Muscle Strains

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Muscle Structure

Fibres form fasciculi form muscle

⬇

Sarcolemma (cell membrane)

⬇

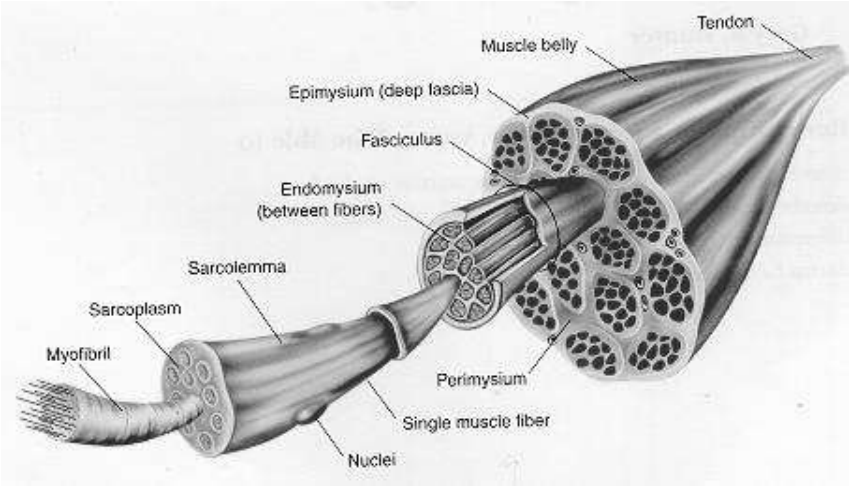
Myofibrils

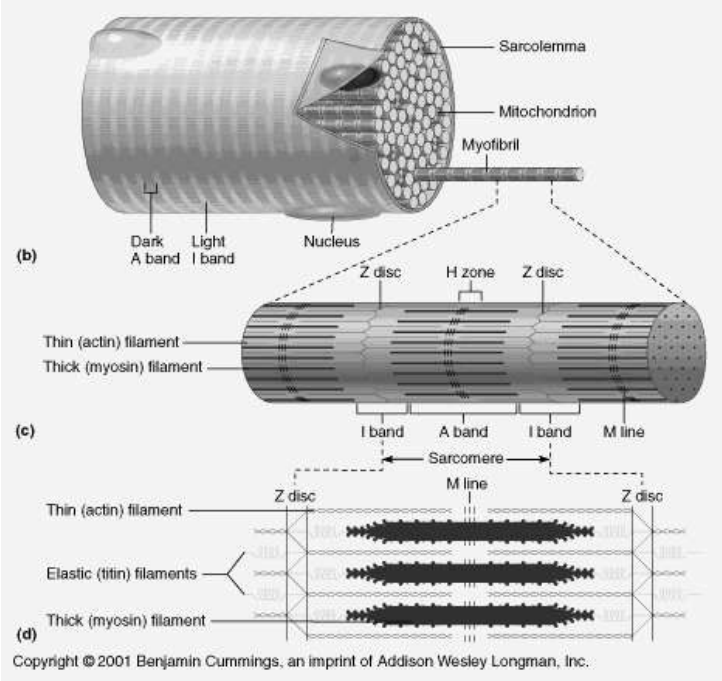
⬇

Actin/Myosin Filaments

⬇

Sarcomere



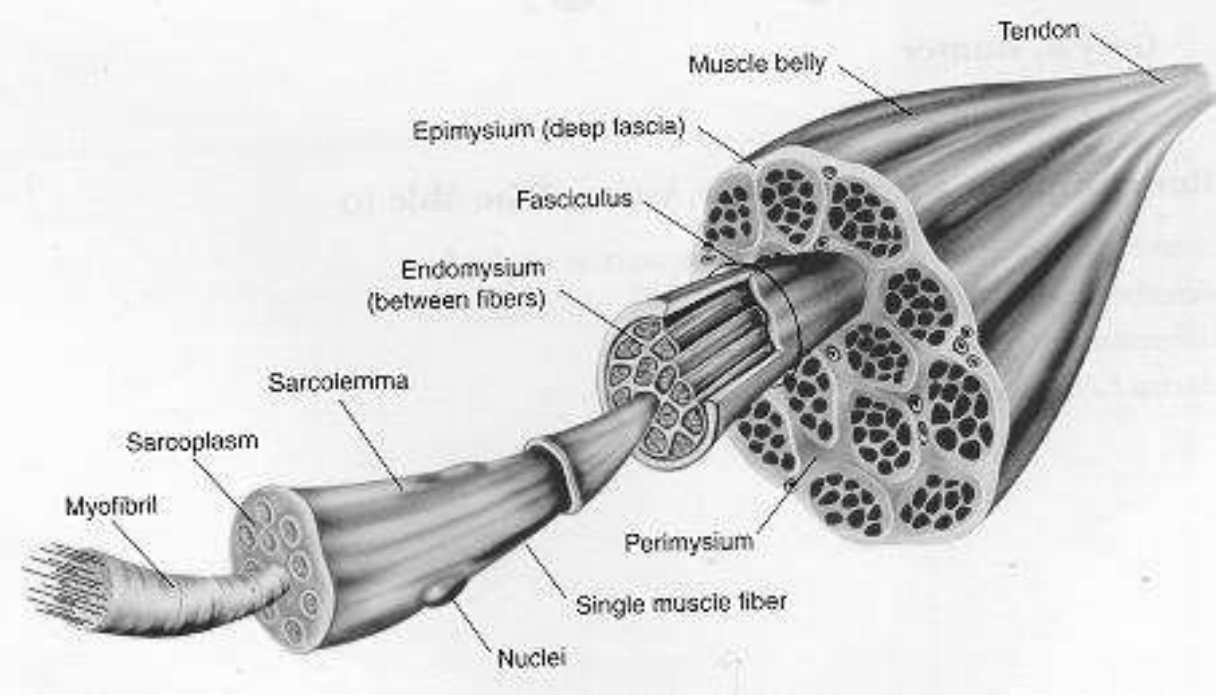


Connective Tissue

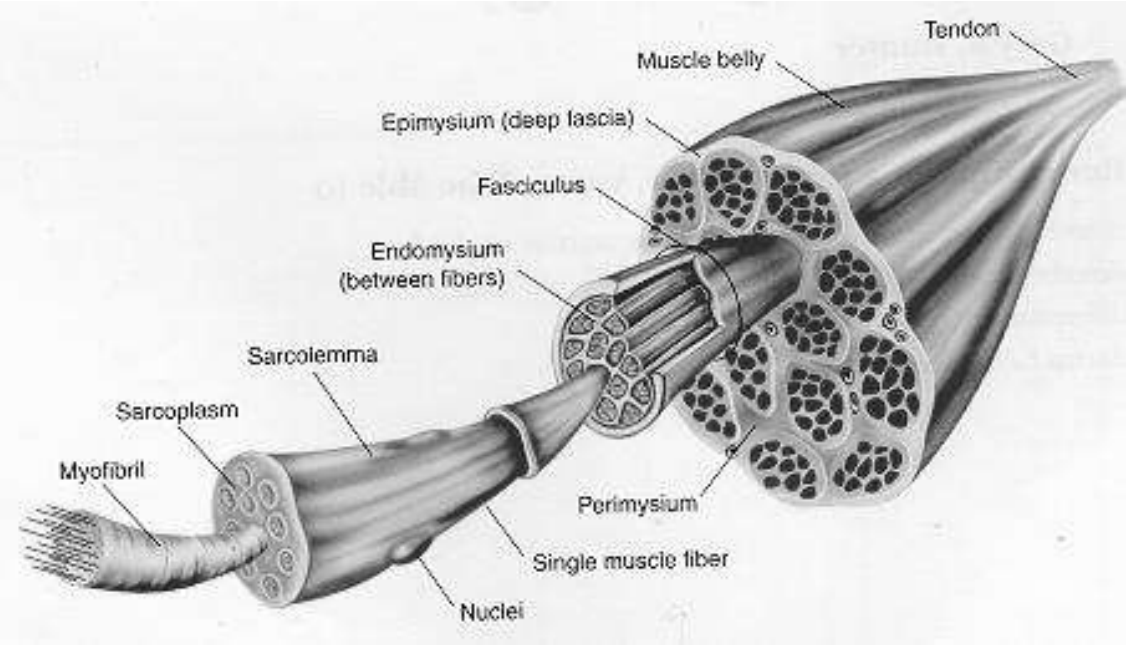
- Surrounds fibres, fasciculi and muscle belly
- Type I > III blends to forms tendons
- Non-contractile tissue with contractile function
- Contains nociceptors – no innervation of muscle fibres
    - Langevin (2005)

Connective Tissue

- Epimysium (whole muscle) – Type I
  - Series elastic component
  - Transfers contractile forces



Connective Tissue



- Perimysium/Endomysium – Type III
  - Parallel Elastic Component
  - Prevents over-stretching due to even stress distribution within the muscle

Mechanism of Injury

- Muscle Injuries can occur as a:
  - Contusion
  - Strain
  - Laceration

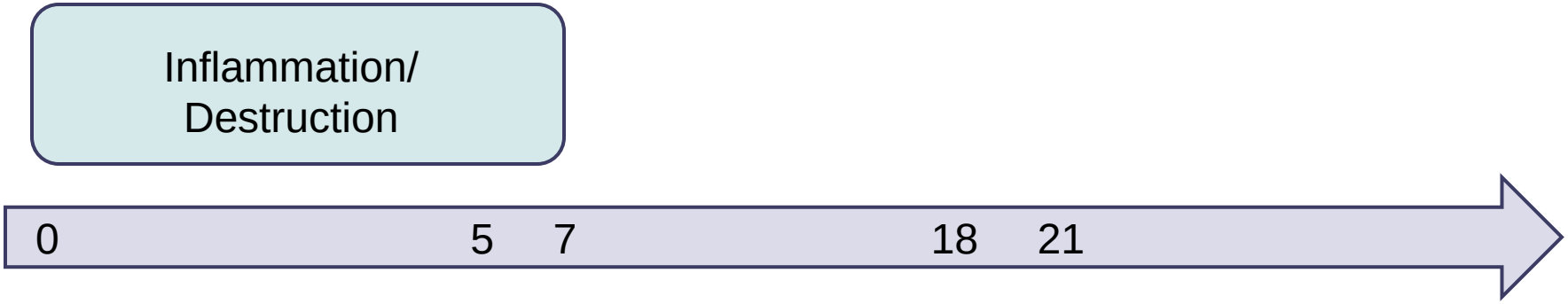
- Presumably occur when the tension in the muscle is sufficiently high to result in muscle fibre failure

