BRITISH COLUMBIA ASSOCIATION OF KINESIOLOGISTS

FUNCTIONAL ASSESSMENT OF THE SPINE AND EXTREMITIES



All Rights reserved. *No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher.* BC Association of Kinesiologists Previous editions copyrighted 1999, 2009

Editors: Andreja Kovacevic, Erin Macri, Stacy Benmore
Illustrations: Andreja Kovacevic

Table of Contents

Mechanisms of Tissue Injury 12
Mechanical Injury 12
Phases of Healing 13
Selective Tissue Tension Testing (Cyriax)[1] 15
Assessment Types 15
Active Movement 15
Passive Movement 15
Resisted Isometric Test 15
Tissue Lesions 16
Inert Lesion 16
Contractile Lesion 16
Classifications of Contractile Lesions 16
Muscle Strength Grading[2] 16
Grading of Ligament Sprains[3] 17
Posture 18
Ideal Environment / Tools Required 19
What to Look For 19
Posture Assessment and Observations 20
Right-Handedness Pattern 21
Typical observation from posterior view[4] 21
Tonic and Phasic Muscles 21
Categorized based on fiber type, innervation type and recruitment pattern. 21
Tonic (Postural) Muscles → "Stabilizers" 21
Phasic Muscles → "Movers" 21
Janda's Theory of Muscle Imbalance Patterns: 21
Upper-Crossed Syndrome Characteristics 22
Lower-Crossed Syndrome Characteristics 22
Layer Syndrome Characteristics 23
Fascia 23
Fascial Properties 23
Motor Neuron Lesions 24

Upper Motor Neuron Lesion[3, 8] 24
Lower Motor Neuron Lesion 25
Neurological Assessment[3] 27
Conduction Tests 27
Myotome Testing 27
Dermatome Testing 28
Deep Tendon Reflexes 28
Irritative Tests (Neurodynamic Tests) 29
Straight Leg Raise: 29
Femoral Nerve Stretch Test 29
Upper Limb Neurodynamic Test 1 29
High Test – Upper Motor Neuron Lesion (UMNL) Testing 30
Babinski (aka Plantar Response) 30
Clonus 30
Low Test – Lower Motor Neuron Lesion (LMNL) Testing 30
Saddle area sensation 30
Cauda Equina Syndrome 30
History Taking 31
Purpose of a History 31
Questions to Ask 32
Pain Location / Site of Dominant Pain 32
Variability: Constant vs. Intermittent Pain 32
Aggravating and Easing Factors 32
Quality of Pain[3] 33
Duration of Symptoms 33
Mechanism of Injury 34
Work / ADL's / Leisure / Sport History 34
Management of this Episode and of Past Episodes 34
Mandatory Questions 35
Pain Referral Patterns 35
Pain Centralization and Peripheralization Phenomena 35
What is Referred Pain? 36

Cervical Spine Assessment 36
Cervical Pain Referral Pattern[3] 36
Subjective Examination 37
Standard History[3] 37
Mandatory Questions 37
Special Questions 37
Objective Examination 37
Observation: 37
Active ROM 37
Neurological Examination 38
Case Study #1: Cervical Assessment 39
Case Study #2: Cervical Assessment 40
Lumbar Spine Assessment 41
Lumbar Pain Referral Pattern[3] 41
Subjective Examination 41
Standard History 41
Mandatory Questions 41
Special questions: 41
Objective Examination 41
Observation 41
Active ROM 42
Sacroiliac Joint 44
History/special questions[3] 44
Objective Examination 44
Observation 44
Active ROM 44
Neurological Examination 44
Special Tests 44
True Leg Length Discrepancy test 44
Functional Leg Length Discrepancy test 45
Active Straight Leg Raise 45
Lunge 46
Case Study #1: Lumbosacral Assessment 47

Case Study #2: Lumbosacral Assessment 48
Thoracic Spine Assessment 49
Thoracic Pain Referral Patterns 49
Scoliosis 49
Type 51
Characteristics 51
Structural 51
Functional 51
Subjective Examination 51
Standard History 51
Mandatory Questions 51
Special Questions 51
Objective Examination 52
Observation 52
Active ROM 52
Costovertebral Expansion (breathing) 52
Neurological Examination 52
Case Study #1: Thoracic Spine Assessment 53
Case Study #2: Thoracic Spine Assessment 54
Non-Organic Pain Signs 55
Low Back 55
The 'Malingerer' 55
The 'Symptom Magnifier' 55
Understanding the Challenges with Non-Organic Testing 56
Lumbar Non-Organic Tests 56
Axial Loading 56
Straight Leg Raise Discrepancy 57
Acetabular Rotation 58
Cogwheel Releasing/Weakness 58
Sensory Disturbance 58
The Hip Joint 60
Surface Anatomy Exercise 60
Hip Joint Assessment 60

Subjective Examination 60
Standard History 60
Mandatory Questions 60
Special Questions 60
Objective Examination[5, 13-16] 61
Observation 61
Lumbar/Neurological Scan 61
Range of Motion 61
Client in supine 62
Client in prone 62
Resisted Tests 62
Client in supine 62
Client in side lying 62
Client in prone 62
Special Tests[3] 62
Active Straight Leg Raise 62
Resisted External De-Rotation 62
FABER 63
FADIR 63
Flexion-Internal Rotation 63
Thomas Test 64
Modified Thomas 64
Modified Ober's Test 64
Leg Length Discrepancy tests (true vs. functional): 65
Palpation 65
Case Study #1: Hip Joint Assessment 66
Case Study #2: Hip Joint Assessment 67
The Knee Joint 68
Surface Anatomy Exercise: 68
Knee Joint Assessment 68
Subjective Examination 68
Standard History 68
Mandatory Questions 68

Special questions 68
Objective Examination[3, 16 21-25] 69
Observation 69
Lumbar/Neurological Scan 69
Range of Motion 70
Client in supine 70
Resisted Tests 70
Client in supine 70
Client in standing 70
Special Tests[3] 71
Valgus stress 71
Varus stress 71
Anterior drawer: 71
Lachman's test: 72
McMurray's test: 73
Apley's Compression test: 73
Wipe test (brush, stroke, bulge test): 74
Palpation 74
Case Study #1: Knee Joint Assessment 75
Case Study #2: Knee Joint Assessment 76
The Ankle Joint 77
Surface Anatomy Exercise 77
Ankle Joint Assessment 77
Subjective Examination 77
Standard History 77
Mandatory Questions 77
Special Questions 77
Objective Examination 78
Observation 78
Lumbar/Neurological Scan 78
Range of Motion 79
Client in supine lying and ankle off edge of table: 79
Resisted Tests 79

Client in supine lying with hip flexed to 45º and knee flexed to 90º 79
Client in supine lying 79
Special Tests 79
Lateral ligaments 79
Calcaneofibular 80
Deltoid ligament 80
Inferior tibiofibular 80
Anterior Drawer Test 80
Calf squeeze test 81
Palpation 81
Case Study #1: Ankle Joint Assessment 82
Case Study #2: Ankle Joint Assessment 83
The Shoulder Joint 84
Surface Anatomy Exercise 84
Shoulder Joint Assessment 84
Subjective Examination 84
Standard History 84
Mandatory Questions 85
Special Questions 85
Objective Examination 85
Observation 85
Cervical/Neurological Scan 86
Range of Motion 86
Client in standing 86
Resisted Tests 88
Client in sitting with elbow flexed mid-range 88
Special Tests[3] 88
Empty/Full Can Test 88
Drop Arm Test 89
Hawkins-Kennedy Test 89
Anterior Apprehension Test 90
Palpation 90
Supraspinatus Tendon 90

Infraspinatus Tendon 91
Biceps Tendon 91
Case Study #1: Shoulder Assessment 92
Case Study #2: Shoulder Assessment 93
The Elbow Joint 94
Surface Anatomy Exercise 94
Elbow Joint Assessment 94
Subjective Examination 94
Standard History 94
Mandatory Questions 94
Special Questions 94
Objective Examination 94
Observation 95
Cervical/Neurological Scan 96
Range of Motion 96
Client in sitting or standing 96
Resisted Tests 96
Client in sitting with elbow flexed mid-range and palm up: 96
Client in sitting, elbow flexed to 90^{o}, forearm in approximately neutral, grasp forearm: 96
Special Tests[3] 97
Valgus Stress Test 97
Varus Stress Test 97
Tinel Sign 97
Tennis Elbow Test 97
Golfer's Elbow Test 98
Palpation 98
Case Study #1: Elbow Assessment 99
Case Study #2: Elbow Assessment 100
The Wrist and Hand 101
Surface Anatomy Exercise 101
Wrist and Hand Assessment 101
Subjective Examination 101

Standard History 101
Mandatory Questions 101
Special questions 101
Objective Examination 101
Observation 101
Cervical/Neurological Scan 102
Range of Motion 102
Client in sitting, hands on a table or pillow on lap 102
Resisted Tests 103
Client in sitting, hands on a table or pillow on lap 103
Special Tests 103
Phalen's test 103
Tinel's sign 104
Finkelstein's test 104
Allen capillary refill test 104
Palpation 104
Case Study #2: Wrist Assessment 106
Answers to Case Studies 107
Case Study #1: Cervical Spine 107
Case Study #2: Cervical Spine 107
Case Study #1: Thoracic Spine 107
Case Study #2: Thoracic Spine 107
Case Study #1: Lumbar Spine 107
Case Study #2: Lumbar Spine 107
Case Study #1: The Hip 107
Case Study #2: The Hip 107
Case Study #1: The Knee 107
Case Study #2: The Knee 107
Case Study #1: The Ankle 107
Case Study #2: The Ankle 108
Case Study #1: The Shoulder 108
Case Study #2: The Shoulder 108
Case Study #1: The Elbow 108

Case Study #2: The Elbow 108
Case Study #1: The Wrist/Hand 108
Case Study #2: The Wrist/Hand 108
References 109
Appendix A: History Taking Template (example) 111
Appendix B: Goniometer Landmarks 112
Appendix C: Common Abbreviations & Their Meaning 115

Mechanisms of Tissue Injury

Cause of Injury	Properties	Example
Mechanical	– Excessive or abnormal force – Compression, Tension, or Shear (Figure 1) – Intermittent pain	– Ligament sprain following an ankle inversion injury
Chemical	– Exposure to a substance which is not normally present – Constant pain	– Sequestered Disc (nuclear material exposure) – Chemicals of inflammation
Thermal	– External or internal exposure to excessive heat or cold	– Frostbite – Electrical burn
Infectious	– Foreign material, bacteria or virus	– Wound infection following surgery

Mechanical Injury

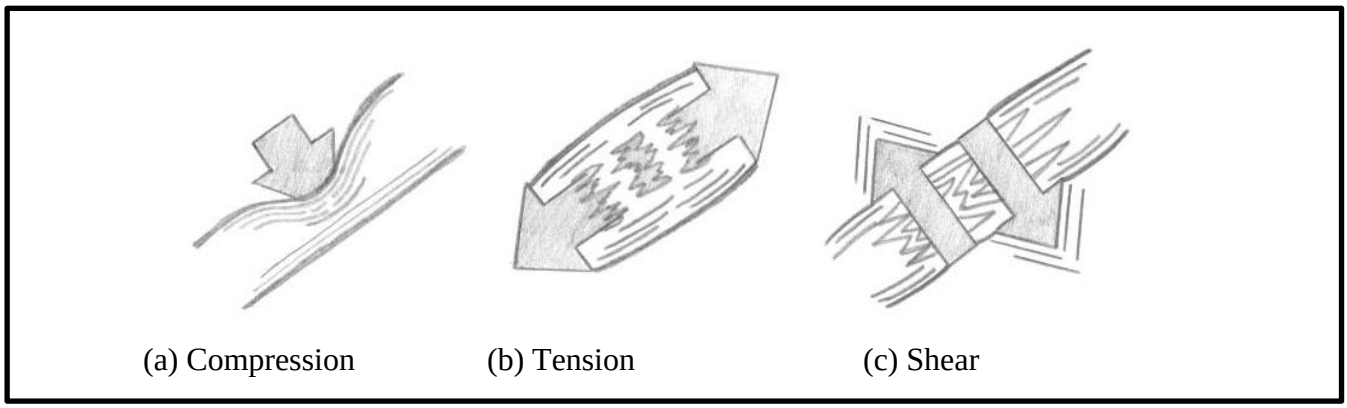


Figure 1. Types of Mechanical Forces. (a) *Compression Force:* tissue is subjected to pressure from an external force; (b) *Tension Force:* tissue is stretched beyond its normal limit; (c) *Shear Force:* force is applied across the normal muscle / tendon fiber orientation, can lead to micro or complete tear.

Phases of Healing

Phase	Acute (Inflammatory)	Subacute (Repair)	Remodelling (Maturation)
Duration	0 to ~ 6 days post injury	~5 to 21 days post injury	3 weeks to 18 months
Key events and/or characteristics	– Ultimate goal: prevent infection – Phase ends: blood vessel clotting, inflammatory response subsiding, mechanical protection against entry of foreign bodies	– Phagocytosis: debris and dead tissue removed – Revascularization: vascular network to support new tissue growth – Scar tissue forms: new collagen alignment is random and thick – Wound strength is proportional to collagen quality – Scar contracts by 3 weeks post injury (up to 20% less than original size) – Phase ends: scar is vascular, wound can tolerate moderate stress, scar contracture complete	– Inflammation subsides – Function and mobility restored – Pain may persist though healing is complete – Tensile strength returning to normal – Intermolecular cross-linking and alignment of fibres along lines of stress – Remodelling of ligament, fascia, tendon and capsule is stimulated by tension – Scar contracture reversed with stretching – Scar vascularity reduces to normal
Clinical signs	– Inflammation – Pain (chemical irritation of nociceptors) – Redness (bleeding/hyperemia)	– Visible improvement in mobility and function – Scar is red, does not bleed with functional activity – No pain at rest	– No pain or swelling at rest or with light activity – Minimal pain or swelling with vigorous activity – Scar whitens

	– Swelling (bleeding/hyperemia) – Palpable heat (hyperemia, increased local metabolism – Loss of function	– Cardinal signs reduced, occurring mainly following activity – Injured tissue remains tender on palpation	– Functional ROM and strength progress to full
Goals of treatment	– Hemostasis (control of bleeding) – Wound closure – Control (<u>not stop</u>) inflammation – Prevent further damage – Pain management	– Prevent scar adhesions – Maximize collagen production – Prevent contracture (could limit joint ROM) – Begin functional activity	– Progressive return to all pre-injury activity, including sport and work – Restore normal mobility strength and proprioception – Encourage a functional and mobile scar
Treatment	– PRICE: Protection, Rest, Ice, Compression, Elevation	– Control inflammation (PRICE) as needed – Passive and active ROM as tolerated – Begin progressive resisted exercise (active and isometric w/i pain tolerance), progress to full weight-bearing isotonic exercise – Begin neuromuscular and proprioceptive re-training once partial weight-bearing, progress as weight-bearing increases	– Progressive increase in exercise – Resisted exercise focusing on concentric and eccentric work through ROM – Functional and full weight-bearing, neuromuscular re-training – Gradual increase in work/ leisure/ sport participation – Work simulation if applicable

Selective Tissue Tension Testing (Cyriax)[1]

A method of applying tension to different tissues and interpreting the results in order to determine origin of pain (i.e. inert vs. contractile structures):

- *Inert tissues* (stressed by stretch): joint capsule, ligament, bursa, dura mater, nerve root, fascia
- *Contractile tissues* (stressed by stretch or contraction): muscle, tendon, tendo-periosteal attachments (fascia)

Assessment Types

Active Movement

- Observe client moving through available range of motion (ROM)
- Tests both inert and contractile tissues by active tension in the agonist contractile unit, passive tension on the antagonist contractile unit and inert tissues
- Looking for: quantity of movement, quality of movement, willingness/ability to move, pain

Passive Movement

- Passive movement through available ROM, overpressure added if pain free (if active ROM is full, passive ROM is not needed: do overpressure only)
- Tests inert structures and places passive tension on the antagonist contractile unit
- Looking for: quantity of movement, pain, end-feel (pattern of limitation)

Resisted Isometric Test

- Maximal test at mid-range to minimize joint compression forces and stress to inert tissues and antagonist muscles
- Tests contractile structures by active tension
- Looking for: pain, strength

Tissue Lesions

Inert Lesion

- Active and passive movements are painful in the same direction.
- Resisted movements are pain free.
- Pain commences toward the end of range.
- Pattern of limitation may be capsular or noncapsular.*

Contractile Lesion

- Passive and active movements are painful in opposite directions.
- Resisted movement is painful.

