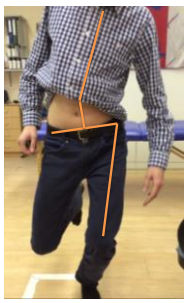
Preventing knee and ankle injuries

Rolandas Kesminas PT, MS

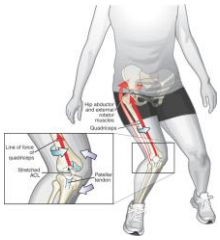
2016.02.27

Tartu

Young basketball players performing Single leg squat/Single leg hop



Mechanism of knee injury



Specific for ACL injury

Inadequate Sensitivity: 1/3 of high risk individuals can't be detected.

Other injuries:
Meniscus tears
Patelofemoral knee pain

J Orthop Sports Phys Ther. 2009 Sep;39(9):665-74.
Reliability and validity of observational risk screening in evaluating dynamic knee valgus.
Ekegren CL, Miller WC, Celebrini RG, Eng JJ, Macintyre DL.

Lumbo-pelvic stability

- Assessment:
  - Foam roller test
  - ASLR

Global stabilizers of the trunk

Latisimus dorsi
C6, C7, C8
Toracodorsal n.

Gluteus Maximus
L5, S1, S2
Inf Glut.n.

Local stabilizing muscles

Cx n.phrenicus: C3, C4, C5

Multifidus, Rotator brevis longus L1-S1

Transversus, OI Th7-L1

S2, S3, S4

Before 2015

- Long distance runner

- **Pelvic drop = 10°**
- Hip add = 11°
- Femoral pelvic angle = 69°

- Poor lumbopelvic stability

Poor lumbo-pelvic stability

↓

Poor eccentric control of lower extremity

In 2015

- **Pelvic drop = 13°**
- Hip add = 8°
- Femoral pelvic angle = 69°

- Main problem:
  - Achiles tendinopathy
  - Left Hamstring pain/tightness
- Achilles and Hamstrings strongly innervated by S1 nerve root
- Possible cause: gentle S1 radiculopathy at L5/S1 segment

Prevention = good running form

Body posture and lumbo-pelvic stability: where does it come from?

- Diagnosis: C1 subluxation and alar ligament tear
- Alar ligament test positive:
  - head side bending to the Right does not rotate C2 to the Right.
- Patient problem: low back pain



13 y.o. basketball player/playing 7 y.

Lumbo-sacral hypermobility

Kyphosis in lordosis

Hypermobility in TLJ

Low back/leg pain
Retro spondilolisthesis
Ankle and knee pain
Possibly ankle, knee injury

Low back/SIJ pain
Lateral or anterior hip pain

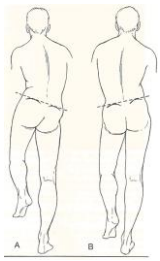
Injury Prevention = sitting posture/education

Fencer

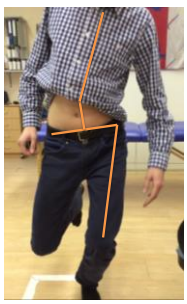


Single leg balance

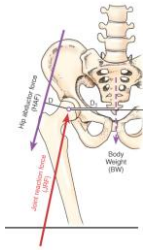
- Balance
  - Quality, symmetry, time
- Foot position/movement
- Pelvic position
  - Hip muscle weakness?
  - Lumbopelvic stability?



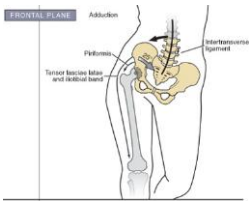
Single leg squat/Single leg hop

We always analyze gluteus in neutral (0 hip flexion)
Abductor Weaknes = hip drop (trendelenburg)



Pelvic on femoral hip adduction



Lets analyze hip in flexion !!!