- Sarcomeres are stretched beyond the limit
  → elongating the passive elements
  → damage to the nearby sarcolemma
  → influx of extracellular calcium activation of autodegradative and proteolytic pathways

(Best and Hunter 2000)

Pathobiology:

1. Inflammation and Destruction Phase



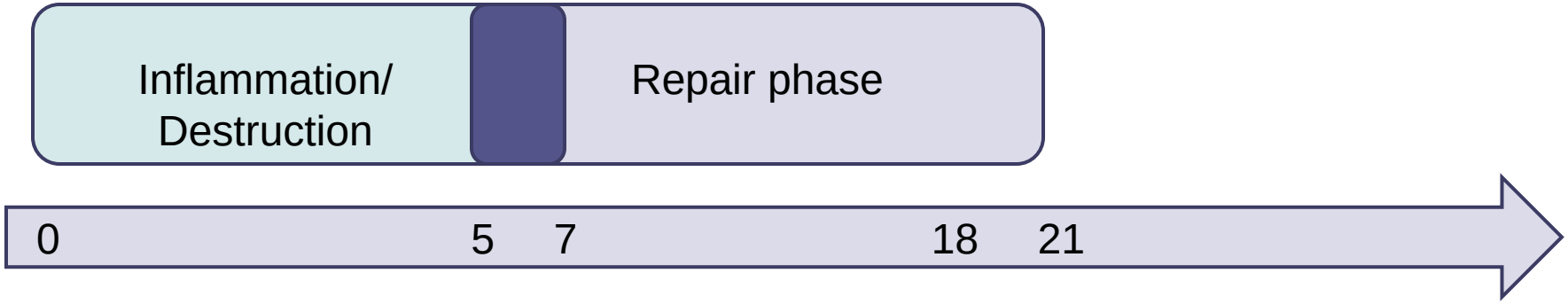
The Inflammatory/Destruction Phase

1. Rupture of the muscle
2. Tearing of the sarcolemma and a subsequent necrosis of part of the myofibres
3. Associated tearing of the local blood vessels, allowing the blood borne inflammatory cells to gain access to the injury site- Haematoma formation
4. Satellite cells and necrotized part of the myofibres release various growth hormones
5. Macrophages and fibroblasts produce additional chemotactic signals for the circulating inflammatory cells.
6. Polymorphonuclear leukocytes are replaced by monocytes after the first 24 hours
7. Monocytes then transform into macrophages to participate in macrophage **phagocytosis**

(Jarvinen et al 2005, Tidball 2005)

Pathobiology:

2. Repair Phase



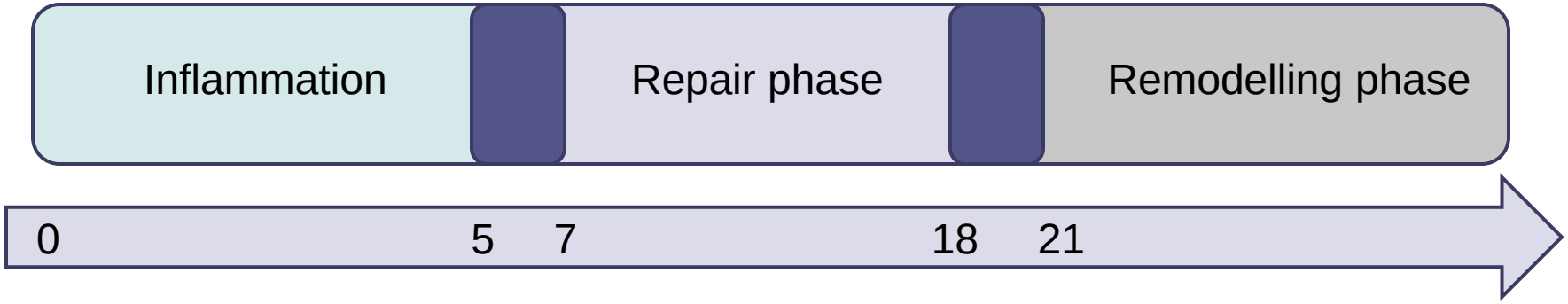
The Repair Phase

1. Phagocytosis of necrosed tissue
2. Regeneration of myofibres and concomitant formation of scar tissue by fibroblasts
3. Revascularisation and in-growth of capillaries

(Jarvinen 2006)

Pathobiology:

3. Remodeling Phase



Remodelling Phase

1. Maturation of regenerated myofibirls
2. Retraction and re-organisation of scar tissue
3. Scar tissue becomes muscle again
4. Recovery of functional capacity

(Jarvinen 2006)

Repairing the muscle

Regeneration of Myofibres:

- Satellite cells transform into myoblasts– enhanced by stretching and mechanical loading
- Join onto myotubes which extend from the torn ends of myofibres
- Form branches which extend into the scar tissue

Formation of CT (scar):

- 'Gap' between ruptured muscle fibres is initially filled with haematoma
- Inflammatory phagocytosis occurs and fibrin cross-links form granulation tissue that acts as a scaffold for fibroblasts
- Collagen synthesis occurs first with Type III then with Type I (takes up to 6 weeks to reach a balance)
- After 10 days the scar is no longer the weakest link in the chain, but if subject to load the rupture occurs in the adjacent muscle tissue at the newly formed mini MTJ's
- Large ruptures or re-ruptures increase the density of the CT and can create a mechanical barrier which restricts the regeneration of the myofibres across the injury 'gap'

(Best and Hunter 2000; Jarvinen et al 2005)

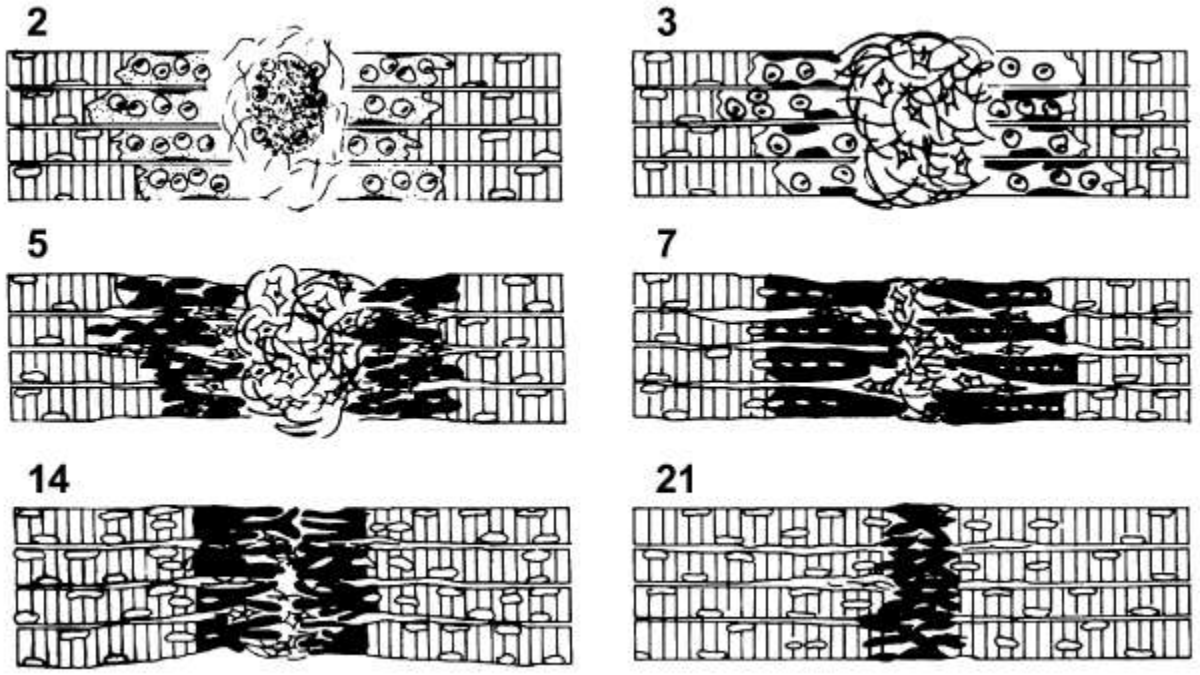


Figure 1. A schematic illustration of the healing of skeletal muscle. Day 2: The necrotised parts of the transected myofibres are being removed by macrophages while, concomitantly, the formation of the connective tissue scar by fibroblasts has begun in the central zone (CZ). Day 3: Satellite cells have become activated within the basal lamina cylinders in the regeneration zone (RZ). Day 5: Myoblasts have fused into myotubes in the RZ and the connective tissue in the CZ has become denser. Day 7: The regenerating muscle cells extend out of the old basal lamina cylinders into the CZ and begin to pierce through the scar. Day 14: The scar of the CZ has further condensed and reduced in size, while the regenerating myofibres close the CZ gap. Day 21: The interlacing myofibres are virtually fused with little intervening connective tissue (scar) in between. (Reproduced, with permission, from Järvinen TAH et al., 2005).[1]

Diagnosis of a Muscle Injury

- History of injury
  - Mechanism of injury important..what, how, why, where, when
- Physical Examination
  - Muscle stretch
  - Muscle contraction
  - Palpation
- Imaging
  - Ultrasound- cost effective and accurate however result dependant on user experience
  - MRI- imaging of choice particularly when injury close to MT junction or in groin

Clinical Classification of Muscle Injuries

- INTRA vs INTER MUSCULAR
  - INTRA-
    - Tear within the muscle fascia(endomysium)
    - Bleeding within muscle fascia limits size of haematoma due to increase in intramuscular pressure
  - INTER-
    - Surrounding muscle fascia(epimysium) is torn and bleeding is allowed to exit into surrounding inter-fascial compartments
    - Blood loss is more extensive to loss of increase in intramuscular pressure

Jarvinen et al 2006

- DEGREES OF INJURY
  - Mild(1st)-
    - tear of only a few fibres with minor swelling
    - Minor loss of strength
    - Minor loss of movement
  - Moderte (2nd)-
    - Greater damage to muscle structure
    - Loss of strength
    - Loss of movement and stretch
  - Severe (3rd)-
    - Severe damage to muscle structure extending entre cross section of muscle
    - Complete loss of function
    - Excessive range of movement

Management Principals

- Short Period of rest (0-3 days)
  - WHY?
    - Minimise inflammatory response
    - Prevent re-rupture of healing tissue
    - Prevent damage of new capillary structure formation
    - Reduce excessive scar formation
  - HOW?
    - RICE
    - Immobilisation- taping, compression, crutches
    - Electrotherapy Modalities??
    - Narcotics
    - Anti-inflams??