Classifications of Contractile Lesions

	Painful	**Pain-free**
Strong	Grade I contractile lesion	Normal contractile element
Weak	Grade II contractile lesion (rule out fracture, acute inflammation)	Grade III complete rupture of contractile element (rule out neurological, deconditioning)

- If resisted movements in all directions cause pain: low pain tolerance, acute joint inflammation or joint compression, referred signs, psychosomatic
- Repetition is painful but initial testing pain-free: vascular compromise, compartment syndrome, chronic/remodeling stage of injury (less irritable)

Muscle Strength Grading[2]

Muscle Grade	Description
5 - Normal	Complete range of motion against gravity with full resistance
4 - Good	Complete range of motion against gravity with some resistance
3 - Fair	Complete range of motion against gravity
2 - Poor	Complete range of motion with gravity eliminated
1 - Trace	Evidence of slight contractility. No joint motion
0 - Zero	No evidence of contractility

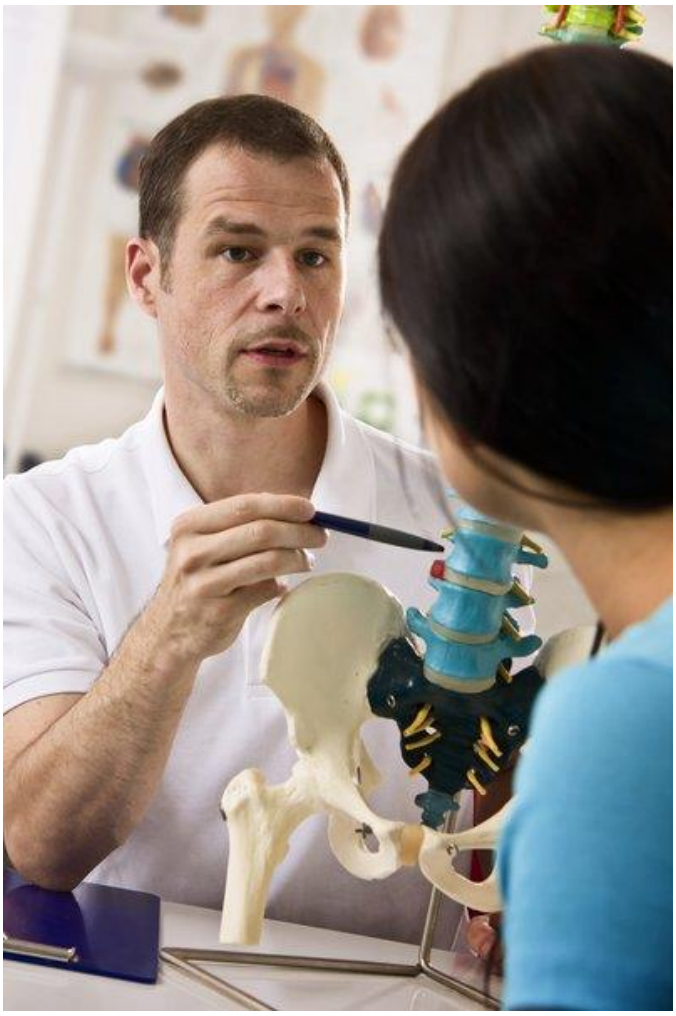
+ refers to having 1 grade above but for less than half the available ROM

– refers to having 1 grade below but for less than half the available ROM

Grading of Ligament Sprains[3]

Grade	Signs	Implications
Grade I (mild)	– Minimal loss of structural integrity – No abnormal motion – Little or no swelling – Localized tenderness – Minimal bruising	– Minimal functional loss – Early return to training/work – Some protection may be necessary
Grade 2 (moderate)	– Significant structural weakening – Possible laxity – Firm end feel – More bruising and swelling – Possible hemarthrosis and effusion	– Tendency to recurrence – Need protection from risk of further injury – May need immobilization
Grade 3 (complete)	– Loss of structural integrity – Marked laxity / instability – May be empty end feel – Significant bruising – Hemarthrosis	– Needs prolonged protection – Surgery may be considered – Often permanent functional instability

Assessment of the Spine



Posture

Defined as: *"the relative arrangement of the parts of the body. Good posture is that state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity irrespective of the attitude in which these structures are working or resting. Under such conditions the muscles will function most efficiently, and the optimum positions are afforded for the thoracic and abdominal organs. Poor posture is faulty relationship of the various parts of the body which produces increased strain on the supporting structures and in which there is less efficient balance of the body over its base of support"* (proposed by the posture committee of the American Academy of Orthopaedic Surgeons [1947]).

Ideal Environment / Tools Required

- Wall grid / posture board (represents a standard of vertical and horizontal planes)
- Hanging plumb-line (assists in determining deviations from ideal)
- Minimal / less restrictive clothing (e.g. shorts, tank-tops, etc.)
- No shoes/socks

What to Look For

- Surface anatomy
- Body contours
- Joint positions / joint angles → indicates which muscles are in an elongated or shortened state
- Skeletal Structures
- Muscle definition / tone / atrophy / imbalance
- Signs of previous injury
- Discoloration / scars
- Comparison of right and left sides
- Deviations compared to neutral / ideal
- Adaptive lengthening or shortening secondary to sustained postures

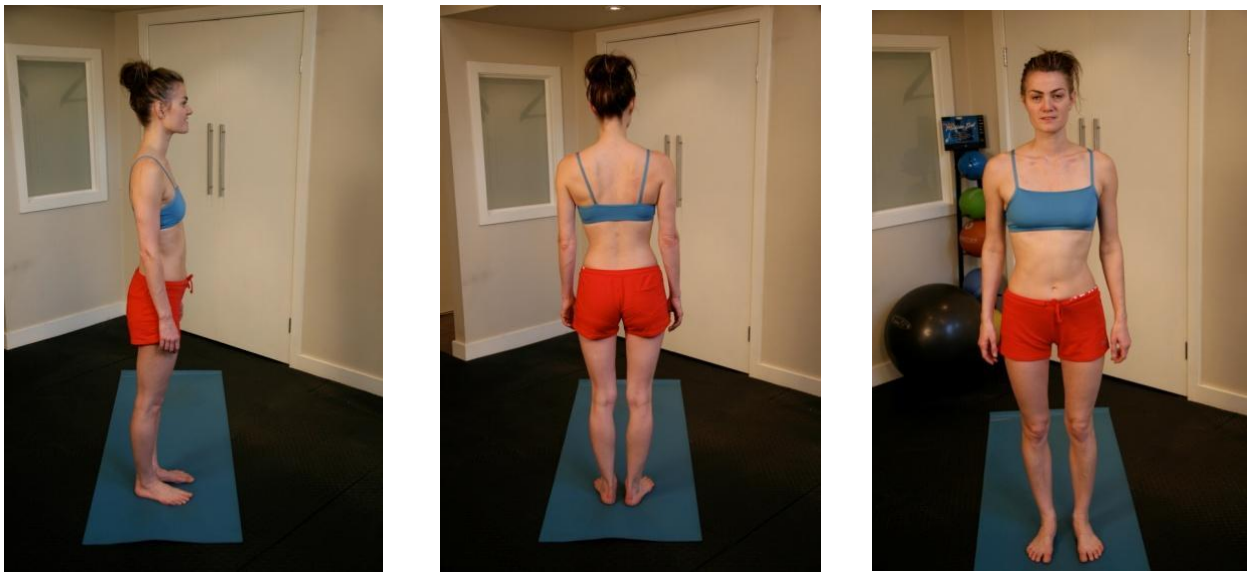


Figure 2. Left to right: lateral view, posterior view, anterior view

Posture Assessment and Observations

In ideal alignment a plumb-line would intersect the following points:

Lateral View	**YES**	**NO**	**Observations**
slightly anterior to lateral malleolus			
slightly anterior to axis of knee joint			
slightly posterior to axis of hip joint			
through bodies of lumbar vertebrae			
through the shoulder joint			
through bodies of most cervical vertebrae			
through external auditory meatus			
slightly posterior to apex of coronal suture			
forearms hand slightly anterior to vertical			
xiphoid process same plane as pubic symphysis			
ASIS directly over pubic symphysis			
Posterior View	**YES**	**NO**	**Observations**
midway between the calcanei			
tendocalcanei are vertical			
feet parallel or slightly out-toeing			
hips & knees neutral rotation (no Varus/Valgus)			
gluteal folds symmetrical			
to bisect the vertebral bodies and sacrum			
shoulder, scapulae and pelvis are level			
to bisect occipital protuberance			
Anterior View	**YES**	**NO**	**Observations**
bisect the cranium			
bisect neck, manubrium and sternum			
through umbilicus and pubic symphysis			
patellae of knees should point straight ahead			
a point midway between medial malleoli			
shoulders, clavicles and pelvis level			

Right-Handedness Pattern

Typical observation from posterior view[4]

- **Right** shoulder is lower than the **left** shoulder
- Pelvis is deviated from the plumb-line, slightly toward the right
- **Right** hip appears slightly higher than the **left** hip

Tonic and Phasic Muscles

Categorized based on fiber type, innervation type and recruitment pattern.

Tonic (Postural) Muscles → "Stabilizers"

- Composed of predominantly Type I fibres (slow twitch)
- Innervated by tonic motor units
- Muscles responsible for maintaining upright posture (anti-gravity)
- "Tend to become" hypertonic / tight / short with pathology
- Respond to overuse, underuse, disuse and abuse by getting short and tight
- Have lower threshold for stimulation vs. phasic muscles (aka can "steal" the neural signal before it arrives to the intended muscle)

Phasic Muscles → "Movers"

- Composed of predominantly Type II fibres (fast twitch)
- Innervated by phasic motor units
- Produce dynamic movement
- "Tend to become" weak / lengthened / inhibited with pathology

Janda's Theory of Muscle Imbalance Patterns:

- Vladimir Janda, a Czech Neurologist, identified stereotypical patterns with respect to chronic pain disorders which he titled *Upper-Crossed Syndrome* (UCS), *Lower-Crossed Syndrome* (LCS), and *Layer Syndromes.*[5]
- His work stems from the belief that tonic and phasic groups of muscles are prone to tightness and weakness.
- Each syndrome presents a specific pattern of muscle weakness and tightness that crosses the body from front to back, which varies between individuals.
- Muscle imbalance is controlled by the CNS and weakness results from reciprocal inhibition of the antagonist.
- Each identified pattern may lead to postural changes, joint dysfunction, or degeneration.

Upper-Crossed Syndrome Characteristics

- Tightness of upper traps and levator scapulae crosses the body, tightness of pec major/minor
- Weakness of deep cervical flexors crosses the body, weakness of mid and lower traps
- Postural changes typically observed: head forward posture, increased cervical lordosis, rounded shoulders, and increased thoracic kyphosis
- Common in people who work at a desk or who sit for majority of the day with poor posture

Lower-Crossed Syndrome Characteristics

- Tightness of thoracolumbar extensors crosses the body, tightness of iliopsoas and rectus femoris
- Weakness of deep abdominal muscles crosses the body with weakness of gluteus max/med
- Postural changes typically observed: anterior pelvic tilt, increased lumbar lordosis
- Common in individuals who sit for prolonged periods, perform tasks with poor posture for extended periods, or have been immobilized

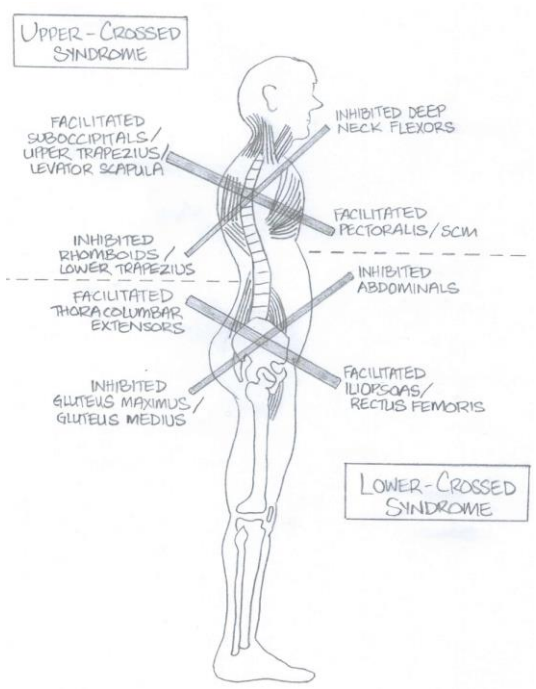


Figure 3. UCS/LCS

Layer Syndrome Characteristics

- Combination of Upper and Lower Crossed Syndromes
- Results from longstanding dysfunction and muscle imbalance
- Common in older adults

Fascia

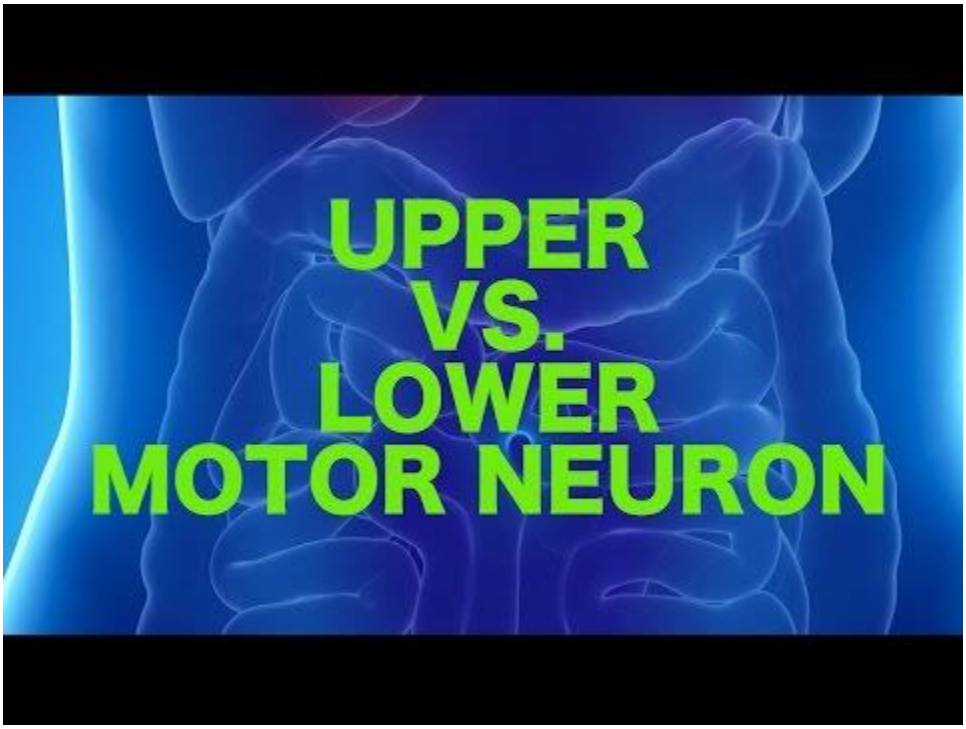
Definition: all the collagenous soft connective tissue that links the musculoskeletal system into one unit

Fascial Properties

- Made up of collagen protein → strong with little elasticity
- Can exert tensile force through its attachments between muscle and bone
- Orients itself along the lines of stress → follows Wolfe's Law
- 2 Types: subcutaneous superficial fascia and deep fascia
- Superficial fascia has a crisscross network of fibers
- Trauma to superficial fascia creates micro-bleeding that lays down scar tissue which changes the tensile strength of the musculoskeletal system
- Scar tissue in fascia creates altered tensile forces where trigger points can manifest
- Deep fascia is able to store water, allowing structures to glide over each other without friction
- Dehydration, inflammation, and trauma deplete the hydrated matrix within the fascia creating adherence to tissues, fatigue, ischemia, and a buildup of metabolic toxins
- Changes to deep fascia can present as ROM limitations, altered lymphatic channels, functional weakness, postural imbalances, and secondary contractures
- Fascial network responds to trauma, disease states (e.g. diabetes, rheumatologic conditions), overuse syndromes, and poor mechanics or postures

Motor Neuron Lesions

Motor neuron lesions occur due to trauma (e.g. concussion, contusion, laceration/maceration), or non-traumatic disease processes (e.g. MS, diabetes, infections). Clinical presentation depends on the area affected, and nature/severity of damage[6 7]



Video, detailing upper vs lower motor neuron lesions

Upper Motor Neuron Lesion[3, 8]