At >50 º hip flexion the whole gluteus medius is internal rotator of the hip

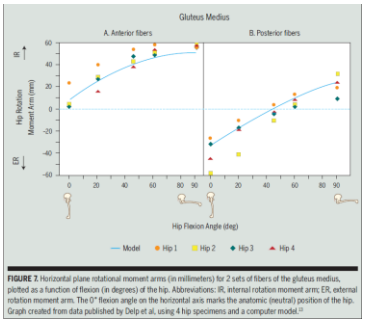


FIGURE 7. Horizontal plane rotational moment arms (in millimeters) for 2 sets of fibers of the gluteus medius, plotted as a function of flexion (in degrees) of the hip. Abbreviations: IR, internal rotation moment arm; ER, external rotation moment arm. The 0° flexion angle on the horizontal axis marks the anatomic (neutral) position of the hip. Graph created from data published by Delp et al, using 4 hip specimens and a computer model.[2]

Lunge = nice exercise

- Lets say at 90 hip flexion gravity produces pelvic on femoral hip external rotation (sagital axis)
- So gluteus medius is holding the pelvis from falling down and is doing pelvic on femoral internal hip rotation

FIGURE 3. Single-limb squat exercise.

FIGURE 6. Forward lunge.

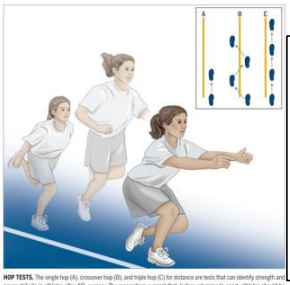
Some EMG evidence
we can see Gluteus medius is very active during single leg squat

TABLE 2 NORMALIZED GLUTEUS MEDIUS MEAN SIGNAL AMPLITUDE (% MVIC)

Exercise	Mean ± SD (95% CI)
Side-lying hip abduction	81 ± 42 (62, 101)
Single-limb squat	64 ± 24 (53, 75)
Lateral band walk	61 ± 34 (46, 76)
Single-limb deadlift	58 ± 25 (47, 70)
Sideways hop	57 ± 35 (41, 73)
Transverse hop*	48 ± 25 (37, 59)
Transverse lunge*	48 ± 21 (38, 57)
Forward hop*	45 ± 21 (38, 57)
Forward lunge*†	42 ± 21 (33, 52)
Clam with 30° hip flexion*	40 ± 38 (23, 57)
Sideways lunge*†	39 ± 19 (30, 47)
Clam with 60° hip flexion*†	38 ± 29 (25, 51)

Abbreviations: CI, confidence interval; MVIC, maximum voluntary isometric contraction.
** Exercises are significantly different than the hip abduction exercise (P<.05).*
† Exercises are significantly different from the single-limb squat (P<.05).

Imagine how eccentrically gluteus medius decelerates pelvis on femoral hip external rotation landing during single leg jump



HOP TESTS. The single hop (A), crossover hop (B), and triple hop (C) for distance are tests that can identify strength and power deficits in athletes after ACL surgery. The researchers suggest that, before returning to sport, athletes should be able to jump on their repaired legs at least 90% of the distance they can hop on their unrepaired legs.

For eccentric deceleration we need:

Trunk muscles

Gluteus maximus /medio-lateral axis

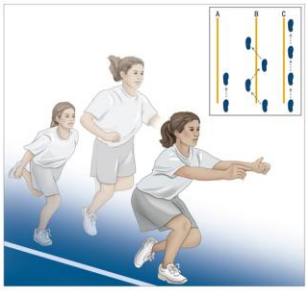
Gluteus medius / hip sagital axis

Quadriceps /medio-lateral axis

Foot plantar flexors

Etc.

Hop tests



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Hop – hight

Hop 1-5 quality/shock atennuation

1 Hop - distance

3 Hops – distance

6 m Timed Hop

Performance on the single-leg squat task indicates hip abductor muscle function

Am J Sports Med. 2011

- Single-leg squat task as "good," "fair," or "poor."
- Excelent to substantial intrarater and interrater reliability
- agreement 87%-73%; κ = 0.800-0.600).
- Good performers had earlier activation of anterior and posterior gluteus medius compared to poor performers.
- Good performers also exhibited greater hip abduction torque and trunk side flexion force
- There was no difference in hip external rotation torque (P > .05) between the 2 groups.

- **CONCLUSION:**
  - single-leg squat task is a reliable tool that may be used to identify people with hip muscle dysfunction.

Neuromuscular Evaluation With Single-Leg Squat Test at 6 Months After Anterior Cruciate Ligament Reconstruction.