Jarvinen (2005); Sherry & Best (2004)0

- Early Mobilisation(3-7 days)
  - WHY?
    - Clearing haematoma (inflammatory cells)
    - Regeneration of myofibres
    - CT contractile properties/tensile strength
    - Fibre alignment- Wolfs Law
    - Facilitates re-vascularisation and nerve regeneration
  - HOW?
    - Massage
    - Manual Therapy
    - Dry Needling?
    - Muscle mobilisations

Jarvinen (2005); Sherry & Best (2004)0

Soft tissue techniques

- Basic massage
- Trigger Points
  - Acupressure
  - Dry Needling
- Myofascial Release
  - Muscle on stretch and release
- Active Fascial Release
  - Release with active eccentric contraction

- Rehab and Return to Sport
  - WHY?
    - Reduce scar tissue
    - Facilitate/improve myofibre alignment and organisation
    - Improve tensile strength of new muscle tissue
    - Regain neuromuscular co-ordination/proprioception
    - Identify possible contributing factors to injury
  - HOW?
    - Exercise therapy- strength, stretch, neuromuscular drills
    - Functional strengthening
    - Global picture of muscle control
    - Return to sport drills
    - Return to Game play plan

Jarvinen (2005); Sherry & Best (2004)0

Eccentric Muscle Strengthening

- Most important way to re-strengthen and re-organise injured soft tissue
- Most effective way to regain tensile strength in injured muscle
- Improves cross-linking within muscle fibre structure.
- Restores musculotendon length for active tension to normal
- Excessive concentric exercise may serve to only shorten muscle and change length-tension relaionship
- Every muscle can contract eccentrically and it needs to happen in all muscle injury rehab

(Heiderscheit et al 2010)

Co

- N
  -
  - s
  - then

Practical- Quad and Calf

1. Demonstrate Ax of main objective asterix's. How diff between potential muscles
   - Calf
   - Quad
2. Muscle Releases
   - Calf
   - Quad
3. Active Fascial Release
   - Calf
   - Quad
4. Eccentric exercise demo
   - Quad
   - Calf

HAMSTRING INJURIES

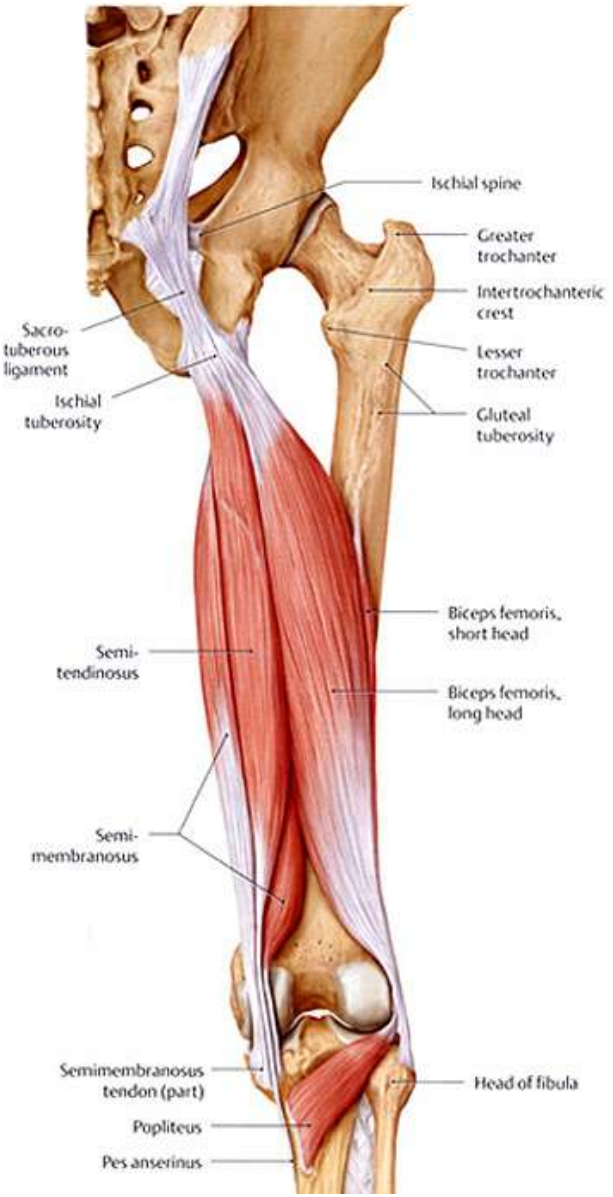
Hamstring Strains

- Among the most common injuries in sport (11-16% of all injuries)
- Associated with high speed running and acceleration
- Most commonly during an eccentric contraction
- High re-injury rate (12-34%)

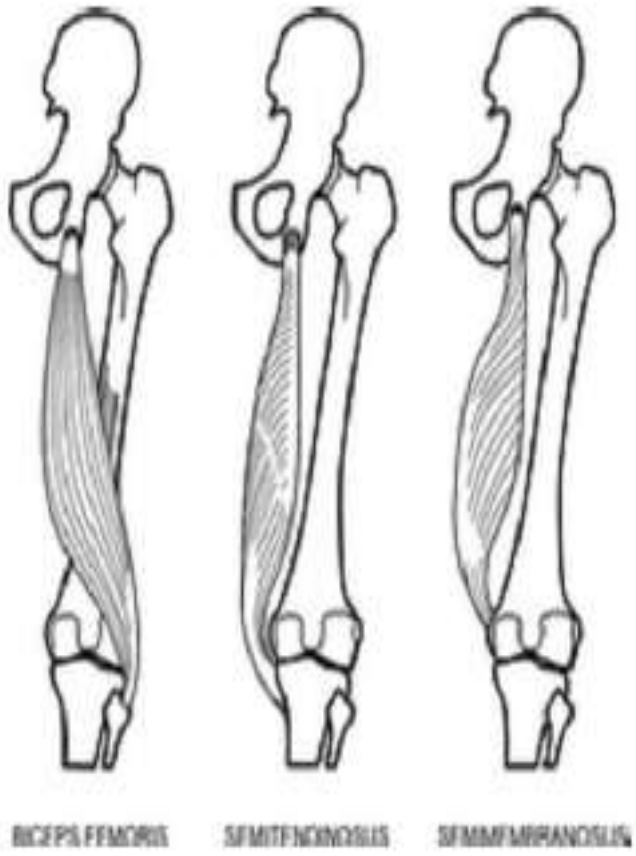
(Hoskins and Pollard 2005; Peterson and Holmich 2005)