- Lesions to the first order neuron (corticospinal tract), within the **central nervous system** (brain, brainstem, spinal cord)
- The following signs and symptoms are seen *below the level of the lesion*, once spinal shock has subsided:
  - Hypertonicity / spasticity of muscles
  - Weakness / paralysis
  - Hyperreflexia
  - Babinski Sign
  - Clonus
- Lesions to the brain will cause signs and symptoms *contralaterally*
- Spinal cord lesions will cause signs and symptoms *ipsilaterally*
- Other signs and symptoms depend on the area of damage (e.g. speech, sensation, balance, memory, vision, perception)

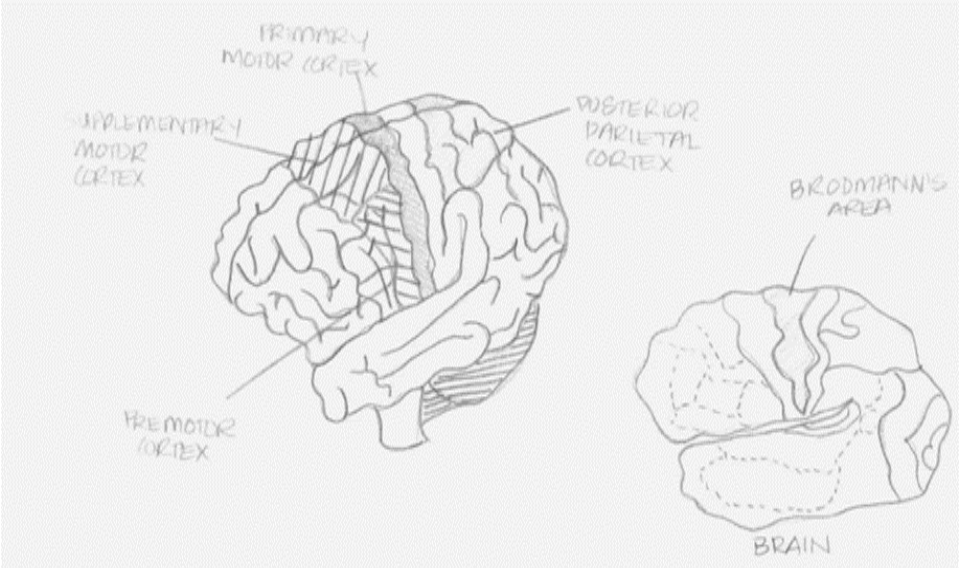


Figure 4. Areas of the Brain

Lower Motor Neuron Lesion

- Lesions to the **peripheral nervous system** (anterior gray horn, nerve roots, peripheral nerves, cauda equina)
- The following signs and symptoms are seen *at the level of the lesion*:
  - Hypotonia / flaccidity
  - Weakness / paralysis, muscle wasting / atrophy
  - Hyporeflexia / areflexia
  - Absence of Babinski
  - Absence of clonus (1-2 beats)

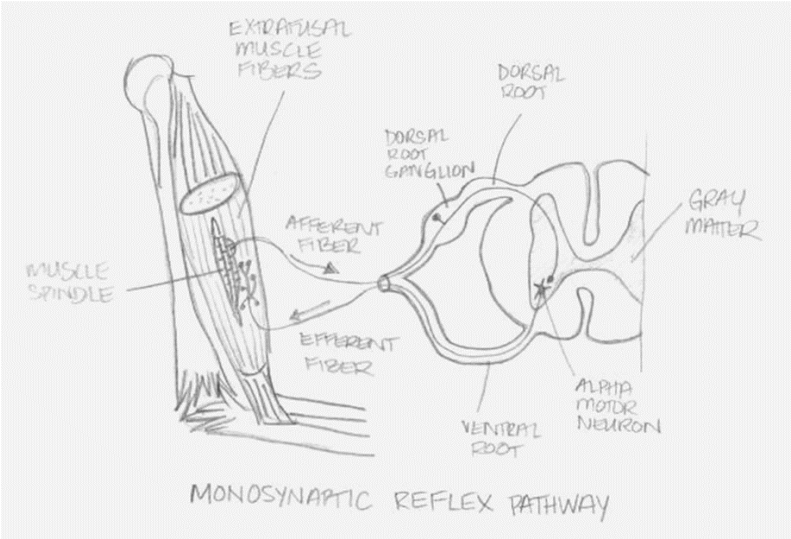


Figure 5. Monosynaptic Reflex Pathway

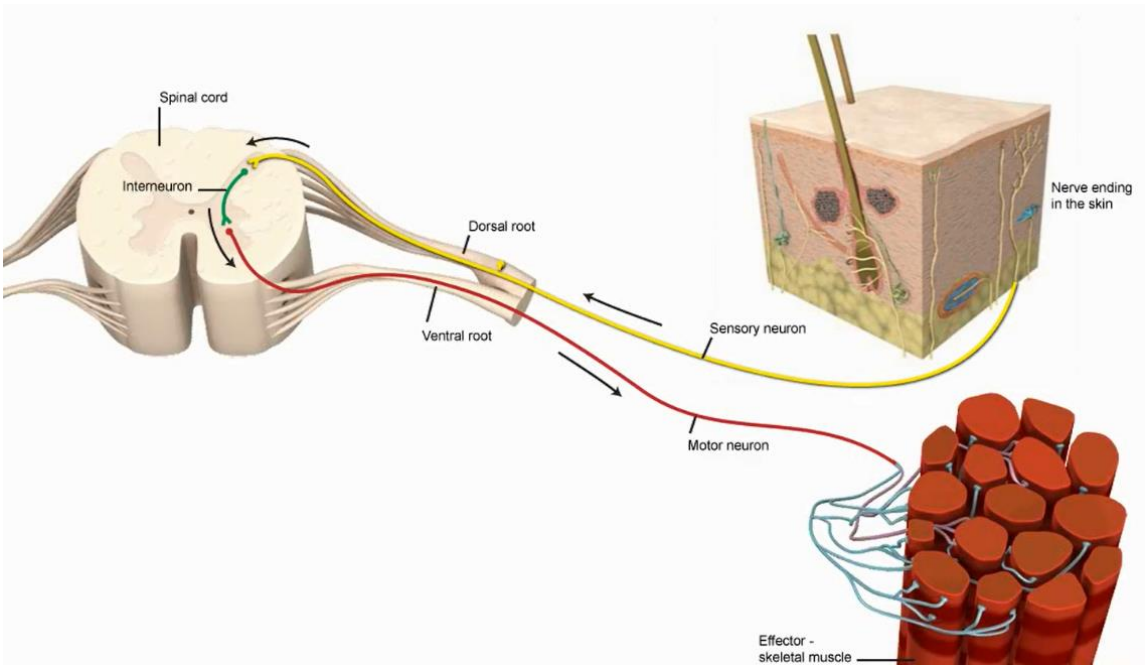


Figure 5. Monosynaptic Reflex Pathway and the Brain

- Disc injuries, if compressing a nerve root, may mimic a lower motor neuron lesion.
- **Second Number Rule:** Because of the physical relation of a nerve root to the intervertebral disc, a lesion at one vertebral level in the lumbar spine will affect the nerve root numbered one ***below***. Generally, a lesion at the L4-5 level will affect the L5 nerve root. In the cervical spine, the nerve root exits ***above*** its' corresponding numbered vertebral body. A lesion at the C5-6 level will affect the C6 nerve root (see Figure 6).

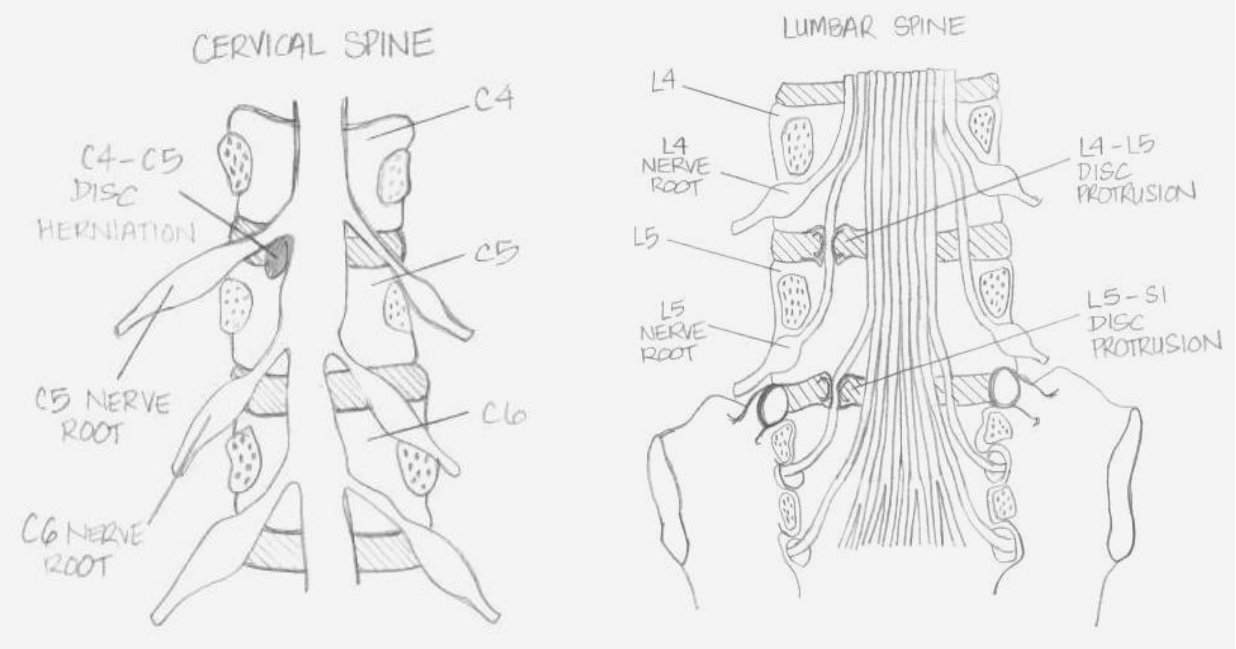


Figure 6. Second Number Rule in Cervical and Lumbar Spine

Neurological Assessment[3]

Conduction Tests

- Myotomes, dermatomes, reflexes
- Also known as “hard” neuro signs

Myotome Testing

- Muscles innervated primarily by a single nerve root.
- Most muscles are innervated by multiple nerve roots so there are typically some that overlap.
- Myotome function is evaluated by a 5-6 second, sustained maximal isometric resisted contraction.
- Positive response: premature fatigable weakness. There is a feeling of smooth letting go. This is often found in absence of pain.
- In the cervical spine, the most commonly affected nerve roots are C6 and C7. In the lumbar spine, it’s L5 and S1.

Dermatome Testing

- Area of skin supplied by a single nerve root
- Dermatomal regions overlap, and there are also discrepancies between individuals
- Difficult for a client with a nerve root irritation to pinpoint the exact area of altered sensation
- Dermatome function often tested with light touch of a tissue running along the length of the dermatome
- Not used as a primary diagnostic tool but, rather for secondary confirmation

Deep Tendon Reflexes

- To evaluate the integrity of the monosynaptic stretch reflex (both sensory and motor component)
- A tendon tap is performed on a relaxed and slightly stretched tendon, the response is noted and compared to the contralateral side
- Findings charted as normal, increased or decreased
- Abnormal reflexes are only clinically relevant if found with sensory or motor abnormalities
- Jendrassik maneuver (patient clenches teeth, forms fingers into hooks, connects them in front of body, and attempts to pull apart) can facilitate reflexes that are hard to elicit
- Dysfunction in the lower motor neuron loop causes hyporeflexia or areflexia at that level due to impaired motor unit conduction
- Dysfunction in the upper motor neuron loop results in hyperreflexia below the level of the lesion due to loss of normal CNS inhibition

Reflexes and nerve roots tested[3, 9]:

Root Tested	Tendon
C5/C6	Biceps brachii tendon Brachioradialis muscle belly
C7/C8	Triceps tendon
L3/L4	Quadriceps tendon
S1/S2	Achilles tendon

Irritative Tests (Neurodynamic Tests)

Straight Leg Raise:

- Serially applied lower quadrant movements are utilized to tension the lumbosacral plexus (L4 – S2) via the sciatic nerve.
- During the first 30°, slack is taken up in the sciatic nerve.
- Between 30 and 70°, the sciatic roots are tensioned over the intervertebral discs, tissues slide inferiorly.
- Beyond 70°, there is no further deformation of the sciatic roots. The movement of neuromeningeal tissues is lateral.
- A positive SLR is the reproduction of typical leg symptoms.
- Client is supine, with cervical spine and hip neutral. Passively flex hip with knee extended.
- Can confirm with use of active neck flexion, ankle dorsiflexion or hip internal rotation (all of which tension the lumbosacral plexus).

Femoral Nerve Stretch Test

- Serially applied lower quadrant movements that tension the L2 – L4 neuromeningeal tissue via the femoral nerve
- A positive test is reproduction of typical anterior thigh pain
- Client prone, passively flex the knee to 90°, if no symptoms, passively extend hip

Upper Limb Neurodynamic Test 1

- Serially applied upper limb movements to tension the cervical plexus neuromeningeal tissue via the median nerve (C5 – 7)
- A positive test is reproduction of typical upper extremity symptoms
- Client supine. Fix the scapula to prevent elevation during testing. Abduct to 110° and externally rotate shoulder, supinate forearm, extend wrist and fingers/thumb, extend elbow
- Start with shoulder movement, and put peripheral components of test on one at a time
- Confirm with contralateral side flexion of the neck
- Not considered as accurate a test as lumbar spine irritative tests. Generates false positives. Only used to confirm neurological involvement following positive findings with myotome and reflex testing
- Use caution with this test. Neural tension testing can have a latent effect, meaning the patient may have increased symptoms after testing (i.e. later that day or night)

High Test – Upper Motor Neuron Lesion (UMNL) Testing

Babinski (aka Plantar Response)

- Stroking of the plantar surface of the foot from the heel, along the lateral border of the foot and across the metatarsal heads
- Normal response is downward pointing/flexing toes as a first response
- Positive test is splaying of the toes with extension of the great toe

Clonus

- Abrupt dorsiflexion of the foot. Check for pulsing of movement.
- Normal response is 1 – 2 beats.
- Positive response is demonstration of several beats.

Low Test – Lower Motor Neuron Lesion (LMNL) Testing

Saddle area sensation

- Gently stroke the crease area of the upper buttocks (S2 – 4)
- Positive test is altered sensation or numbness in the area
- Can be indicative of a central disc protrusion affecting the cauda equina
- Further mandatory questioning must be carried out regarding bowel and bladder function

Cauda Equina Syndrome

There are two syndromes that involve the cauda equina. The acute syndrome is caused by a large central disc protrusion or space occupying lesion compressing the cauda equina centrally. *This syndrome is a medical emergency and the client should be immediately referred to the hospital emergency ward.*

The second syndrome is chronic and is caused by intermittent neurogenic claudication, commonly associated with spinal stenosis. Neurogenic claudication affects the circulation to the spinal cord/cauda equina. This is not a medical emergency and may be affected positively through a flexion-based exercise program. This is not to be confused with “intermittent claudication” of vascular origin, which is generally related to peripheral vascular disease and affects circulation to the lower extremity.

Acute Cauda Equina Syndrome	Chronic Cauda Equina Claudication
Subjective	
– Bilateral leg pain – Bowel incontinence – Bladder retention (dribbling) – Symptoms present only short term (hours/days)	– Predominantly leg pain with walking – Symptoms relieved with posture change (usually sitting) – May affect one or both legs – Usually long history – Older individuals (age 55 or greater)
Objective	
– Absent S1 nerve root bilaterally – Saddle area anesthesia – Positive crossover sign with SLR – Abnormal gait pattern	– May have neuro findings with exercise – Usually increase of typical pain with extension of the lumbar spine

History Taking

Obtaining an accurate history is imperative in guiding objective assessment and subsequent treatment. The information obtained will help clarify the nature and mechanical behavior of the client's condition. The therapist must understand the intent of each question, and then develop the skill of drawing out accurate responses from the client without biasing them. The questions often have to be repeated and rephrased. As accurate information is gained, patterns of mechanical disorders versus more serious pathology emerge.

Purpose of a History

- Determine mechanism of injury → examiner tries to determine the direction and magnitude of the injuring force (e.g. rear-end in an MVA, shoulder dislocation from a fall); may help reveal which tissue is injured
- Determine if an injury is behaving mechanically or not
- Help rule out serious pathology ***("Red Flags"),*** such as malignant tumors, systemic diseases or nerve involvement
- Identify psychosocial factors ***("Yellow Flags")*** which may influence recovery
- Help guide treatment (e.g. if past treatment modalities have been helpful or not)
- Relationship building → an opportunity to build good rapport and trust with the client

Questions to Ask

Pain Location / Site of Dominant Pain

- **Example:** Where is your pain? / Where is the pain the worst?
- Gather information on what is the source of pain and what is referred pain. Referred pain is pain that is felt at a site other than the injured tissue.
- Spinal injuries can more easily be diagnosed if the pain is back / leg dominant or neck / arm dominant.