Orthop J Sports Med. 2015

CONCLUSION:

- Nearly half of patients demonstrated persistent neuromuscular deficits on SLST at 6 months, which is when many patients return to unrestricted activity. Those with poor performance were of a significantly older age, decreased hip abduction strength, decreased single-leg hop distance

CLINICAL RELEVANCE:

- The SLST can be used to identify neuromuscular risk factors for ACL rupture. Many patients at 6 months have persistent neuromuscular deficits on SLST. Caution should be used when using time alone to determine when patients can return to unrestricted activity.

Whether any of these tests can predict injury remains **unknown** !

Test
One leg hop for distance: 1 hop
One leg hop for distance: 3 hops
6 m timed hop
Crossover hop for distance
Triple jump
Single leg vertical jump

Clinician-friendly lower extremity physical performance measures in athletes: a systematic review of measurement properties and correlation with injury, part 1. The tests for knee function including the hop tests

Hegedus EJ, *et al. Br J Sports Med* 2015;**49**:642–648.

Statistical property				
Reliability	Agreement	Hypothesis testing	Criterion validity	Responsiveness
Poor	No studies	Fair	Good	Poor
Poor	No studies	Poor	Good	No studies
Poor	No studies	Poor	Good	No studies
Fair	No studies	Poor	Good	Good
No studies	No studies	Fair	No studies	Poor
Fair	No studies	Mixed—good to poor	Mixed—good to poor	Mixed—good to poor

BJSM

Clinician-friendly lower extremity physical performance tests in athletes: a systematic review of measurement properties and correlation with injury. Part 2—the tests for the hip, thigh, foot and ankle including the star excursion balance test

Hegedus EJ, *et al. Br J Sports Med* 2015;**49**:649–656.

Test
Star excursion balance test
Sprint test: 40 yards
Shuttle run
Vertical jump
One leg hop for distance
One leg hop for distance: three hops
Triple crossover hop for distance
6-meter timed hop
6-meter timed crossover hop
Hexagon hop
Medial hop
Lateral hop
T-agility
Multistage fitness

- The one leg hop for distance was the single test of use at the knee and ankle since it is responsive to rehabilitation after anterior cruciate ligament reconstruction and discriminant in cases of ankle instability.
- Only one test, the modified star excursion balance test (SEBT), has shown strong evidence of the ability to predict injury in the lower extremity.
- Poor performance on the modified SEBT, seems to predict injury based on the results of one study.

Star Excursion Balance Test as a Predictor of Lower Extremity Injury in High School Basketball Players

J Orthop Sports Phys Ther • Volume 36 • Number 12 • December 2006

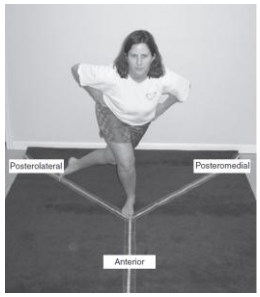

TABLE 6. Adjusted odds ratios for potential lower extremity injury risk factors among high school basketball players.

Risk Factor	Category	LE Injury AOR‡ (95% CI)
All players		
Normalized composite right reach distance*	≤94.0%	3.0 (1.5, 6.1)
Anterior reach distance difference†	≥4 cm	2.7 (1.4, 5.3)
Girls		
Normalized composite right reach distance*	≤94.0%	6.5 (2.4, 17.5)
Boys		
Anterior reach distance difference†	≥4 cm	3.0 (1.1, 7.7)

* Reach distance is reach distance divided by limb length multiplied by 100. Right reach done by standing on left limb and reaching with the right limb.
†Difference between right and left anterior reach distances.
‡ Adjusted odds ratio for gender, grade, previous injury, participation in a neuromuscular training program since initial measurement, and lower extremity tape/brace use.

Case 1: long jumper

- History: stretching sensation in the right hamstring after single long jump
- What do you think happed?
- Neurologist Dx: Hamstring tear
- My assesment

Case 1: My assesment

- FB but stop before pain/stretching
- Extend the head/cervical spine


Case 1: long jumper

- At 50% of FB stretching sensation R hamstrings
- Head/neck extension eliminates simptoms
- Is it really a hamstring tear?
- Why extension decresease symptoms?