Anatomy

- Fusiform
- Primarily Type II fast twitch fibres
- Bi-articular
- Innervated by Sciatic Nerve

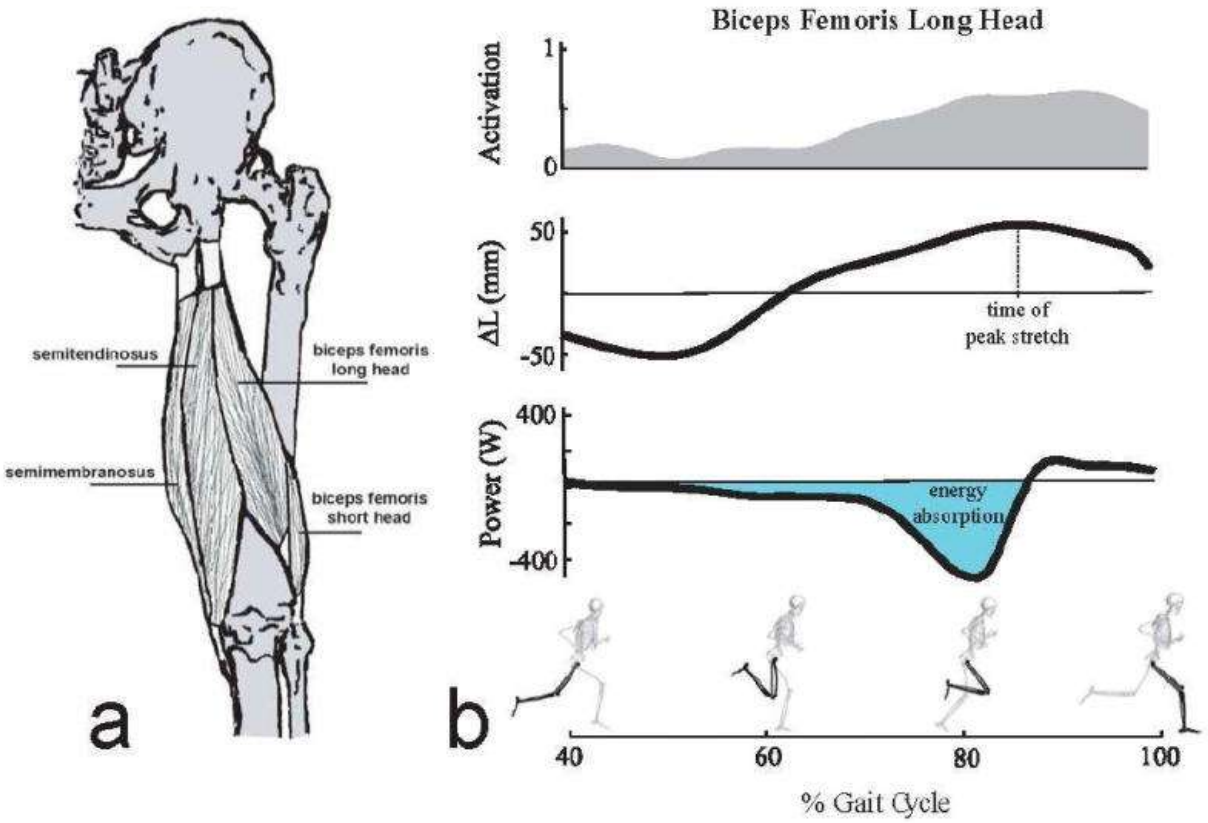


- Biceps femoris
  - Long head : ischial tuberosity → head of fibula
  - Short head : lateral supracondylar line → fibula
- Semitendinosus
  - Ischial tuberosity → superomedial tibia
- Semimembranosus
  - Ischial tuberosity → medial condyle of tibia