Variability: Constant vs. Intermittent Pain

- **Example:** Do the symptoms come and go? Do they shut-off in certain positions or with certain movements? Are the symptoms present every waking moment of the day? Is there a moment in the day when you have no pain?
- Important for ruling out serious pathology. Mechanical pain is expected to be intermittent and affected by movements and postures.
- If pain is intermittent (i.e. shuts-off at times) there is no reason why the client should not reach a pain free status with correct positioning / postural change / specific pain control skills.
- Constant pain suggests chemical irritation, tumors, or visceral lesions.
- **Pain can be constant for several reasons:**
  - Tumors / cancer
  - Systemic diseases → Rheumatoid Arthritis, Diabetes, Multiple Sclerosis
  - Infection
  - Pain disorders: chronic pain, fibromyalgia (FM), Complex Regional Pain Syndrome (CRPS), other disease pathology
  - Constant “mechanical” pain due to an accompanying inflammatory component (e.g. nerve root irritation is mechanical plus chemical irritant)
  - Behavioural
  - Examiner did not ask the question correctly, received wrong information

Aggravating and Easing Factors

- **Example:** What makes the pain better / worse?
- Determine which symptoms are affected and if symptoms are better, worse or unaffected by certain movements or postures (e.g. bending, sitting, standing, walking, lying down).

- Daily variations:
  - morning pain (inflammation, arthritis)
  - evening pain (mechanical pain)
  - night pain (mechanical pain due to sleep posture, tumors)
- Activity dependent[3 10]
  - pain at rest (inflammation)
  - pain worse at beginning of activity vs. end (inflammation vs. mechanical)
  - pain not affected by rest / activity (bone pain, systemic disorder, pain disorder)
  - pain and cramping with prolonged walking (lumbar structures aggravated by extension [e.g. facet joints, stenosis], peripheral vascular disease)
  - pain aggravated by lumbar extension and rotation (facet joints, stenosis)
  - pain aggravated with sitting and forward / lateral / oblique flexion (lumbar structures aggravated by flexion [e.g. intervertebral disc])
- Determine the nature of the pain (ie. mechanical vs. nonmechanical)
- Provides the examiner with direction for further assessment and treatment
- Provides information regarding comfort in weight bearing (loading)

Quality of Pain[3]

- **Example:** What type of pain do you feel? Can you describe the quality of your pain? (e.g. Burning, sharp, pins & needles, tingling, achy, dull)
- Nerve pain: typically sharp, burning, may follow dermatomal pattern
- Bone pain: typically deep, boring and localized
- Vascular pain: typically diffuse, achy, not well-localized, may refer
- Muscle pain: typically dull, achy, hard to localize, may refer

Duration of Symptoms

- **Example:** When did the pain first begin? When did the injury happen?
- Provides information as to the injury's *"stage of healing":*
- Inflammatory / Acute: 0 – 5 days
- Repair / Subacute: 5 days – 3 weeks
- Remodeling / Chronic: 3 weeks – 18 months
- Record the date of onset of the symptoms
- If more than 6 months, consider psychosocial factors

Mechanism of Injury

- Record the cause of onset of symptoms. Do not prompt the client or search for a cause if the client cannot recall one (66% of low back injuries are insidious in onset).
- Determines the direction and magnitude of the injuring force (e.g. rear-end in an MVA, shoulder dislocation from a fall).
- Provides clues to identify which tissue might have been injured
- Gives examiner a basis for the client's understanding of their injury
- Inquire if there are any predisposing factors that may have led to the problem (ie. general health, familial or genetic problems).

Work / ADL's / Leisure / Sport History

- May give you clues as to the cause of injury and pre-injury activity level.
- Length of time off work / sport will determine the level of job / sport specific de-conditioning.
- Gather information on specific job demands / tasks to establish a job specific treatment plan. Gather information on work frequency to assist in future GRTW planning.
- Record the client's perceived intensity of work (i.e. sedentary, light, medium, heavy, very heavy) to assist in GRTW planning.
- May provide insight into psycho-social factors if the client has not returned to work (e.g. job satisfaction, relationship with boss or coworkers).
- Record frequency and duration of leisure and sport participation.
- Record limitations or modifications in performing functional work tasks.
- Record limitations or modifications in performing Activities of Daily Living.
- Compare pre- and post- injury activity.

Management of this Episode and of Past Episodes

- **Example:** Have you had this problem in the past? Was there any treatment done previously, and if so was the problem resolved with treatment?
- Discuss and record effects of previous treatments for this, and previous, episodes.
- Successful treatment of past episodes may provide the examiner with information that will help treat the current pain episode. Inquire on how long it took to get better the first time.
- If manual/mechanical treatment has helped this episode this may suggest the injury is mechanical in nature.
- Information assists with a differential diagnosis.

Mandatory Questions

- General Health: probe the client (i.e. asthma, diabetes, arthritis, cancer, predisposing factors / conditions etc.)
- Medication: e.g. pain medication, anti-inflammatory agents, muscle relaxants, or long-term corticosteroids. Signs and symptoms may be masked by medications or contraindications/ precautions may influence treatment planning
- Previous Surgeries
- Investigations to date: X-ray, MRI, CT scan, nerve conduction tests etc.
- Any recent unexplained weight-loss: *"Red Flag"* for cancer
- Night pains / night sweats? *"Red Flag"* for cancer
- Any changes in bladder or bowel function? *"Red Flag" for CES*
- Saddle area paresthesia / anesthesia)? *"Red Flag"* for CES
- Bilateral / quadrilateral paraesthesia / anesthesia
- Neuro signs and symptoms, including nystagmus, perioral numbness
- Note the "5 – D's" (Vertebrobasilar Insufficiency): Dizziness, Diplopia, Dysphagia, Dysarthria, Drop Attacks

Pain Referral Patterns

Pain Centralization and Peripheralization Phenomena

- This concept was developed by Robin McKenzie (1981), a physiotherapist from New Zealand.
- It has been scientifically validated and studies have demonstrated that if pain centralizes on performing exercises the chances of rapid and complete recovery are excellent.
- Repeated end-range movements in both standing and lying positions are performed 10-12x.
- If centralization occurs, it can indicate good exercise prescription for treatment and can become part of the exercise program.

Centralization: pain moves toward the midline of the spine and away from the extremities (arms or legs). Indicates the correct treatment direction. Clients may complain of a temporary increase in central spinal pain as peripheral symptoms decrease.

Peripheralization: pain moves from the midline of the spine toward the extremities. Indicates the incorrect treatment direction, even if the central symptoms improve as the distribution peripheralizes.

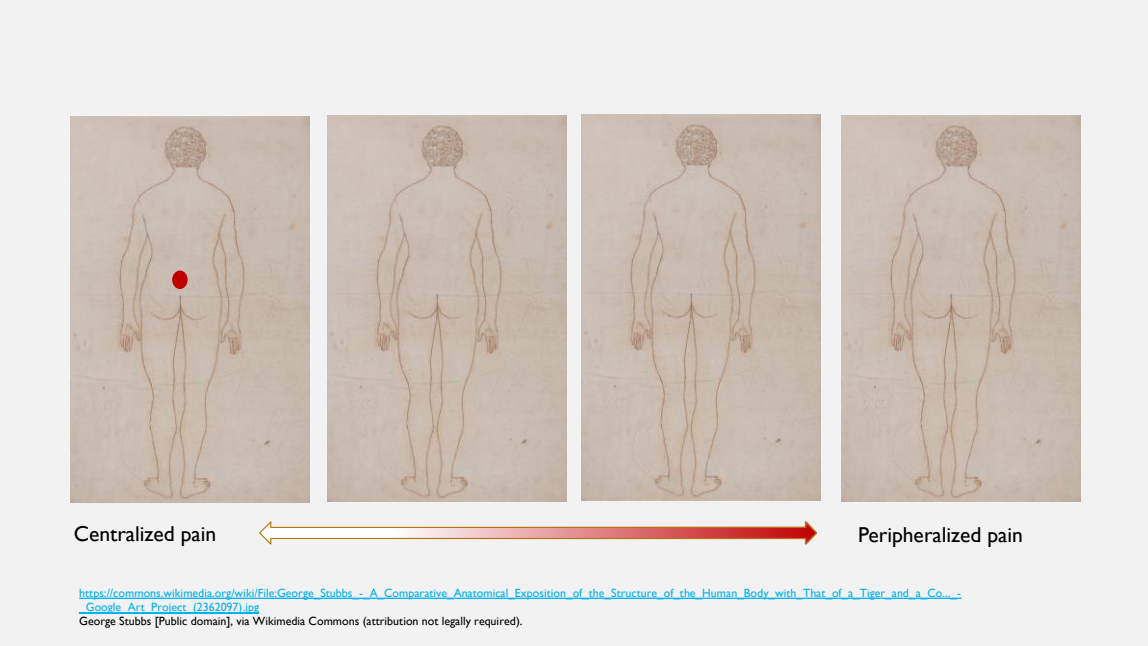


Figure 7. Centralized and Peripheralized pain patterns

What is Referred Pain?

- **Definition:** Pain that is felt at a site other than the injured tissue (Magee, 2008).
- **Reason:** Often the same or adjacent neural segment supplies the referred pain location.
- Most common example of referred pain is when someone having a heart attack experiences chest or left arm pain
- **Trigger point (myofascial) pain** is a type of referred pain. Known as a localized area of hyperirritability within a muscle that is tender to compression (direct pressure) where nerve impulses bombard the CNS and if sensitive enough are expressed in the body as referred pain. Referred pain from a trigger point may present as steady, deep and achy pain.

Cervical Spine Assessment

Because neck injuries often refer symptoms to the regions listed below, physical therapists always start upper quadrant examinations with a cervical spine assessment.

Cervical Pain Referral Pattern[3]

- Neck
- Upper trapezius region
- Interscapular region
- Upper limb (shoulder, arm, hand)

Subjective Examination

Standard History[3]

Mandatory Questions

- General health
- Medication
- Investigations to date
- Recent unexplained weight loss
- Night pains / night sweats
- Bladder and bowel changes
- Saddle area paraesthesia / anaesthesia
- Bilateral or quadrilateral paraesthesia / anaesthesia
- Neuro signs & symptoms, including nystagmus, perioral numbness

Special Questions

The "5 D's": Dizziness, Diplopia, Dysarthria, Dysphagia, Drop Attacks

Objective Examination

Observation:

Posture: head, neck and shoulder girdle positioning; muscle tone/spasm

Posture Correction:

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, poor body awareness, pain, other structural factors)
- Do their symptoms change?

Function: general quality of movement throughout examination

Active ROM

Use an inclinometer and goniometer to measure the following[11]. Note limitations and pain.

Ideal Ranges

- Flexion 50 - 60° (or up to 2 finger widths between chin and sternum)
- Extension 70°
- Side flexion 45°
- Rotation 80°

Since this is a scan of the entire upper quadrant, add Apley's scratch test for the upper extremities:

- Hand behind back (HBB)
- Hand behind head (HBH)

Neurological Examination

Roots (Nerves Tested)		**Area**
Reflexes	**C5,** C6 (Musculocutaneous Nerve)	Biceps
	C5, **C6** (Radial Nerve)	Brachioradialis
	C7, C8 (Radial Nerve)	Triceps
Myotomes	C3 -C4	Shoulder shrugging
	C5	Shoulder abduction
	C6	Elbow flexion
	C7	Elbow extension
	C8	Thumb extensor
	T1	Finger adduction/abduction
Dermatomes	C4 – T1	Light touch
Upper limb neurodynamic test		See Figure 8

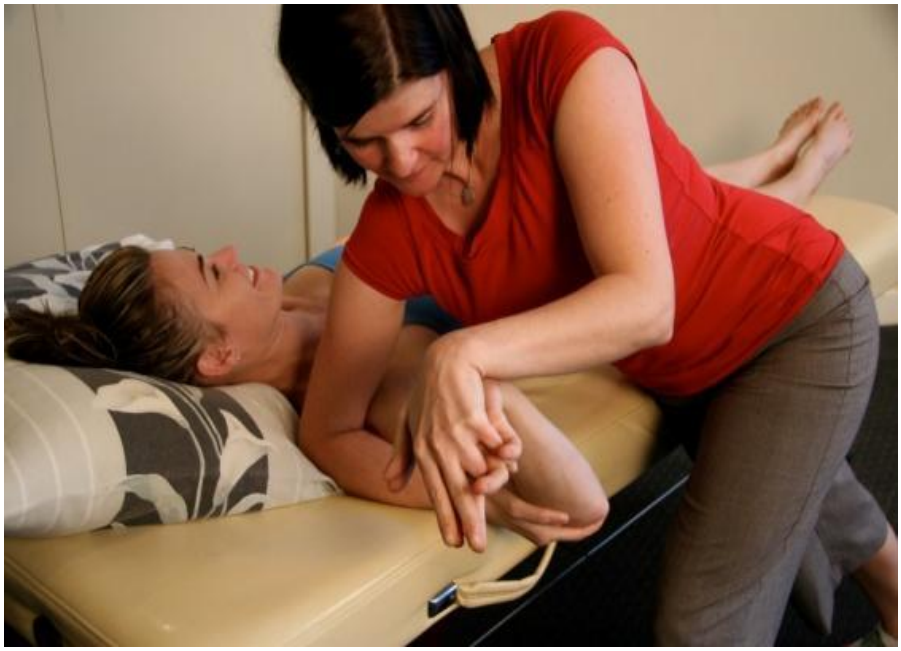


Figure 8. Upper Limb Neurodynamic Test

Case Study #1: Cervical Assessment

History:

*Age:*45
Pain location: lower neck and upper shoulders and upper back, right side worse than left
Nature of pain: intermittent, worse with all neck movements. At its worst radiates all the way into the thumb.
Mechanism of injury: MVA - turning left on a yellow and the oncoming car ran the light and clipped his back end, spinning his car around several times.
Developed immediate neck pain. Went to emergency for x-rays. Followed up with his GP the next day. Two days later began developing pain and tingling in the right upper arm. It is now a month post injury and the pain and tingling have progressed down past the elbow into the forearm. He has not sought therapy because he can't afford it and has not seen the GP since the day after the accident.
Occupation: Civil servant, computer work, sits ++ of day
Investigations: C-sp X-rays revealed mild degeneration with osteophyte formation mid to lower C-sp
General health: sedentary; smoker; elevated BMI
Medications: ibuprofen
Family history: negative
Past Medical Hx: chronic back pain x 10 years

Objective:

Observation: crease across lower neck; head forward posture and rounded shoulders with a tendency to hold head in slight left rotation
AROM: flexion 35°, extension 40°, side flexion 30° right and 45° left, rotation 45° right and 60° left. All limited by pain. Upper extremities WNL.
Neuro: myotomes normal except weak right shoulder abduction and elbow flexion. Dermatomes no clear dermatomal pattern. Reflexes diminished biceps reflex on the right. ULNT1 slightly decreased ROM on right
Palpation: diffuse tenderness throughout the neck and upper back with multiple trigger points throughout.

Case Study #2: Cervical Assessment

History:

Age: 29
Pain location: posterior neck pain and headaches, started about 1 month ago for no apparent reason.
Nature of pain: intermittent, worse towards end of her work day. Neck symptoms are progressively getting worse.
Occupation: systems administrator - sedentary, computer work. Her department has been undergoing renovations for past 3 months which has caused her to move around to different workstations.
Recreation: she pole walks regularly with her mother, rollerblades in the summer, goes to the gym occasionally, mostly on the circuit
Investigations: none
General health: good
Medications: Tylenol ES 1-2/day at work
Family history: mother is diabetic
Past Medical Hx: MVA 4 years ago with neck and upper back involvement, complete resolution after several months

Objective

Observation: Head forward posture (HFP), holds shoulders elevated and forward, flat feet right more so than left
AROM: slightly decreased flexion, remaining planes all WNL with end range pain in flexion, side flexion and rotation. Upper extremities WNL.
Neuro: Myotomes, dermatomes unremarkable. Reflexes diminished brachioradialis and triceps reflexes bilaterally. ULNT1 unremarkable
Palpation: tender at the base of the skull with trigger points in upper fibres of trapezius, levator scapula and suboccipital muscles bilaterally

Lumbar Spine Assessment

Back injuries often refer symptoms to the regions listed below, therefore physical therapists always start lower quadrant examinations with a lumbar spine assessment.