Case I: long jumper

- Lumbar Flexion SNAG on the Right L5
- Almost touching the floor and stretching sensation in both legs
- Treatment prioroty = lumbar spine

Neurodynamic tests

- SLUMP test (Sitting/Standing) L4,L5,S1
  - Short hamstrings
- SLR, SLR+DF, SLR+ADD, SLR+ IR


Neurodynamic tests

- Prone knee bent test
  - Short RF/Quadriceps
- Femoral nerve slump (L2-4)

Trainor K, Pinnington MA. Reliability and diagnostic validity of the slump knee bend neurodynamic test for upper/mid lumbar nerve root compression: a pilot study. *Physiotherapy*2011: 97; 59-64.

Muscle length tests or Tonic stretch reflex evaluation?

- SLR = 70/80º
- 90/90 =0-20º
- Ely's = 135º
- Tomas test
- Other…

1) 90-90 Straight Leg Raising Test

- **Normal flexibility in the hamstrings : knee extensor should be within 20˚ of full extension**
- **Positive : if the hamstrings are tight, the end feel will be muscle stretch**

Tonic stretch reflex

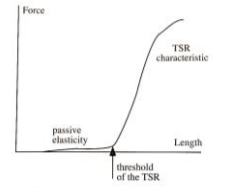

Figure 9.6 A muscle is slowly stretched by an external force. At first the muscle resists the stretching due to its passive elasticity. Then, at a certain threshold, recruitment of α-motoneurons begins, leading to an active force development (tonic stretch reflex). The whole curve is called a *tonic stretch reflex characteristic*.

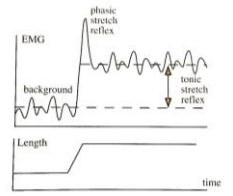

Figure 9.3 The tonic and phasic components of the muscle reflex resulting from stretch.

Neurophysiological Basis of Movement - 2nd Edition. Mark Latash 2008

PROTECTIVE MUSCLE ACTION DURING NEURAL LOADING

- J Orthop Sports Phys Ther. 2009. **Mechanosensitivity of the lower extremity nervous system during straight-leg raise neurodynamic testing in healthy individuals.**
- J Sports Med 2014. **Immediate Effects of Neurodynamic Sliding versus Muscle Stretching on Hamstring Flexibility in Subjects with Short Hamstring Syndrome**
- Man Ther. 2012 **Normal neurodynamic responses of the femoral slump test.**

Case II

- 12 y.o girl had lateral ankle sprain
- History: kayaking, cycling, running – injury
  - Unable to walk, ankle pain
- Testing of ATFL and CFL
- History = SLUMP test = head movements changes ankle symptoms
- Unable to walk – Neurodynamic mobilisation = could stand and walk

Motor control impairment in subjects with peripheral neuropathy

- Motor Control. 2015 **Postural Steadiness and Ankle Force Variability in Peripheral Neuropathy.**

Sensorimotor and balance function is impaired in adults with nerve root compression

- Clin Orthop Relat Res. 2002 **Sensorimotor and balance function in older adults with lumbar nerve root compression.**

Case I Case II

- Could positive neurodynamic testing be a screen test for injury prevention?
- Muscle stretching or neurodynamic mobilization?
- Could nerve mobilization be a preventive exercise?
- Sliding or tensioning the nerve?

Slump test - mandatory test in the assessment of hamstring strain

- J Orthop Sports Phys Ther. 1989. **The effect of stretching neural structures on grade one hamstring injuries.**
- Professional Australian Rules football players.
- Grade I hamstring injuries
- Positive responses to the slump test (a neural tension test).
- 16 were treated traditionally, with the remaining 12 receiving slump stretch as an addition to the treatment regime.
- Results indicated that traditional treatment plus slump stretch technique was more effective ($p < 0.001$) in returning the player to full function than the traditional regime alone.

J Sports Med 2014. **Immediate Effects of Neurodynamic Sliding versus Muscle Stretching on Hamstring Flexibility in Subjects with Short Hamstring Syndrome.**

- Neurodynamic sliding technique increased hamstring flexibility to a greater degree than static hamstring stretching in healthy subjects
- Hamstring flexibility in sports may lead to a decreased incidence in injuries; however, this needs to be formally tested.

Neurodynamic changes in subjects with anterior knee pain

- J Orthop Sports Phys Ther. 2014 **Neurodynamic responses to the femoral slump test in patients with anterior knee pain syndrome.**
- Arch Phys Med Rehabil. 2015 **Predictors for identifying patients with patellofemoral pain syndrome responding to femoral nerve mobilization.**

Which screening tools can predict injury to the lower extremities in team sports?: a systematic review.