Hamstring Function

1. Works maximally as decelerator of lower leg at terminal swing, just before heel strike



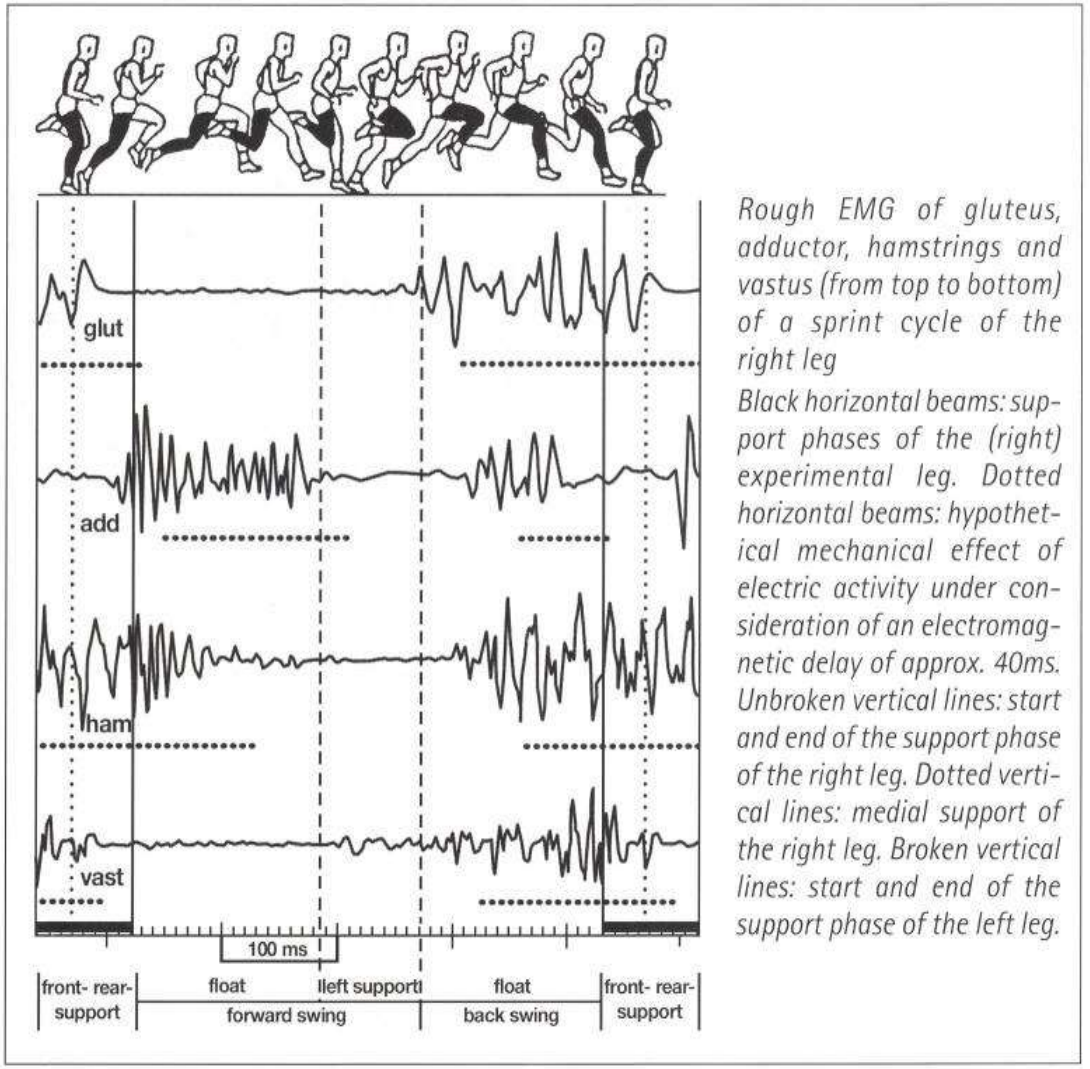
Actions

1. Extends the hip and flex the knee
2. Biceps femoris : lateral rotation
3. Semitendinosus/semimembranosus : medial rotation
4. Gait : decelerate tibia during swing phase
5. Controls forward lean
6. Posterior pelvic tilt

Stretch Shortening Cycle

- an eccentric contraction of the hamstring followed by an immediate concentric contraction of the muscle.
- Requires perfect neuromuscular control

Figure 1. EMG Analysis and the Phases of Sprinting. Adapted from Weimann and Tidow (1995)



Rough EMG of gluteus, adductor, hamstrings and vastus (from top to bottom) of a sprint cycle of the right leg
Black horizontal beams: support phases of the (right) experimental leg. Dotted horizontal beams: hypothetical mechanical effect of electric activity under consideration of an electromagnetic delay of approx. 40ms. Unbroken vertical lines: start and end of the support phase of the right leg. Dotted vertical lines: medial support of the right leg. Broken vertical lines: start and end of the support phase of the left leg.

Aetiology- When do hamstring injuries occur?

- Rapid change-over from eccentric to concentric function of the hamstring is when the muscle is most vulnerable to injury.

- Increased active tension, or a passive increase in muscle length, or a combination of both.

Risk Factors

1. Age
2. Muscle Strength
3. Muscle Length
4. History of Injury
5. Fatigue
6. Warm-up
7. Neuromotor Recruitment
8. Body Mechanics

Age

- Increase in age means a greater chance of hamstring injury.
- A reduction in cross sectional area of muscle and increases in non contractile connective tissue

(Gabbe et al, 2005)

Muscle Strength

- Weakness compared to contralat side and control group

(Orchard et al 1997, Croisier et al 2008)

- Antagonist/Agonist Balance

(Croisier 2004, Croisier et al 2008)

- Eccentric strength decreases incidence

(Arnason et al 2007)

Muscle Length

- Inconclusive

(Hoskins & Pollard 2005; Orchard et al 1997)

- Increased muscle length could improve shock absorption, thereby making the muscle more resistant to stretch injury.

(Verrall et al 2005)

- Quads length- decrease in quads length means increase in recoil moment at pre-swing phase which means Hamstrings need to contract harder to decelerate limb at end swing

(Gabbe et al, 2005)

History of previous injury

> "The one risk factor for which there is universal agreement" (Orchard & Best 2002)

Why?

- Improper healing and residual scar tissue persists making muscle less contractile and elastic
- Improper return of strength- general and functional
- Risk factors not corrected
- Neuromuscular component of hamstring rehab not addressed

Fatigue

- ↑ Incidence late in game

(Verrall et al 2005;Woods et al 2004)

- Fatigued muscle less able to absorb energy when undergoing stretching and less able to produce force (Hoskins & Pollard 2005;Verrall et al 2005)

Warm-up

- Facilitates CT extensibility
- Decreases muscle stiffness
- Increase muscle length

Neuromotor Recruitment

- Inadequate recruitment to deal with forces

(Edgerton et al 1996)

- Muscles with 2 separate nerve supplies asynchronous contraction

- Tethering of nerve to scar tissue causing sensitisation, muscular hyperactivity?

(Croisier 2004)

Biomechanics

- Decreased hip flexibility
- Pelvic tilt
- Lumbopelvic posture and stability

Hamstring Injury Diagnosis

1. History
2. Physical Examination
3. Imaging

You need to be able to provide;

1. Prognosis
2. Expected return to play

Injury History- How, where, when, why?

Info needed	Clinical Reasoning
• Exact position/mechanism of injury?	• Contractile or over stretch injury • Determine specificity of rehab
• Time occurred in game play and conditions?	• Fatigue a factor? Heat? Cold?
• Could you keep playing? • Could you walk off or stretcher? • Swelling, brusing etc? • Immediate Rx- RICER	• Severity
• History of Injury- what rehab, succesful? • Other injuries- groin, OP, Lx	• Identify Potential Risk factors

Physical Examination

- Based on:
  1. typical injury mechanism
  2. local pain
  3. loss of function

- Demonstrated by:
  1. Palpation and Observation
  2. Range of motion
  3. Muscle testing

Observation

- Gait
- Swelling
- Bruising
- etc

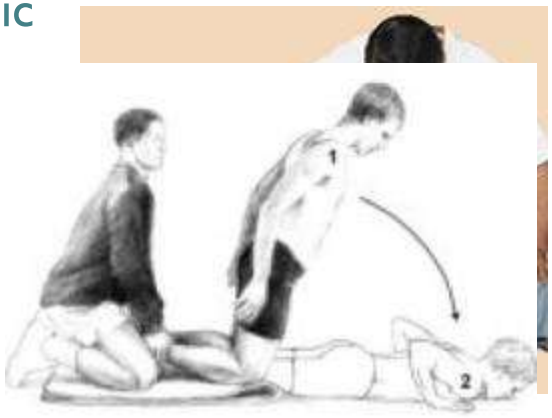
Palpation

- Palpate area related to injury
- Look for defect
- Look for adjoining areas of related muscle spasm
- Palpate for boggy feel within defect