Lumbar Pain Referral Pattern[3]

- Low back
- Buttock
- Lower extremity (thigh, lower leg, foot)

Subjective Examination

Standard History

Mandatory Questions

Special questions:

- effect of a cough; clicking in pelvis
- feeling of giving way

Objective Examination

Observation

Posture: position of ease, trunk list, scoliosis, pelvis, muscle spasm / atrophy

Posture Correction:

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, poor body awareness, pain, other structural factors)
- Do their symptoms change?

Function:

- General quality of movement throughout examination
- Gait
- Squat
- Unilateral stance

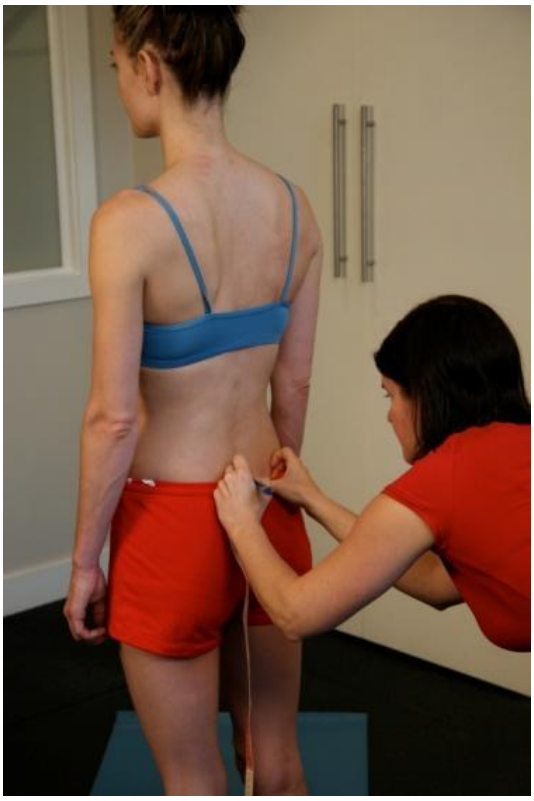
Active ROM

Use an inclinometer positioned at the T12/L1 interspace and a regular goniometer to measure the following. Note limitations and pain[2]

- Flexion 80°
- Extension 30°
- Side flexion 35° (or fingertips to knee joint line)
- Rotation 45°

Modified Schober's: an alternative method of measuring flexion[2]

- Mark between PSISs (i.e. S2)
- Mark 10 cm above in standing
- Have client perform full flexion in standing
- Measure the difference
- At least 4 cm more is considered normal





Figures 9 & 10. Modified Schober's Test

Since this is a scan of the entire lower quadrant, add squat for lower extremity screen (measures range, but also strength, willingness to move, quality of movement) – this will have already been done as part of the functional observation, but be sure to note range at that time.

Neurological Examination		
	Nerve Root	**Area**
Reflexes	L3 S1	Patellar tendon Achilles tendon
Myotomes	L3 L4 L5 S1 S2	Knee extension Ankle dorsiflexion Great toe extension Ankle plantarflexion Knee flexion
Dermatomes	L3 – S2	Light touch
Babinski See Page 30		
Clonus See Page 30		
Straight Leg Raise (SLR)		
Femoral Nerve Stretch Test (FNST)		

Example for ordering tests to minimize repositioning:

- Standing: observation, range of motion, S1 myotome
- Sitting: L3 reflex, L3 and S2 myotomes
- Supine: Babinski, clonus, SLR, L4 and L5 myotomes, dermatomes, ASLR
- Prone: S1 reflex, FNST



Figure 11. Straight Leg Raise (SLR)

Sacroiliac Joint

The SI joint is most commonly affected in traumatic injuries (such as a fall, sudden unexpected step off a curb, or a kick that misses the object, lift and twist maneuver) or during pregnancy (due to an increase in the hormone, relaxin). Symptom location is normally in the buttocks over the SI joints, is normally unilateral, and may refer into the lumbar spine, and ipsilateral hip joint, buttock, or posterior thigh (generally not below the knee)[3].

Differential diagnosis: ankylosing spondylitis; rheumatoid arthritis

Physical therapists use a series of special tests to confirm SI joint involvement if suspected. A kinesiologist may suspect SI joint involvement based on the following:

History/special questions[3]

- location of pain
- mechanism of injury (fall, pregnancy);
- pain made worse when getting in/out of car or bed; turning in bed; stepping up with limb of painful side; climbing up or down stairs; sit to stand
- pain may be constant

Objective Examination

Observation

- *Posture:* check pelvic alignment (ASIS and PSIS ~10° from horizontal; ASIS vertical to symphysis pubis level iliac crests/ASISs/PSISs;) during postural assessment

Active ROM

- Note pain with lumbopelvic flexion (40-60°); extension (20 – 35°); rotation (3 - 18°); side flexion (15 - 20°); end-range hip ROM in all directions

Neurological Examination

Conduct the same neuro scan as in the lumbar spine.

Special Tests

True Leg Length Discrepancy test

- Neutral pelvis: in supine, start with both feet flat on plinth, perform a bridge then return to supine with legs extended
- Measured from ASIS to medial or lateral malleolus
- Discrepancies of up to 1.5 cm are considered normal
- See Figures 12 & 13.

Functional Leg Length Discrepancy test

- Neutral pelvis: in supine, start with both feet flat on plinth, perform a bridge then return to supine with legs extended
- Measured from belly button to medial or lateral malleolus
- Indicative of lateral pelvic tilt at time of test as result of pathology or contracture in spine, pelvis or lower extremities



Figure 12. True leg length



Figure 13. Functional leg length

Active Straight Leg Raise

- In supine, client lifts leg 3-4 inches off the treatment table. Is the client able to maintain a neutral pelvis? This is an indicator of core strength / pelvic stability. Note any symptoms.
- *Form closure: Provide external compression to the pelvis and ask client to perform test again.* Note difference in stability and symptoms (may indicate SI belt).
- *Force closure:* Ask client to set core and perform test again (can also add a small weight in the contralateral arm). Note difference in stability and symptoms (may indicate core stability program).
- *Can repeat ASLR in prone.*



Figure 14. Active Straight Leg Raise

Lunge

With proper instruction this exercise may help identify a pattern to the client's pain. For example, if pain increases lunging with the right foot forward and decreases with the left foot forward, it may indicate a rotated pelvis. The lunge that decreased the pain can be used by the client for symptom control. If symptoms are not controlled with this simple test, a referral for assessment by a qualified healthcare practitioner may be indicated.



Figure 15. Lunge

Case Study #1: Lumbosacral Assessment

History:

Age: 43
Pain location: right sided low back and buttock pain, occasionally goes down posterior thigh to mid-calf
Nature of pain: decreases but always there, currently 5/10
Aggravated by: sitting, vacuuming, putting on my shoes
Relieved by: lying on stomach, walking
Occupation: order picker
Mechanism of injury: got a large shipment in at work 5 weeks ago, was lifting boxes all day, towards end of day twisted to the left to pick up a light box from the bottom of the pallet and felt a sharp tweak
Investigations: X-rays negative
General health: smoker x 26 years
Medications: muscle relaxants, T3 PRN
Special questions: constipated

Objective:

Observation: splints himself in chair slightly, stands with poor abdominal tone, rounded shoulders and head forward posture. Able to perform full squat but maintains erect posture
ROM: flexion, extension and side flexion left all ½ of normal, side flexion right 80% of normal, rotation 75% of normal bilaterally (all pain limited)
Neuro: decreased S1 reflex on right; 4 partial range heel raises on right only (remaining myotomes WNL). SLR 60° on left, limited by hamstring tightness and low back pain; 55° on right, limited by right buttock and posterior thigh pain.

Case Study #2: Lumbosacral Assessment

History:

Age: 57
Pain location: central low back pain
Nature of pain: intermittent, lasting 1 year
Aggravated by: work, long walks
Relieved by: rest (if they ask for more detail, specify sitting)
Occupation: meat wrapper at Safeway for 27 years.
Mechanism of injury: can't recall a specific injury, gradual onset of pain.
Investigations: none
General health: excellent
Medications: ibuprofen PRN
Special questions: urinary frequency

Objective

Observation: lordotic posture, flat thoracic spine. Able to perform full squat but uses hands on thighs to recover to standing
ROM: flexion full, extension 10° (pain limited), side flexion and rotation both slightly decreased bilaterally (pain limited)
Neuro: myotomes all generally weak; reflexes brisk and equal bilaterally. SLR 65° bilaterally, limited by hamstring tightness.

Thoracic Spine Assessment

Symptoms felt in the thoracic spine are often referred from the cervical spine or, less often, the lumbar spine. Therefore, the examiner should always begin with either a cervical or lumbar spine assessment. True thoracic spine lesions are often associated with pain in the thoracic spine, or thorax, with deep inspiration. The causes of such symptoms are related to posture. In addition, because the thoracic spine protects vital internal organs, pathology of these organs may also refer pain into the thoracic spine.

- Typically, if pain is reported above T7 the examiner performs a full cervical assessment[10]
- Typically, if pain is reported below T7 the examiner performs a full lumbar assessment[10]
- Thoracic pain is common in persons with conditions such as severe thoracic kyphosis, scoliosis, Scheuermann's Disease and osteoporosis.
- Disc lesions are rare in the T-spine.

Thoracic Pain Referral Patterns

- Thoracic spine
- Around same level rib to anterior chest

Scoliosis

- **Definition:** one or more lateral curves of the T- or L-spine are present.
- C-shaped curve (1 spinal curve present): shoulder is **low** on the side of the **high** hip
- S-shaped curve (2 spinal curves present): shoulder is **high** on the side of the **high** hip

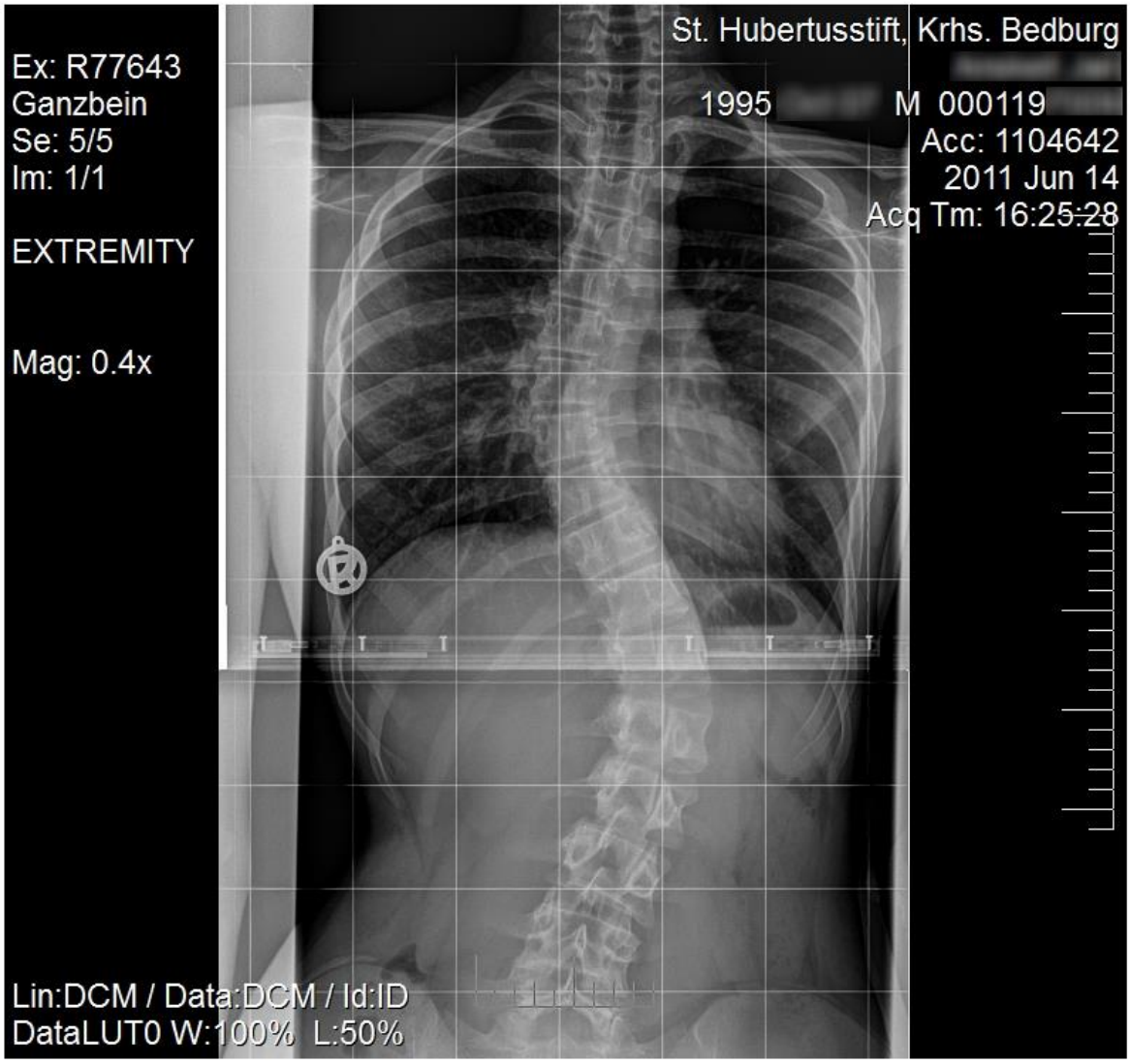


Figure 15. S-shaped scoliotic curve

- Curve is recorded / described with respect to the convexity of the curve[10]
- Scoliosis can be structural of functional (see table below)

Vertebral deformities to consider → wedging

- Scheuermann's disease – presents as kyphotic aka. "hunchback"
- Wedge fractures from trauma or osteoporosis

Characteristics-Structural versus Functional Scoliosis

Type	Characteristics
Structural	– Structural change in bone – Curve is maintained with forward-bending or side-bending – Causes include: idiopathic (unknown origin), genetic, bony deformity, excessive muscle weakness (long term quadriplegia), wedged vertebra, vertebral deformity, neuromuscular (upper or lower motor neuron lesion), arthrogryposis (persistent joint contracture), trauma – Higher incidence in females than males – May be a visible "hump and hollow" resultant from deformation of the ribs and spine – Findings: normal flexibility of the spine is lost
Functional	– Curve is reduced with forward-bending or side-bending – Causes include: poor posture, nerve root irritation, inflammation in the spine area, leg length discrepancy, contracture in the L-spine or hip, a response to an injury, muscle imbalance – When muscular based can reverse with appropriate treatment and exercise – Findings: normal flexibility of the spine is lost; especially side flexion and rotation

Subjective Examination

Standard History

Mandatory Questions

Special Questions

- Pain with inspiration?
- History of smoking? Risk factors for heart disease?
- Onset of menopause, hysterectomy, estrogen replacement?
- History of gastrectomy?
- History of thoracic back pain as a teenager?

Objective Examination

Observation

Posture: position of ease, head, neck, upper back (kyphosis), deformity, clavicles, winged scapulae, barrel chest, muscle tone/spasm, atrophy

Posture Correction

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, poor body awareness, pain, other structural factors)
- Do their symptoms change?

Function: general quality of movement throughout examination

Pattern of Inspiration / Expiration

- Note breathing pattern (Female/Male/Children/Older Adults)
- Note breathing rate (tends to decrease when pain present)
- Common compensatory strategies include: shallow breathing, excessive use of superficial muscles, chest breathers, absent lateral excursion of lower ribs (Janda)

Active ROM

Use an inclinometer and goniometer to measure the following. Note limitations and pain.
Patient assumes a sitting position with arms crossed over chest and hands resting on shoulders[3]

- Trunk flexion 20 - 45°
- Trunk extension 25 - 45°
- Right and left trunk side flexion 20 - 40°
- Right and left trunk rotation 35 - 50°

Costovertebral Expansion (breathing)

- Place tape measure around chest/nipple level
- Patient exhales as much as possible and examiner measures circumference
- Patient inhales maximally and examiner takes second measurement
- Normal difference between inspiration/expiration is 3 – 7.5cm[3]

Neurological Examination

- Perform full Cervical and/or Lumbar spine neurological scans.

Case Study #1: Thoracic Spine Assessment

History:

Age: 25

Pain location: mid-back just below the shoulder blade

Nature of pain: sharp pain on the right, made worse with deep inspiration.

Mechanism of injury: Tackled by another player while playing soccer several days ago. Thinks he was elbowed but not sure as his back was turned to the other player.

Recreational: active in many sports

Occupation: bartender

Investigations: none

Medications: none

Family History: negative

Past Medical History: negative, no previous history of neck or back pain

Objective:

Observation: significant bruising just below right scapula

Active ROM: Trunk ROM limited in all planes due to pain.