- Sports Med. 2012 Sep 1;42(9):791-815. Dallinga JM[1], Benjaminse A, Lemmink KA.

- General joint laxity, hyperextension of the knee
- Star excursion balance test (SEBT) may predict leg injuries.
- Lower hamstring/quadriceps (H : Q) ratio
- Decreased range of motion (ROM) of hip abduction
- Side-to-side differences in anterior-posterior knee laxity
- Differences in knee abduction moment between both legs are suggested to be predictive tests for sustaining an ACL injury and height was a predictive screening tool for knee ligament injuries.
- There is some evidence that when age increases, the probability of sustaining a hamstring injury increases.
- Hamstring flexibility (Debated predictive screening tool)
- Body mass index and the age of an athlete could contribute to an ankle sprain.
- There is support in the literature to suggest that greater strength of the plantar flexors may be a predictive measure for sustaining an ankle injury.
- Postural sway is a predictive test for an ankle injury.

Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors

Knee Surg Sports Traumatol Arthrosc. 2009

- Most ACL tears in soccer players are non-contact in nature.
- Mechanisms of injury
  - Cutting maneuvers combined with deceleration
  - Landing from a jump in or near full extension
  - Pivoting with knee near full extension and a planted foot.
- The most common non-contact ACL injury mechanism include a deceleration task with high knee internal extension torque (with or without perturbation) combined with dynamic valgus rotation with the body weight shifted over the injured leg and the plantar surface of the foot fixed flat on the playing surface.

Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors

- Extrinsic non-contact ACL injury risk factors
  - dry weather and surface
  - artificial surface instead of natural grass.
- Intrinsic risk factors include:
  - Generalized and specific knee joint laxity,
  - Small and narrow intercondylar notch width
  - Pre-ovulatory phase of menstrual cycle in females not using oral contraceptives
  - Decreased relative (to quadriceps) hamstring strength and recruitment
  - Muscular fatigue by altering neuromuscular control
  - Decreased "core" strength and proprioception
  - Low trunk, hip, and knee flexion angles, and high dorsiflexion of the ankle when performing sport tasks
  - Lateral trunk displacement and hip adduction combined with increased knee abduction moments (dynamic knee valgus), and increased hip internal rotation and tibial external rotation with or without foot pronation.

THE INFLUENCE OF HIP STRENGTH ON KNEE KINEMATICS DURING A SINGLE-LEGGED MEDIAL DROP LANDING AMONG COMPETITIVE COLLEGIATE BASKETBALL PLAYERS.

Int J Sports Phys Ther. 2015

- A smaller knee flexion angle and larger knee valgus angle during weight-bearing activities = risk factors for non-contact anterior cruciate ligament (ACL) injuries.
- Purpose
  - influence of hip strength on knee kinematics in both genders during a single-legged landing task in the frontal plane.
- Three-dimensional motion analysis during a single-legged medial drop landing (SML).
- Hand-held dynamometer was used to assess hip isometric strength.
- **CONCLUSIONS:**
  - Significant correlations between hip strength and knee kinematics during SML were observed in both genders.
  - Study suggest that **increased hip strength may help to prevent non-contact ACL injuries in athletes of both genders.**

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The effectiveness of exercise interventions to prevent sports injuries: a systematic review and meta-analysis of randomised controlled trials

Jeppe Bo Lauersen, Ditte Marie Bertelsen and Lars Bo Andersen
Br J Sports Med published online October 7, 2013

- Conclusions:
  - Physical activity can significantly reduce sports injuries
    - Acute injuries
    - Overuse injuries reduced by half
- Not effective
  - Stretching
  - Multiple exposure programs – emphasis on single effective...
  - Proprioception
  - Strength training – remains crucial
- Most effective

The effectiveness of neuromuscular warm-up strategies, that require no additional equipment, for preventing lower limb injuries during sports participation: a systematic review.

CONCLUSIONS:

- neuromuscular warm-up strategies can reduce lower extremity injury incidence in young, amateur, female athletes and male and female military recruits.
- warm-up strategy:
  - Stretching
  - Strengthening
  - Balance exercises
  - Sports-specific agility drills
  - Landing techniques applied consistently for longer than three consecutive months.