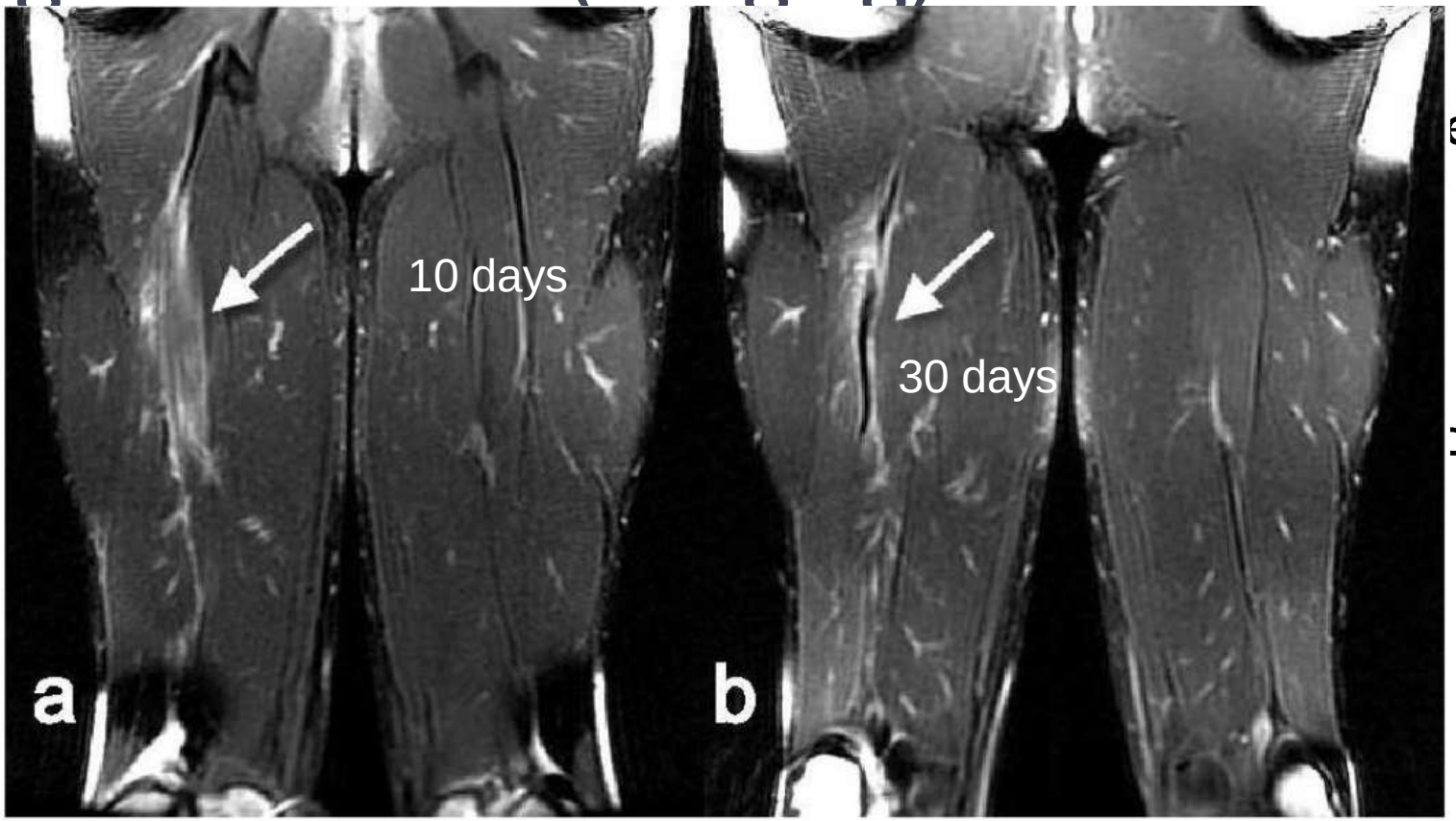
Diagnostic Tests

- ROM
  1. General
  2. SLR
  3. 90/90- upper ham vs distal
  4. Slump

- Resisted
  Iso, Conc, Ecc
  (Through range)
  - Hip extn
  - Knee Flex
  - SL Bridge
  - Nordic



Diagnostic Tests (Imaging)



(Schneider-Klosky et al 2006)

What are you dealing with...

Grade I Hamstring Strain

• Tearing of a few muscle fibres in a cross-sectional
area of muscle
• Little or no loss of strength and movement
• Athlete reports moderately painful pulling but can
continue the activity - often no obvious incident
• Frequently the muscle is sore and stiff 24hrs after
injury
• Walking and slow jogging is not inhibited but running
>50% pace may cause pain
• Minimal to no swelling
• Straight leg raise is mostly normal
• 14-21 days return to sport

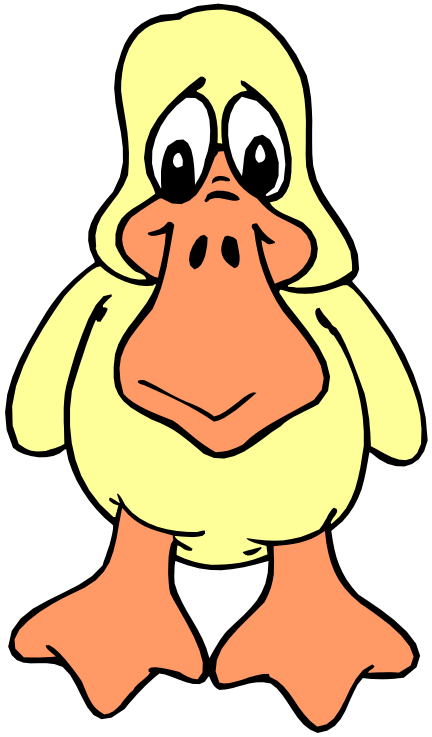
Grade II Hamstring Strain

• Tearing of muscle fibres in a greater cross-sectional area of muscle
• Obvious loss of strength and movement • History of a painful grabbing whilst sprinting forcing
the athlete to stop activity and limp
• Tenderness is marked over the area of injury and bruising may become evident in subsequent days
• Straight leg raise is painfully limited
• 21-35 days return to sport

Grade III Hamstring rupture

• Complete tearing of entire cross-section of muscle
• Total loss of muscle function and severe functional disability
• Most often occurs with avulsion of the ischial tuberosity - surgical repair required
• Incidence higher in water-skiing than other sports
• 6-12 months return to sport

If it walks, looks and talks like a duck....