Neuro: myotomes unremarkable, dermatomes no clear dermatomal pattern, reflexes: brisk and symmetrical

Special tests: SLR negative

Case Study #2: Thoracic Spine Assessment

History:

Age: 16

Pain location: mid-back pain worsening over last 6 months.

Nature of pain: sharp pain on the right, made worse with deep inspiration.

Mechanism of injury: none known

Recreation: recently started playing minor league baseball

Investigations: none

Medication: none

Family History: negative

Past Medical History: Broke her femur falling off the monkey bars at age 7. No previous history of neck or back pain

Objective:

Observation: right shoulder high, Right pelvis high

Active ROM: trunk ROM limited in left rotation and left side bend, no humping of ribcage on forward flexion.

Neuro: myotomes unremarkable; dermatomes no clear pattern; reflexes: brisk and symmetrical

Special tests: true leg length – right longer

Non-Organic Pain Signs

Low Back

The following tests were developed in 1980 (revised 1998 in The Back-Pain Revolution) by Dr. Gordon Waddell[12], an orthopaedic surgeon from the United Kingdom. They are objective tests designed to "fool" the client into thinking that the spine is being tested when in fact there is no movement occurring in the spine. These tests are scored positive if the client reports pain when pain is not mechanically produced. The tests indicate exaggerated or inappropriate pain behaviour in a client "presumed to be suffering from pain relating to a lumbar spine soft tissue injury". It is important to note that these tests do not indicate that the client is "malingering" but rather that the pain response is inappropriate relative to the severity of injury.

The 'Malingerer'

A malingerer will be **inconsistently inconsistent**. That means that if you repeat testing in various positions or numerous times, the client will display different objective findings. For example, when testing the lumbar range of motion, the client displays different ranges from trial to trial. Another example would be if the client claims that he/she cannot bend past their thigh level but displays no difficulty bending over to tie his/her shoes within the same assessment.

The 'Symptom Magnifier'

A symptom magnifier will be **consistently inconsistent**. That means that no matter how often a particular body part is tested within the same assessment, the client will display identical objective findings. The client may be showing signs of exaggerated pain response however to him/her symptoms are real and limit function. For example, if a client cannot bend past their thighs he/she will also not be able to obtain enough range of motion to tie his/her shoes or will do so with great difficulty.

Observe how and for how long the client sits while you take a history. Observe the client removing items of clothing or how comfortable he/she appears in casual conversation/observation and compare this to when the formal objective testing begins.

Understanding the Challenges with Non-Organic Testing

- Waddell signs have been misused and misinterpreted over the years clinically and in medical legal proceedings.
- Signs have been misused by assessors as a means of discrediting MVA claimants and impacting their monetary settlements.
- Waddell signs relate only to symptom magnification or pain behaviour influenced by psychosocial factors.
- Psychosocial factors can hinder a successful outcome when treating chronic LBP.
- The term "non-organic" has been used to label Waddell signs which suggests no physical cause; however, the brain is an "organic" thing and a person's response whether appropriate or inappropriate, needs to be considered as it originates from an organic source.
- Pain is subjective and can be influenced by a multitude of things (ex. Fear of injury, anger, depression, anxiety, motivation to RTW, and worry about the future).
- From continued bombardment of the pain, pathway changes may occur that make an individual more sensitive to pain → *central sensitization.*
- After much review by Waddell and others, a neuroanatomical approach has been proposed to replace the term "non-organic". Waddell suggested neuroanatomical maladaptations to long-continued pain.

Lumbar Non-Organic Tests

When performing these tests do not ask the client "Do you have back pain when I do this?" Rather, ask the question "What do you feel when I do this?"
Scoring: Each sign is scored individually as positive or negative. A finding of 3 or more positive signs is clinically significant.

Axial Loading

Low back pain is reported on vertical loading (2-3 lbs. of pressure) over the standing client's skull/head by the examiner's hands. Neck pain is common and should be discounted. If a client presents with neck pain symptoms due to the injury, then the vertical load can be applied to the shoulders by the examiner.



Figure 16. Axial Loading

Straight Leg Raise Discrepancy

Test the SLR in both sitting and supine and compare reaction and ROM obtained with both tests. In sitting the client will often display 70-90° of SLR with minimal complaints of pain. In supine, the client will often demonstrate a greatly reduced ROM with a display of pain.



Figure 17. SLR Discrepancy

You may also perform a "double" SLR by passively lifting both legs at the same time and comparing to previous "single" SLR testing. Anatomically there should be no difference in the ROM obtained between tests. Higher ROM can typically be achieved with a double SLR.

Acetabular Rotation

Therapist stands from behind. Back pain is reported when shoulders / trunk and pelvis are passively rotated (1/4 turn) in the same plane as the client stands relaxed with the feet together and hands tightly against hips. In the presence of root irritation, leg pain may be produced and should be discounted *(Note: the first 30° of rotation occurs through the hip joints).*



Figure 18. Acetabular Rotation

Cogwheel Releasing/Weakness

Weakness is demonstrated on formal testing by a partial cogwheel "giving-way" of many muscle groups that cannot be explained on a localized neurological basis.

Sensory Disturbance

Include diminished sensation to light touch, pinprick fitting a "stocking" or "glove" rather than a dermatomal pattern. Weakness and sensory disturbances often affect the same areas.

ASSESSMENT OF THE EXTREMITIES



The Hip Joint

Surface Anatomy Exercise

Locate the following structures on your partner:

- Anterior superior iliac spines
- Iliac crests
- Posterior superior iliac spines
- Greater trochanters
- Sacroiliac joints
- L4 -5 spinous processes

Hip Joint Assessment

Subjective Examination

Standard History

Mandatory Questions

- general health
- medication
- investigations to date
- recent unexplained weight loss
- night pains/night sweats
- bladder and bowel changes
- saddle area paraesthesia / anaesthesia
- bilateral or quadrilateral paraesthesia / anaesthesia

Special Questions

- pain with weight bearing or walking (joint compression);
- stiffness with prolonged sitting (early OA);
- effect of a cough (lumbar disc);
- painful clicking/snapping (labral tear);
- giving way (instability, SI joint)

Objective Examination[5, 13-16]

Clinicians should not rely on a single physical exam test when diagnosing other hip joint pathologies[13]

Observation

Posture: position of ease, symmetry of weight bearing, muscle balance

Posture Correction

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, poor body awareness, pain, other structural factors)
- Do their symptoms change?

Function

- gait
- Trendelenburg
  - L5 myotome
  - 30s hold: pain (gluteal tendinopathy), ≤83° pelvis on femur angle (weakness)
- full squat/crouch (screen functional ROM/strength, movement strategies/clues)
- single leg partial squat

Lumbar/Neurological Scan

Lumbar spine lesions can refer symptoms into the buttock and hip regions. Therefore, always include lumbar observation, range of motion, neurological assessment and palpation.

Range of Motion

Active ROM: note quality of movement, quantity of movement, pain, willingness to move

Passive ROM: note quantity of movement, pain, end-feel

*(*note PROM and overpressure testing should be completed by a qualified healthcare practitioner)*

"Normal" Range of Motion[11]	
Flexion	110-120°
Extension	10-15 °
Abduction	30-50°
Adduction	30°
Internal rotation	30-40°
External rotation	40-60°

Client in supine

- Flexion (knee bent to remove muscle length as a limiting factor)
- Internal rotation (knee flexed to 90°)
- External rotation (knee flexed to 90°)
- Abduction
- Adduction

Client in prone

- Extension (apply downward pressure to buttock to avoid lumbar spine movement)

Resisted Tests

- Note pattern of pain, strength. Keep joint in mid-range position. Start light, and progressively increase to maximum strength or limitation due to pain.

Client in supine

- Flexion -knee flexed over shoulder of examiner (lateral pain? - OA)
- Internal rotation (knee flexed to 90°)
- External rotation (knee flexed to 90°)
- Adduction
- Knee flexion
- Knee extension

Client in side lying

- Abduction (weak and painful? gluteal tendinopathy)

Client in prone

- Extension (pain? osteoarthritis)

Special Tests[3]

Active Straight Leg Raise

- see SI joint section Figure 10.

Resisted External De-Rotation

- supine, knee and hip flexed to 90°
- maximum internal rotation start position (or as far as able without pain)
- resisted return to neutral rotation
- positive test: pain (? gluteal tendinopathy)



Figure 19. Resisted External De-Rotation



Figure 20. FABER Test

FABER

- tests general mobility, non-specific intra-articular pathology, iliopsoas spasm, SI joint
- in supine, place leg in **F**lexion, **Ab**duction and **E**xternal **R**otation with foot placed next to medial side of contralateral knee
- positive test: leg does not lower to at least parallel to opposite leg, pain
- can measure vertical distance lateral patella to plinth
- may indicate iliopsoas spasm, hip joint pathology, or SI joint involvement

FADIR

- tests for impingement, labral tear, intra-articular pathology
- in supine, 90°knee and hip flexion
- clinician passively moves into adduction, then internal rotation to end range
- positive test: pain, locking, clicking, catching
- if test negative, repeat with hip flexed 120°[17]

Flexion-Internal Rotation

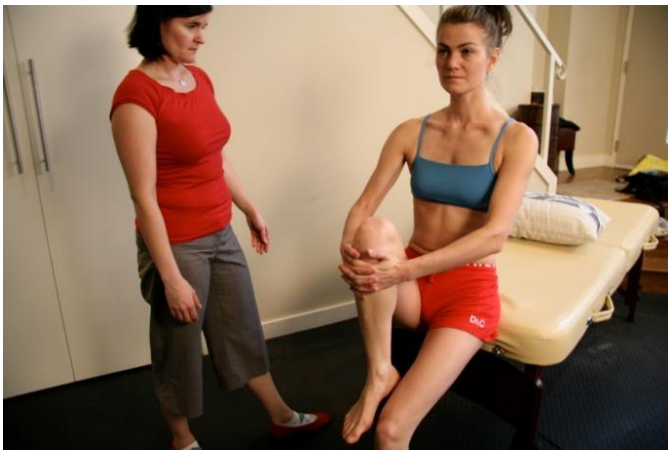
- tests for impingement, labral tear, intra-articular pathology
- in supine, 90°knee and hip flexion
- clinician passively moves into internal rotation to end range
- positive test: pain, locking, clicking, catching

Thomas Test

- tests for hip flexion contracture
- in supine, flex one knee to chest to maintain neutral lumbar curve
- positive test: straight leg lifts off treatment table
- if straight leg rises = flexion contracture; if straight leg abducts = tight iliotibial band

Modified Thomas

- tests rectus femoris shortening / contracture, intra-articular pathology
- in supine, at edge of treatment table, flex one knee to chest to maintain neutral lumbar curve
- normal: thigh stays parallel to trunk, knee flexed 90°
- positive test: pain, painful click





Figures 21 & 22. Modified Thomas Test

Modified Ober's Test

- for shortening of tensor fasciae latae / iliotibial band
- client in side lying with affected side up, bottom hip and knee flexed for stability
- take hip into abduction and extension (top knee straight tensions IT band), lower leg toward floor with leg supported on therapist's forearm
- positive test findings: hip remains abducted, does not fall to the table




Figures 22 & 23. Modified/Ober's Test

Leg Length Discrepancy tests (true vs. functional):

- see SI joint section Figures 12 & 13

Palpation

- completed last to avoid flaring up before finishing assessment
- confirm, localize the lesion by reproduction of pain
- feel for temperature changes, altered muscle tone, swelling, thickening/scars

Case Study #1: Hip Joint Assessment

History:

Age: 53
Pain Location: right proximal medial thigh
Nature of Pain: intermittent
Aggravated by: running (runs on same side of road all the time), hiking, worse in the evening
Relieved by: rest, ibuprofen
Mechanism of injury: slipped on ice while delivering mail 2 weeks ago (stopped themselves from falling)
Occupation: postal worker
Investigations: X-rays clear
General health: good, Dx'd with OA in both knees R > L 5 years ago

Objective:

Observation: slight antalgic gait; one leg stance decreased balance on right; ½ range crouch with more weight bearing through left leg, single leg squat decreased balance on right, mild dynamic knee valgus on right
Neuro: clear
L-sp ROM: slightly decreased flexion, remaining planes full
ROM: flexion and extension ¾ of normal; abduction ½ of normal, ER ½ of normal, IR slightly limited (all movements limited by pain)
Resisted tests: weak and painful adduction, painful and slightly weak IR and flexion
Special tests: ASLR mild asymmetry on right; Positive FABER (decreased ROM and painful), FADIR pain at end range; Ober and modified Thomas decreased ROM

Case Study #2: Hip Joint Assessment

History:

Age: 46
Pain Location: right buttock and lateral hip pain (over greater trochanter)
Nature of Pain: intermittent
Aggravated by: walking, standing, lifting boxes of books, doing chores
Relieved by: rest (watching TV), hot bath
Duration: 1 year
Mechanism of injury: unknown, gradual worsening that may have started after a couple of days doing inventory at work when short staffed
Occupation: book store clerk
Investigations: none
General health: good, sedentary lifestyle
Medications: Tylenol ES

Objective:

Observation: slight antalgic gait, 1/2 range squat, unable to tolerate standing on right leg due to pain
Neuro: clear
L-sp ROM: flexion and extension mildly limited, contralateral SF slightly reduced
ROM: flexion and extension slightly limited; adduction ½ of normal; abduction full; IR ¾ of normal; ER WNL; all movements painful especially IR
Resisted tests: weak and painful abduction, mild discomfort with external rotation
Special tests: ASLR slight asymmetry on right; moderate pain on resisted external de-rotation; positive Ober, modified Thomas; mild pain with FADIR at 120°
Palpation: TOP over area of palpable swelling over greater trochanter and gluteal muscles (med/min esp)

The Knee Joint

Surface Anatomy Exercise:

Locate the following structures on your partner:

- Tibial tuberosity
- Patellar tendon
- Semitendinosus/ semimembranosus
- Knee joint line
- Lateral collateral ligament (LCL)
- Medial collateral ligament (MCL)
- Head of fibula
- Biceps femoris tendon
- Iliotibial band (IT band)
- Vastus medialis obliquus (VMO)
- Popliteal fossa
- Gastrocnemius muscle, medial and lateral heads.

Knee Joint Assessment

A thorough history is likely superior to any physical test in diagnosing common knee injuries[18]. Lachman's is the only test with adequate sensitivity and specificity to rule in or out ACL injury, with no other test able to conclusively stand alone as a diagnostic indicator for any knee condition[18-20]. Diagnostic accuracy decreases with acute injury (synovitis); partial ligament tears; combined injuries[19, 21].

Subjective Examination

Standard History

Mandatory Questions

Special questions

- "Pop" at time of injury? (e.g. ACL)
- clicking, locking (meniscus),
- catching, giving way (knee instability, meniscus pathology, patellofemoral pain)

Objective Examination[3, 16 21-25]

Clinicians should not rely on a single physical exam test when diagnosing other knee joint pathologies[13]

Observation

Posture: position of ease, symmetry of weight bearing, muscle balance/atrophy (quadriceps/VMO, gastrocnemius), swelling, scars (colour, mobility)

Architectural design: patella alta / baja, "squinting" or "frog eyes" patellae, genu Valgus / Varus / recurvatum

Posture Correction

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, pain, swelling, other structural factors e.g. meniscus flap)
- Do their symptoms change?
- What is the effect of their typical shoes on static and dynamic postures?

Function

- gait
- one legged stance (Trendelenburg)
- full squat/crouch on two legs
- single leg partial squat
- jump and land (kissing knees)

Lumbar/Neurological Scan

Lumbar spine lesions can refer symptoms into the thigh and lower leg regions. Therefore, always include lumbar observation, range of motion, neurological assessment and palpation.