BMC Med. 2012

Foot posture as a risk factor for lower limb overuse injury: a systematic review and meta-analysis.

J Foot Ankle Res. 2014

- Strong evidence that a pronated foot posture was a risk factor for medial tibial stress syndrome (MTSS) development
- Very limited evidence that a pronated foot posture was a risk factor for patellofemoral pain development,
- No relationship was identified between a pronated footposture and any other evaluated pathology (i.e. foot/ankle injury, bone stress reactions and non-specific lower limb overuse injury).
- Evaluation of static foot posture should be included in a multifactorial assessment for both MTSS and patellofemoral pain.

Passive foot or active foot?

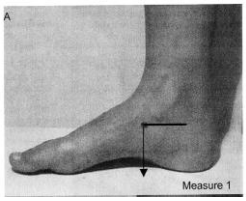
- Passive foot
  - Adapting ground to the foot
  - Habit to be in a passive position
- Active foot
  - Adapting foot to the ground
  - Pliable foot and Stiff foot during gait/sport
  - Habit to be in a active position.

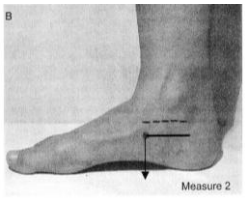
Mobility of first metatarsal

Pronated foot ☺ Subtalar neutral

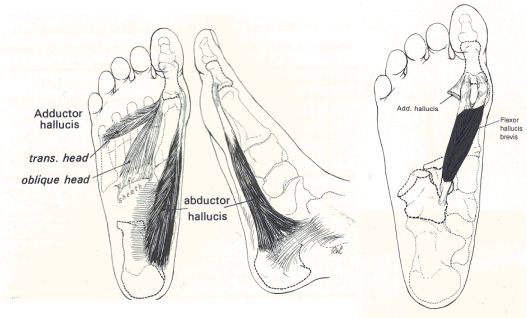
Subtalar neutral

Navicular drop test





Intrinsic foot muscles

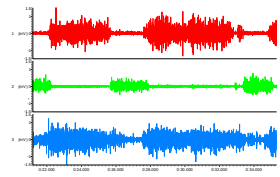


1st metatarsal elevation/depresion

Peroneus Longus

Tibialis Anterior

Abductor Hallucis

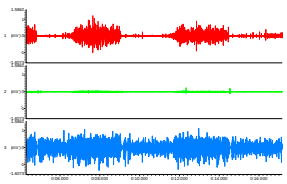


Short foot exercise

Peroneus Longus

Tibialis Anterior

Abductor Hallucis

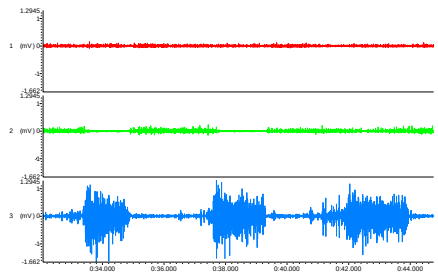


Abduction of the great toe

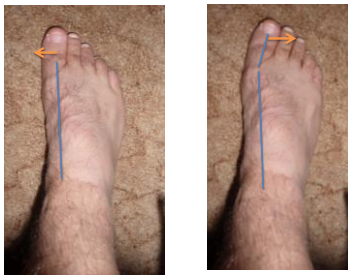
Peroneus Longus

Tibialis Anterior

Abductor Hallucis



Abduction of the great toe

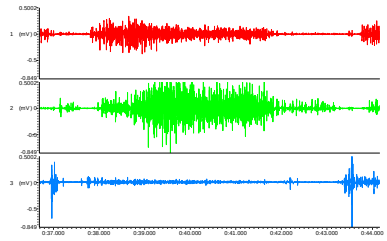


Grabbing a pencil with toes

Peroneus Longus

Tibialis Anterior

Abductor Hallucis

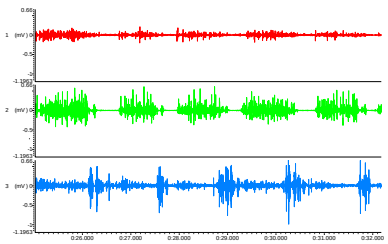


Grabbing a towel with toes

Peroneus Longus

Tibialis Anterior

Abductor Hallucis



Thank you