- But consider:
  - Lx referral
  - SIJ referral
  - Hip pathology- Labrum
  - Knee- post joint
  - Sup Tib Fib
  - ischiogluteal bursa
  - piriformis syndrome
  - avulsion of the ischial tuberosity
  - compartment syndrome of the posterior thigh
  - bone tumour

Test for Risk Factors

- Maybe not Day 1- but is necessary to complete picture and set complete treatment plan
  - Lumbar: posture, PAIVMS
  - Muscle coordination: i.e. firing sequence, tone, length
  - Pelvic Control- stability- glute/TA etc

Prognosis and RTS

- Reoccurrence rate of hamstring injuries reported to be 34%

Brockett et al (2004)

- Early return to activity obviously incorporates a greater risk of re-injury

- Brukner and Khan (2002) indicate:
  - grade I strain : approx. 3 weeks
  - grade II strain : 4-6 weeks
  - grade III strain: 6-12 weeks

- Considerations
  1. Injury Severity
  2. Previous Injury History
  3. Potential Risk Factors identified
  4. Demands on the Athlete

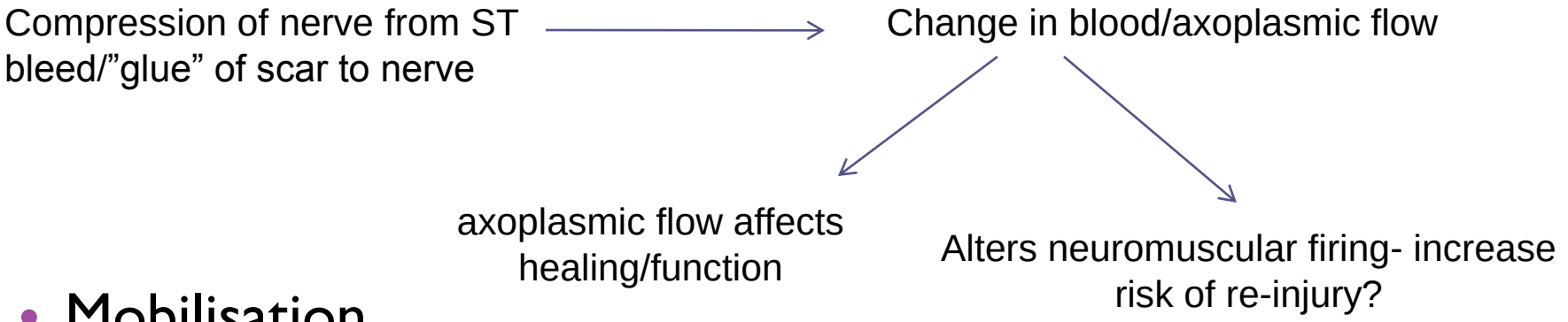
Treatment Options -

1. RICE
2. STM / Trigger points/Myofascial releases: where, when??
3. Dry Needling
4. Electrotherapy
5. Stretching
6. Resisted Contractions : Iso / Conc / Ecc
7. Hydrotherapy
8. NSAIDS- 5 x greater chance of re-injury *(Warren & Bennell 2008)*
9. Lumbar mobilisation
10. Neural mobilisation-

Soft Tissue Techniques

- Soft tissue massage
- Myofascial Releases
  - Release on stretch
- Active Fascial Release *(Di Hopper)*
  - Release through eccentric contraction
- Trigger point releases
  - Acupressure
  - Dry Needling
    - Hamstring
    - Glutes
    - Piriformis
    - *Demo*

Neural : Treatment



- Mobilisation
  - Flossing nerve thru muscle- don't stretch
  - Mobilise Lx spine around neural stretch
  - Reduces chance of scarring
  - Improves axon flow and pressure gradients
  - Improves circulation of CSF
- *Demo*

(Butler & Slater, From Sports Physiotherapy, Zuluaga et al (1995) Physiological responses to injury)

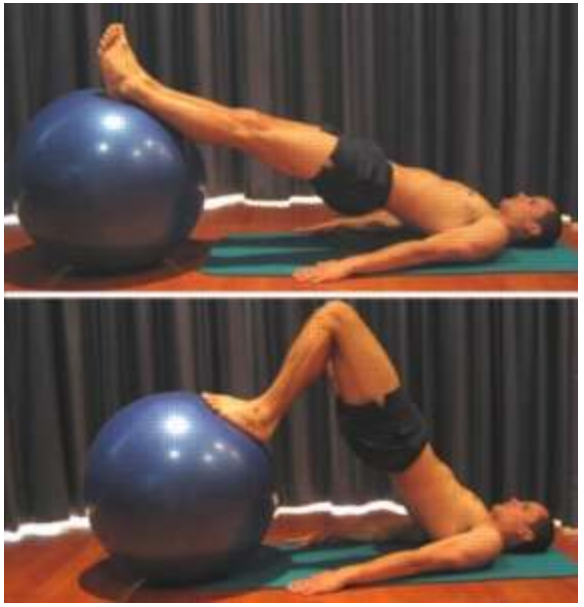
Rehab

- Individualised functional rehabilitation program is most effective – must consider mechanism of injury

- Eccentric Hamstring Exercises
  - Prone
  - Prone off table
  - Standing
  - Hami Machines
  - Roman Dead Lifts
  - Nordic

- Drop Catches
  - High velocity eccentric exercises in the position of range where the hamstring requires functional strength ie Stretch Shorten Cycle-
    - Prone
    - Standing
    - Progress speed and resistance (Woods et al 2004)

- Trunk Stabilisation Exercises
  - Progressive agility and neuromuscluar control exercises
  - When inco-orperated in rehab prog it will significantly reduce re-currence of H/S injuries (Sherry and Best, 2004)



Practical

- Eccentric Hamstring Exercises
  - Prone with band
  - Prone over Bed
  - Roman Dead lifts
  - Nordics
  - Reps and progressions??
- Drop catches
  - Prone
  - Prone over bed
  - Standing
  - Numbers?
  - Progressions- speed, weight

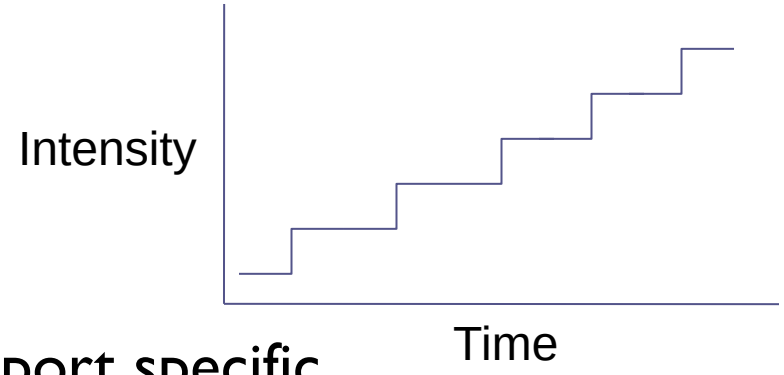
Correct Risk Factors

- Pelvic control- glute med, core
- Lumbar spine involvement
- Neural Involvement
- Glute/Lx/Hams timing control

Negative Positive

Running Rehab

- Must be Graduated- stepped up approach



- Must be sport specific
- Must be injury specific

- Warren (2006):
  - ↓ Re-injury rate when jogging every 1.7 days

- Kelly and Strauss (2009):
  - Painfree jogging pace increases approx 10% each session

Prevention Literature (Soccer)

- Croisier et al (2008) : Normalised HS/Quad imbalances which decreased injury. Non-standard intervention.

- Amason et al (2008): Decreased injuries (incidence and severity) with warm-up, stretch and Nordics (ecc. hams).

Prehab is important

- Must address potential Risk factors
  - Pelvis control- glute med, TA
  - Eccentric Hamstring loading
  - Muscle Flexibility
  - Glute Strengthening/Control
  - Must be sport specific

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