Range of Motion

Active ROM: note quality of movement, quantity of movement, willingness to move, pain
(Passive ROM)

"Normal" Range of Motion[11]	
Flexion	135°
Extension	0-15 °
Internal rotation*	20-30°
External rotation*	30-40°

**Knee bent 90°*
Note: evaluate hip and ankle ROM also

Client in supine

- Flexion
- Extension

Resisted Tests

- Note pattern of pain, strength. Keep joint in mid-range position. Start light and progressively increase to maximum strength or limitation due to pain. May test at varying° of flexion.
- Pain on resisted isometric quads test (elicited at 0, 20, 40, 60° flexion?) has Sp 82% for patellofemoral pain syndrome.[24]

Client in supine

- Flexion
- Extension

Client in standing

- Full range plantar flexion, shift from 2 → 1 leg

Special Tests[3]

Valgus stress

- tests integrity of Medial Collateral Ligament
- brace lower leg between examiner's arm and trunk, knee in full extension
- place hand over medial knee joint line for palpation
- apply Valgus stress to knee joint (i.e. lower leg moving laterally)
- palpate medial joint line for gapping
- positive test: gapping and/or pain
- repeat test with knee at 20 – 30° of flexion



Figure 24. Valgus Stress Test

Varus stress

- tests integrity of Lateral Collateral Ligament
- brace lower leg between examiner's arm and trunk, knee in full extension
- place hand over lateral knee joint line for palpation
- apply Varus stress to knee joint (i.e. lower leg moving medially)
- palpate lateral joint line for gapping
- positive test: gapping and/or pain
- repeat test with knee at 20 – 30 of flexion

Anterior drawer:

- tests integrity of ACL
- Sn lower than Lachman's, may be preferable with large knees/small hands/inexperienced examiners
- client in supine with knee at 90° flexion
- stabilize foot by sitting on it
- cup hands around knee with fingers on hamstrings insertion (lumbrical grip) and thumbs on medial and lateral joint lines

- draw tibia toward you
- positive test: greater movement of tibia on affected side, pain
- Note: may give false negative due to protective spasm of hamstring muscles if acute injury; false positive if PCL injury.



Figures 25 & 26. Anterior Drawer Test

Lachman's test:

- tests integrity of the Anterior Cruciate Ligament (ACL)
- Sn 85%, Sp 94%[18 26]
- less painful position than anterior drawer so less likely to have protective muscle spasm
- secondary restraints contribute less to stability in this position than anterior drawer
- client in supine with knee flexed 20- 30□, relaxed
- therapist stabilizes femur with one hand
- grasps tibia below knee with other hand
- move tibia anteriorly (i.e. follow the joint line)
- positive test: gapping and/or pain



Figure 27. Lachman's Test

McMurray's test:

- tests integrity of medial and lateral menisci
- client supine with leg relaxed
- grasp foot firmly and fully flex the knee
- medial compartment: externally rotate foot while slowly extending the knee, add Valgus stress positive if palpable click (likely painful) occurs
- lateral compartment: repeat test with foot internally rotated





Figures 28 & 29. McMurray's Test

Apley's Compression test:

- tests integrity of medial and lateral menisci
- client lies prone with knee flexed to 90°
- grasp the client's foot and rotate knee medially and laterally while compression is applied
- positive test: reproduction of typical pain



Figure 30. Apley's Compression Test

Wipe test (brush, stroke, bulge test):

- tests for minor effusion
- client in supine with leg in extension
- stroke hand proximally along medial side of patella several times (milking fluid laterally)
- follow by stroking distally along lateral side of patella
- look for swelling to traverse the joint and fill the medial side

Palpation

- Localize the lesion by reproduction of pain (e.g. joint line tenderness for possible meniscus lesion).
- Feel for temperature changes, altered muscle tone, pitting edema, deformities.

Case Study #1: Knee Joint Assessment

History:

Age: 24
Pain Location: medial aspect of right knee
Nature of Pain: constant
Aggravated by: weight bearing
Relieved by: ice, pain medication
Duration: 4 hours
Mechanism of injury: playing soccer, opponent fell onto his right leg from the outside, and his knee felt like it bent inward
Occupation: student
Investigations: none
General health: excellent
Medications: Ibuprofen

Objective:

Observation: antalgic gait, using crutches, slight swelling and redness noted medial aspect of knee
Neuro: clear
L-sp ROM: flexion moderately reduced
ROM: flexion ¾ of normal, extension limited about 15° by pain/swelling
Resisted tests: flexion and extension limited by pain (Grade 4)
Special tests: pain and slight laxity on valgus stress testing; pain without laxity Lachman and Anterior Drawer; unable to test McMurray's due to pain; positive wipe test
Palpation: hamstrings increased tone, heat and tenderness over medial joint line

Case Study #2: Knee Joint Assessment

History:

Age: 28
Pain Location: antero-medial aspect of distal thigh, superior to the left knee
Nature of Pain: intermittent
Aggravated by: climbing stairs, squatting
Relieved by: rest
Duration: 3 weeks
Mechanism of injury: playing squash for the first time in over a year, felt a sharp twinge near end of game, unable to finish game
Occupation: insurance broker
Investigations: none
General health: excellent
Medications: none

Objective:

Observation: weight bearing over right leg more so than left in stance; hesitant in single leg stance; ½ range crouch; reluctant to do single leg squat
Neuro: clear
L-sp ROM: WNL
ROM: flexion ½ of normal limited by pain
Resisted tests: extension painful and weak (Grade 3)
Special tests: positive modified Thomas, unable to test McMurray's due to decreased flexion ROM
Palpation: tenderness over distal quads

The Ankle Joint

Surface Anatomy Exercise

Locate the following structures on your partner:

- Medial malleolus
- Lateral malleolus
- Calcaneus
- Deltoid ligament (4 parts)
- Anterior talofibular ligament (ATFL)
- Posterior talofibular ligament (PTFL)
- Calcaneofibular ligament (CFL)
- Achilles tendon
- Longitudinal arch (Medial and Lateral)
- Transverse arch
- Peroneus longus
- Peroneus brevis
- Tibialis posterior tendon
- Flexor digitorum longus tendon
- Flexor hallucis longus tendon
- Tibialis anterior tendon
- Extensor hallucis longus tendon
- Extensor digitorum longus tendon

Ankle Joint Assessment

Subjective Examination

Standard History

Mandatory Questions

Special Questions

- History of “giving way”?
- Use of orthotics?

Objective Examination

Clinicians should not rely on a single physical exam test when diagnosing musculoskeletal injuries.[13]

Observation

Posture: position of ease, symmetry of weight bearing, muscle balance/atrophy, swelling, scars, bruising, soft tissue contour, deformity, compare sides

Architectural design: patellae forward facing and feet slightly outward pointed (~ 5-10°), integrity of longitudinal and transverse arch, Achilles tendon (normal / Varus / Valgus)

Posture Correction:

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, pain, swelling, other structural factors)
- Do their symptoms change?

Function:

- gait with and without shoes (e.g. hobble, walk with flat foot, short stance gait, lack of heel-strike or push-off)
- one legged stance (eyes open, eyes closed, balance time recorded)
- squat
- toe raise / calf raise (e.g. walk on heels / walk on toes)
- stand on lateral edge of the foot (medial and lateral)
- single leg calf raise (6 reps)

Lumbar/Neurological Scan

Lumbar spine lesions can refer symptoms into the thigh and lower leg regions. Therefore always include lumbar observation, range of motion, neurological assessment and palpation.

Range of Motion

Active ROM: note quality of movement, quantity of movement, pain, willingness to move *(Passive ROM)*

"Normal" Range of Motion[11]	
Dorsiflexion	20°
Plantar Flexion	50°
Pronation	15-30°
Supination	45-60°

Client in supine lying and ankle off edge of table:

- Dorsiflexion
- Plantar Flexion
- Pronation
- Supination

Resisted Tests

Note pattern of pain and weakness. Foot is placed in anatomical position. Start light, progressively increase to maximum strength or limitation due to pain.

Client in supine lying with hip flexed to 45^{o} and knee flexed to 90^{o}

- Dorsiflexion
- N.B. plantar flexion done previously as single leg calf raise

Client in supine lying

- Pronation
- Supination

Special Tests

Lateral ligaments

Anterior talofibular – foot relaxed, position hands close to the joint-line, turn foot into plantar flexion and inversion and look for "gapping" (most commonly injured).

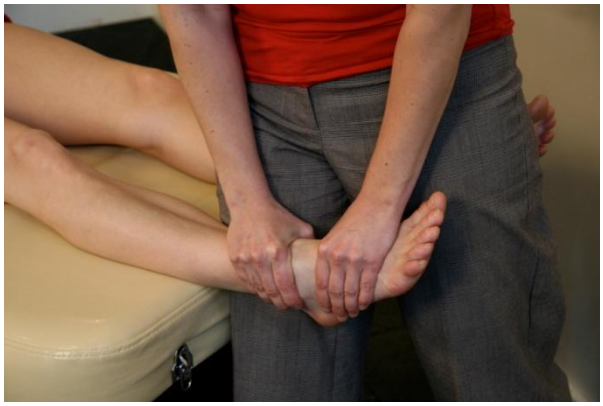


Figure 31. Valgus Stress Test

Calcaneofibular – ankle at 90º angle, position hands close to the joint-line, turn foot into inversion and look for "gapping".

- *Note:* the anterior talofibular and the calcaneofibular ligaments must both be torn to produce gross lateral ankle instability.

Deltoid ligament

- place thumb on ligament, stabilize the leg around the tibia with one hand and grasp / cup the heel with the other hand
- evert the foot
- look for general "gross gaping", note tenderness and pain (eversion injury).

Inferior tibiofibular

- stabilize the patient's leg around the tibia and calcaneus
- evert the foot
- positive if there is "gross gapping" at the joint.
- *note:* the anterior inferior tibiofibular ligament overlies the inferior tibiofibular joint. Clear palpation of the joint is impossible; a slight depression directly over it can be felt.

Anterior Drawer Test

- tests the anterior stability between the tibia and the talus.
- patient sits on edge of examining table with legs dangling (ankle in ~ 20° plantar flexion)
- place one hand on the anterior aspect of the lower tibia
- grip the calcaneus in the palm of your other hand
- draw the calcaneus anteriorly while pushing the tibia posteriorly
- positive if there is forward movement of the talus on tibia
- medial and lateral tear talus typically moves forward
- lateral tear talus turns inward

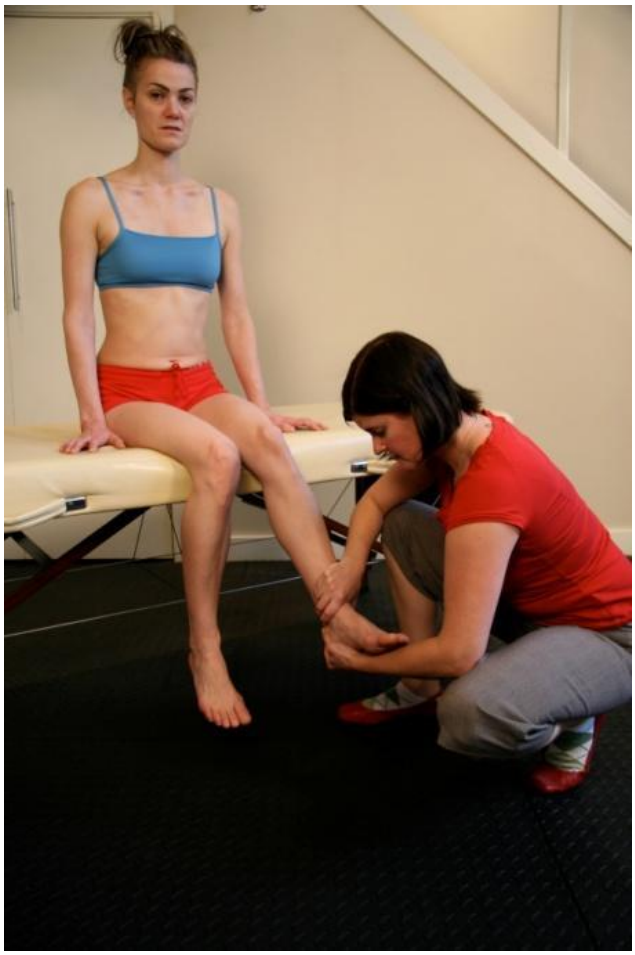


Figure 32. Anterior Drawer Test

Calf squeeze test

- test for continuity of the gastrosoleus muscles' tendon
- patient lies prone with foot hanging over the edge of the bed, or kneeling on a chair
- squeeze the calf at the muscle belly
- should be resultant plantar flexion of the foot
- positive if no plantar flexion occurs or if markedly decreased (suggests tendon tear)

Palpation

- localize the lesion by reproduction of pain.
- feel for temperature changes, altered muscle tone, pitting edema, deformities.

Case Study #1: Ankle Joint Assessment

History:

Age: 32
Pain location: right lateral ankle/foot
Nature of pain: constant
Aggravated by: prolonged standing, walking, hiking
Relieved by: rest, wearing their new running shoes
Duration: 1 week
Mechanism of injury: drank too much last weekend, thinks they might have gone over on their high heel while walking home at the end of the night
Occupation: retail
Investigations: none
General health: excellent
Medication: asthma inhaler PRN (rarely use)

Objective:

Observation: flat feet bilaterally, slight puffiness over right lateral malleolus, slight yellow colouring lateral foot
Neuro: clear
L-sp ROM: WNL
ROM: moderately limited in inversion (end range pain), slightly limited in eversion, moderately limited in plantarflexion (end range pain), slightly limited in dorsiflexion
Resisted tests: strong
Special tests: pain and increased laxity ATFL, pain and increased laxity on anterior drawer
Palpation: tenderness over lateral foot just anterior to lateral malleolus

Case Study #2: Ankle Joint Assessment

History:

Age: 52
Pain location: back of calf
Nature of pain: intermittent
Aggravated by: walking
Relieved by: not doing anything, ice
Duration: 4 days
Mechanism of injury: running across street to make the light with their daughter
Occupation: computer programming
Investigations: none
General health: overweight, sedentary lifestyle, long standing back pain problems
Medication: Synthroid

Objective:

Observation: antalgic gait, wearing flip flops, flat feet, increased lumbar lordosis, some bruising down to foot
Neuro: general weakness on all myotome tests
ROM: slightly limited in dorsiflexion (end range pain), slight pain but full range in plantarflexion
Resisted tests: painful weakness in plantar flexion
Special tests: all normal
Palpation: tenderness over medial belly of gastrocnemius at musculotendinous junction

The Shoulder Joint

Surface Anatomy Exercise

Locate the following structures on your partner:

- Scapula (spine, acromion, medial margin, inferior angle)
- Humerus (lesser tubercle, greater tubercle, deltoid tuberosity)
- Clavicle (distal end, proximal end)
- Manubrium of the sternum
- T1, T3, T4, T7, T8 vertebrae (spinous processes)
- Tendon of long head of biceps (see palpation section below for details)
- Supraspinatus (see palpation section below for details)
- Infraspinatus (see palpation section below for details)
- Teres minor
- Subscapularis
- Glenohumeral joint
- Acromioclavicular joint
- Sternoclavicular joint
- Shoulder girdle (4 components)

Shoulder Joint Assessment

It is important to understand that the glenohumeral joint does not move in isolation. In raising the arm through flexion and elevation, movement occurs in several areas of the shoulder girdle. Problems in any of these areas may cause the client pain and/or limitation in ROM at the glenohumeral joint. The significance of the cervical spine and its frequent involvement in the presence of shoulder problems has already been discussed in the cervical section.

Subjective Examination

Standard History

- Pain is usually located in the deltoid muscle region.
- Pain at the trapezius muscle or at the scapular region is usually indicative of cervical spine involvement.

Mandatory Questions

Special Questions

- Can client lie / sleep on the affected side?
- Did client fall on an outstretched hand?
- Does the limb tire easily?
- Swelling or stiffness in the limb which may extend to the fingers?
- Which hand is dominant?

Objective Examination

Clinicians should not rely on a single physical exam test when diagnosing musculoskeletal injuries.[13]

Observation

Posture: position of ease, muscle balance/atrophy, muscle girth (athletes), swelling, scars, bruising, skin colour, soft tissue contour, step deformity, way arm is held (close to side or across chest), bony structures, shoulder levels, position / alignment of neck, shoulders and scapulae (winging)

Posture Correction:

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, pain, localized or diffuse swelling, other structural factors)
- Do their symptoms change?

Function:

- Functional use of the arm during gait / dressing / activity
- Apley scratch test: client standing, examiner stands behind the client and notes vertebral levels for comparison of sides, looks for limitation of motion and breaks in normal rhythm or symmetry. Observe and record the spinous process level that the client can reach:
  - HBH ("Hand Behind Head" tests flexion, abduction and external rotation) – client reaches behind the head and aims for the superior angle of the opposite scapula
  - HBB ("Hand Behind Back" tests extension, adduction and internal rotation) – client reaches behind the back and aims for the inferior angle of the opposite scapula

Cervical/Neurological Scan

Cervical spine lesions can refer symptoms into the shoulder and arm regions. Therefore, always include cervical observation, range of motion, neurological assessment and palpation.

