. When the pelvis drops on the contralateral side during a single-leg stance on the affected side, or when the lateral thoraco-abdominal region laterally flexes on the weak hip abductor side during forward locomotor movement, most would consider this dysfunction as a sign of gluteal weakness.

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However, this dysfunctional activity seen when standing or walking, could be a sign of over centering of mass on the Trendelenburg side with over referencing of ground by the contralateral 'center of pressure' extremity.

Or, the dysfunctional state could represent over referencing of centering of pressure AND over use of center of mass on the stable or over referenced side, which is opposite to the side of the non-Trendelenburg sign.

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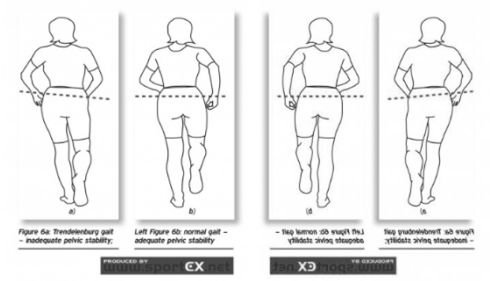

Figure from: https://www.physio-pedia.com/Trendelenburg_Gait

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Human forward locomotor movement relies heavily on adductor related orientation for frontal planes of motor control, on abductor orientation for transverse planes of motor control and on integrated adductor and abductor orientation, for unbiased motor control during sagittal planes of movement.

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If the thoracic abdominal abductors do not contract, as contralateral ischial femoral abductors contract, and vice versa, during forward locomotor movement, sagittal plane of movement (forward plane of movement) becomes biased by overactive back extensors and hip flexors.

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MANAGEMENT OF UPRIGHT LATERAL DISPLACEMENT

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Lateral displacement of our center of mass is one of the most difficult things we, as humans, have to deal with on a day to day basis. Usually this unconscious displacement leads to conscious awareness of pressure points of discomfort associated with weight distribution and neurological balance effort.

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Our center of mass needs to remain within the bounds of our base of support, or we will begin to fall.

The location of the center of pressure can generally be thought of as the cause, while movement of the center of mass is the effect.

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If the center of mass is located too far posteriorly, the center of pressure will move posterior to the center of mass, for the body to move in the anterior, or forward direction.

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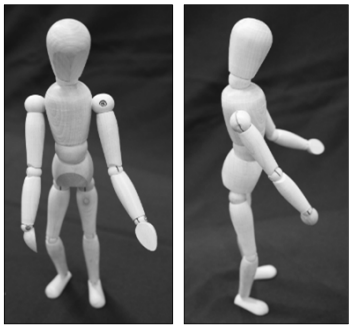

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If our center of mass is located too far laterally to the right, the center of pressure will need to move further to the right of the center of mass which will cause the center of mass to then move to the left, to prevent falling to the right.

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As the center of mass and center of pressure become sites for associated functional cortical dominant behavior, the right ischial-femoral adductor become primary stabilizers for upright postural perturbation.

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This adductor biased behavior contributes to ipsilateral shift or displacement of the center of pressure to the adductor biased side, when the visuo-vestibular system unsuccessfully attempts to regulate center of mass to the contralateral side.

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The biased or over used adductors (center of mass) on the right side of the body, through hip and pelvis attachments, reinforces the cortical postural need to coactivate the left hip abductors, for center of pressure reference, thus heightening, reflexive balanced, controlled sense of limited support, from the contralateral, or left, side.

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This imbalanced and limited sense of ‘center of mass’ alternation and the over use of adapted heterolateralized ‘center of pressure’, directly contributes to the underlying chronic, upright reactive and reflexive neurologic and orthopedic patterns of behavior, that is associated with lateral displacement.

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Management of right lateral displacement of the center of mass, or over referenced center of pressure from the left foot, requires:

- One to minimize dependency that is placed on the right concentric minded lateral thoracic-ilium (abdominal) muscle, that is providing the 'abduction' needs for stabilizing the homo-lateralized center of mass, and
- Maximizing functional cortical integration of ilio-femoral concentric positioned abduction (from gluteal muscle) on the right side, to enhance ease of lateral placement of center of mass to the left, when either in vertical or horizontal states of orientation.

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Achieving a level 4 of the HRUSKA ABDUCTION LIFT TEST requires one to "raise the top leg completely off the wall and hold without using lateral trunk muscle."

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"Inability to raise top leg completely off the wall and hold without using lateral trunk muscle, reflects poor integration between contralateral hip adductors, and ipsilateral hip abductors, i.e. gluteus medius muscle."

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This level of activity reinforces the need to be able to minimize the right lateral thoracic abdominal muscle during lateral placement of the center of mass over to the left side, as the left foot, lower extremity and hip are pushing into the wall through level one application.

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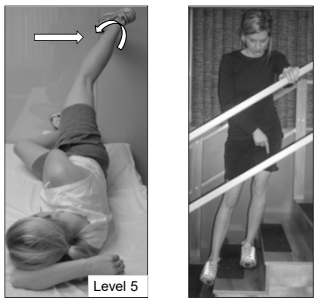

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When one has the “ability to move correctly abducted top lower extremity into extension without extending low back or flexing knee, or rotating leg externally,” they are demonstrating that they can maintain their ‘center of mass’ orientation on the left, through referencing that is offered from the right great toe.

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This reference of pressure provides concomitant ‘center of pressure’ sense that is necessary to activate the right hip abductors without externally rotating the ‘center of pressure’ leg, and without over-extending or “abducting” the low back and lateral abdominals.

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This is a level 5 of the Hruska Abduction Lift Test.

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Achievement of a level 5 should reflect the capability to perform the following three centering of mass functions, when in left single leg support states.

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Center of mass to the right (hands by side) when standing in left single leg support.

Standing Left AF IR with Resisted Left Arm Pull Down and Right FA Abduction (Standing Integration #13)

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Center of mass in center (right hand in air) when in left single leg support.

Single Leg Right Apical Overhead Reach (Standing Integration #88)

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Center of mass to the left (left hand in air) when standing in left single leg support.

Standing Lateral Shift Overhead Reach Occlusal Test (Occlusal Cervical Restoration Course)

Upright Thoracic Abduction with Contralateral FA Abduction (Standing Integration #17)

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Thank you for joining us and for your genuine interest in human abduction assessment.

SAVE THE DATE
for part 3 of this webinar series:

- **A Historical Perspective and Rationale Behind the *Hruska Alternating Reciprocal Rotation Test***

January 26th, 2024
1pm CT

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