Range of Motion

Active ROM: note quality of movement, quantity of movement, pain, willingness to move, painful arc with abduction

(Passive ROM)

"Normal" Range of Motion[11]	
Flexion	180°
Extension	45°
Abduction	180°
Adduction	45°
Internal rotation	55°
External rotation	40-45°

Client in standing

- Flexion (to elevation)
- Extension
- Abduction
- Horizontal Adduction
- Internal Rotation
- External Rotation
- **Painful arc of shoulder**: if pain is present due to impingement, may be reported by the client between 70 to 120^{o} of shoulder abduction during any AROM test
- **4 Point Palpation of Scapula**
  - patient in standing, examiner standing behind.
  - use thumb and middle finger to locate posterolateral corner of acromion and antero-lateral edge of acromion.
  - opposite hand thumb and index finger locate inferior angle of scapula and medial end of spine of scapula.
  - visualize orientation of scapula and note any asymmetry relative to other side.
  - also note resting position of scapula (neutral, up vs. downward rotation, medial vs. lateral tilt).

- **Scapulohumeral rhythm:** it should be noted that observing scapulohumeral rhythm on its own is not a stand-alone assessment tool. The observations made should be confirmed with other objective tests[27]
  - abduction of the arm occurs in the glenohumeral joint and the scapulothoracic articulation in a 2:1 ratio. For every 3° of abduction at the shoulder, 2° occurs at the glenohumeral joint and 1° occurs at the scapulothoracic articulation.
  - at the shoulder to achieve 180° of elevation through abduction, 120° of movement occurs at the glenohumeral joint and 60° occurs at the scapulothoracic joint[3].
  - to perform the test, have the examiner stand behind the client anchoring the scapula by holding / pinching the inferior angle, ask the client to "slowly" abduct the arm, scapula should not move until the arm is abducted to ~20°, at 20° the humerus and scapula move together in a 2:1 ratio to full abduction.



Figure 33. Scapulohumeral Rhythm

  - observe movement in the ascending and descending phase, typically weakness of the scapular stabilizing muscles is more visible during the descent phase
  - compare sides, look for symmetry. Consider placing small weights (<5lb) in the client's hands and re-test. Loading the muscles with light weight can help with muscle activity during elevation.
  - frozen shoulder (adhesive capsulitis) – glenohumeral joint does not move in its normal ratio (humerus is fixed in adduction), client will compensate by shrugging the shoulder to nearly 90° of abduction using the scapulothoracic motion (a visible "hike" of the entire shoulder complex versus a smooth and coordinated movement of abduction)

Resisted Tests

- Note pattern of pain and weakness. Start light, progressively increase to maximum strength or limitation due to pain. Performed with arm bent to 90°.

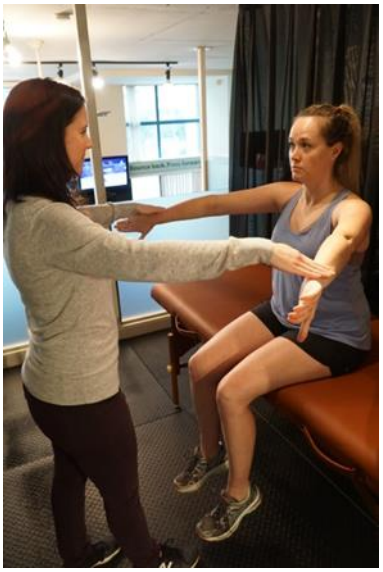
Client in sitting with elbow flexed mid-range

- Flexion of elbow in mid-range
- Extension of elbow in mid-range
- Abduction with bent elbows
- Adduction with bent elbows
- Internal rotation with bent elbow and arms at sides
- External rotation with bent elbow and arms at sides

Special Tests[3]

Empty/Full Can Test

- client's arm abducted to 90 ° in scapular plane
- test resisted abduction with thumbs pointing up (full can – thought to elicit maximal rotator cuff muscle activity), repeat with thumbs pointing down
- positive test: weakness and/or pain in both tests, may indicate tear/pathology of supraspinatus tendon
- pain in empty can position only: patient likely to be suffering from impingement symptoms, not necessarily pathology of supraspinatus/rotator cuff[16]





Figures 33 & 34. Empty/Full Can Tests

Wall Push-up Test

- client stands facing a wall with hands on the wall at shoulder height
- client performs a push-up at the wall
- examiner looks for winging of the medial border and/or inferior angle of the scapula

Drop Arm Test

- detects complete tear in the rotator cuff (especially supraspinatus)
- client abducts the affected arm to 90º, examiner observes scapulohumeral rhythm
- client then slowly lowers the arm to their side
- if client is able to hold the arm in abduction, gently tap the arm.
- positive test: client is unable to slowly lower the arm, therefore the arm drops to the side. Or severe pain when attempting to lower the arm slowly. Or arm falls with gentle tap from examiner

Hawkins-Kennedy Test

- tests for anterior shoulder impingement
- client in standing
- examiner forward flexes the arm to 90° and medially rotates the shoulder
- positive finding: reproduction of client's pain
- test can be performed in varying° of forward flexion or horizontal adduction



Figure 35. Hawkins-Kennedy Test

Anterior Apprehension Test

- tests for chronic shoulder dislocation
- client ideally in supine lying, examiner places one hand over glenohumeral joint for palpation
- examiner abducts the arm to 90° and externally rotates the client's arm slowly to a position towards the direction of instability (use caution, do not dislocate shoulder!)
- positive finding: a look of apprehension on the client's face and resistance to further movement

Palpation

- localize the lesion by reproduction of pain.
- feel for temperature changes, altered muscle tone, pitting edema, deformities.

Supraspinatus Tendon

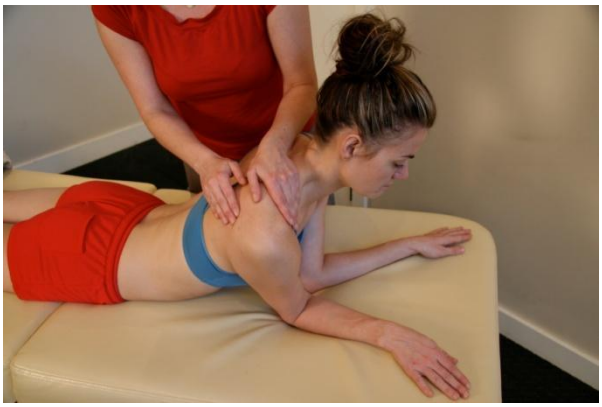
- client places arm behind the back (HBB)
- tendon is placed on a stretch in medial rotation and adduction
- palpate tendon anteriorly and inferiorly to the anterior border of the acromion



Figure 36. Palpation of Supraspinatus Tendon

Infraspinatus Tendon

- client in prone lying propped up on elbows
- position elbows as close together as possible and grab edges of the plinth (shoulder external rotation)
- shoulder is placed in an adducted and lateral rotation position
- palpate tendon just below the most lateral part of the spine on the scapula





Figures 37 & 38. Palpation of Infraspinatus Tendon

Biceps Tendon

- stand behind the client
- palpate long head of biceps in bicipital groove between greater and lesser tuberosities
- with arm flexed and hand supinated externally rotate the shoulder to easily palpate the tendon
- to confirm location of the tendon resist flexion and supination

Case Study #1: Shoulder Assessment

History:

Age: 45
Pain Location: right shoulder
Nature of Pain: intermittent
Aggravated by: overhead reaching, washing hair, driving, sleeping on right side
Relieved by: Ibuprofen
Duration: 3 months
Mechanism of injury: don't recall
Occupation: electrician at a university (maintains lights on campus)
Investigations: none
General health: good, sedentary lifestyle
Medications: none

Objective:

Observation: holds right shoulder in guarded/elevated position, rounded shoulders, HFP; poor scapulohumeral rhythm
Neuro: painful ULNT1 on right
C-sp ROM: decreased cervical left side flexion, right rotation
ROM: slightly decreased flexion, moderately decreased abduction (painful arc), Apley's scratch test both directions painful,
Resisted tests: pain limited weakness in abduction, flexion, external rotation
Special tests: pain with empty can to adopt the position, positive Hawkins Kennedy
Palpation: tenderness on palpation of supraspinatus tendon

Case Study #2: Shoulder Assessment

History:

Age: 29
Pain Location: right shoulder and shoulder blade
Nature of Pain: intermittent
Aggravated by: prolonged reading, computer work
Relieved by: Ibuprofen, lying supine
Duration: 1 month
Mechanism of injury: read-ended in MVA one month ago – patient queries if seatbelt caused this?
Occupation: teacher (elementary school)
Investigations: none
General health: good, runs regularly
Medications: none

Objective:

Observation: slouched, rounded shoulders, right shoulder lower than left; poor SH rhythm (decreased scapular abduction on right during elevation)
Neuro: positive ULNT1 on right (increased shoulder pain, slightly decreased ROM)
C-sp ROM: decreased cervical left side flexion, right rotation
ROM: slightly decreased in all movements, pain throughout most movements
Resisted tests: fatigable weakness in shoulder girdle elevation and shoulder abduction on right
Special tests: clear
Palpation: increased muscle tone and tenderness bilateral upper fibre traps and levator scapulae

The Elbow Joint

Surface Anatomy Exercise

Locate the following structures on your partner:

- Medial epicondyle
- Lateral epicondyle
- Medial supracondylar line of humerus
- Lateral supracondylar line of humerus
- Olecranon
- Olecranon fossa
- Radial head
- Wrist flexor group (6 muscles – name these)
- Wrist extensor group (5 muscles – name these)
- Humeroulnar joint
- Humeroradial joint
- Proximal radioulnar joint
- Ulnar nerve

Elbow Joint Assessment

Subjective Examination

Standard History

Mandatory Questions

Special Questions

- locking or clicking (e.g. loose bodies)
- crepitus (e.g. arthritis)
- direct blow to the elbow or lower arm (rule out fracture)
- longitudinal pull on the arm in young children (i.e. pulled elbow)
- hand dominance

Objective Examination

Clinicians should not rely on a single physical exam test when diagnosing musculoskeletal injuries.[13]

Observation

Posture: position of ease, muscle balance/atrophy, muscle girth (athletes), swelling, scars, bruising, soft tissue contour, deformity, way arm is held, bony structures, position / alignment of neck and shoulder

Architectural design: isosceles triangle in elbow flexion, carrying angle in anatomical position (valgus carrying angle: male 5-10^{o}, female 10-15^{o})[3]



Figure 39. Carrying angle of the elbow

Posture Correction

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, pain, localized or diffuse swelling, other structural factors)
- Do their symptoms change?

Function

- Functional use of the arm during gait / dressing / activity

Cervical/Neurological Scan

Cervical spine lesions can refer symptoms into the arm regions. Therefore, always include cervical observation, range of motion, neurological assessment and palpation.

Range of Motion

Active ROM: note quality of movement, quantity of movement, pain, willingness to move *(Passive ROM*)

"Normal" Range of Motion[11]	
Flexion	140-150°
Extension	0-10° hyper
Pronation	80-90°
Supination	90°

Client in sitting or standing

- Flexion (palm up)
- Extension (palm up)
- Pronation (elbow 90^{o}, closed fist holding pencil)
- Supination (elbow 90^{o}, closed fist holding pencil)

Resisted Tests

Note pattern of pain and weakness. Start light, progressively increase to maximum strength or limitation due to pain.

Client in sitting with elbow flexed mid-range and palm up:

- Flexion
- Extension

Client in sitting, elbow flexed to 90^{o}, forearm in approximately neutral, grasp forearm:

- Pronation
- Supination

Special Tests[3]

Valgus Stress Test

- tests the integrity of the medial collateral ligament
- client's elbow in full extension, forearm in supination
- brace forearm between examiner's arm and trunk
- place fingers over medial joint line for palpation
- apply valgus stress to elbow joint (i.e. forearm moving laterally)
- palpate medial joint line for gapping
- positive test: gapping and/or pain
- repeat test with elbow at 20-30 of flexion

Varus Stress Test

- tests the integrity of the lateral collateral ligament
- client's elbow in full extension, forearm in supination
- brace forearm between examiner's arm and trunk
- place fingers over lateral joint line for palpation
- apply Varus stress to elbow joint (i.e. forearm moving medially to reduce carrying angle)
- palpate lateral joint line for gapping
- positive test: gapping and/or pain
- repeat test with elbow at 20-30 of flexion

Tinel Sign

- designed to elicit tenderness over a neuroma within a nerve
- arm slightly abducted, elbow slightly bent, and wrist in supination
- ulnar nerve tap at the elbow: **t**ap the area of the nerve in the groove between the olecranon and medial epicondyle
- positive: production of a tingling sensation down the forearm in the ulnar nerve distribution

Tennis Elbow Test

- designed to reproduce the pain of forearm extensor tendinopathy
- elbow bent to 90^{o}, forearm pronated
- stabilize client's forearm
- test resisted wrist extension by applying pressure with free hand over the dorsum of client's fist
- positive: reproduction of client's pain just distal to the lateral epicondyle

Golfer's Elbow Test

- designed to reproduce the pain of forearm flexor tendinopathy
- elbow bent to 90^{o}, forearm supinated
- stabilize client's forearm
- test resisted wrist flexion by applying pressure with free hand over volar aspect of the client's fist
- positive: reproduction of client's pain just distal to the medial epicondyle

Palpation

- Localize the lesion by reproduction of pain.
- Feel for temperature changes, altered muscle tone, pitting edema, deformities.

Case Study #1: Elbow Assessment

History:

Age: 55
Pain Location: right medial elbow with tingling down medial border of forearm into 4th and 5th digits
Nature of Pain: constant
Aggravated by: any arm movements
Relieved by: Ibuprofen
Duration: 2 weeks
Mechanism of injury: walking a friend's dog, dog bolted towards another dog and pulled their arm behind them
Occupation: office worker
Investigations: X-ray clear
General health: diabetic
Medical History: MVA 8 months ago, occasional headaches and persistent neck pain
Medications: none

Objective:

Observation: holding arm slightly flexed and held close to body, head forward posture
Neuro: increased reflex C7 on right, unable to test all myotomes due to pain limitation at elbow, ULNT1 reproduces mild tingling
C-sp ROM: WNL
ROM: elbow flexion 135° and extension full, both with end range pain, pronation/supination full, discomfort in supination
Resisted tests: painful around elbow joint and weak with all resisted tests
Special tests: pain but no laxity on valgus stress testing; Positive Tinel's for reproduction of tingling over ulnar nerve; pain with Golfer's test
Palpation: TOP medial elbow

Case Study #2: Elbow Assessment

History:

Age: 30
Pain Location: dorsum of right wrist and forearm
Nature of Pain: intermittent
Aggravated by: typing, opening jars, lifting and carrying objects
Relieved by: rest, Tylenol, heat
Duration: 4 months
Mechanism of injury: dryer broke down and had to wring whole family's laundry for 2 weeks (has young children)
Occupation: homemaker
Investigations: none
General health: good, sedentary
Medications: birth control, asthma inhaler (rarely uses)

Objective:

Observation: guarded movement, protecting hand
Neuro: clear
C-sp ROM: WNL
ROM: all elbow movements WNL; wrist flexion limited to ½ when elbow extended, only slightly limited with elbow flexed
Resisted tests: painful weakness of wrist extensors
Special tests: positive Tennis Elbow test
Palpation: TOP over lateral epicondyle and less so along wrist extensors

The Wrist and Hand

Surface Anatomy Exercise

Locate the following structures on your partner:

- Radius and ulnar styloid processes
- Anatomical snuff box. What forms its borders and floor?
- Bones of the hand
- Carpal tunnel (extends from the pisiform to the navicular proximally and from the hook of hamate to the trapezium distally). What significant structure travels within the carpal tunnel?

Wrist and Hand Assessment

Subjective Examination

Standard History

Mandatory Questions

Special questions

- dominant hand
- cold sensitivity
- dropping held objects
- tingling/pins and needles (and pattern, e.g. first three digits)

Objective Examination

Clinicians should not rely on a single physical exam test when diagnosing musculoskeletal injuries.[13]

Observation

Posture: position of ease, deformity, swelling (wrinkles), discolouration, skin temperature, sweating, skin quality (e.g. waxy, thin), muscle balance/atrophy, scars, nails, hair growth, calluses, fat pads on fingertips

Posture Correction

- Are they able to adopt better positioning? If not, why? (short muscles, weakness, pain, swelling, joint stiffness, other structural factors)
- Do their symptoms change?

Function

- taking off coat, spontaneous use of hand
- fist
- tuck
- opposition
- spread (extension/abduction)

Cervical/Neurological Scan

Cervical spine lesions can refer symptoms into the forearm and hand. Therefore, always include cervical observation, range of motion, neurological assessment and palpation.

Range of Motion

Active ROM: note quality of movement, quantity of movement, pain, willingness to move *(Passive ROM*)

"Normal" Range of Motion[11]	
Pronation	90°
Supination	90°
Wrist Flexion	80°
Wrist Extension	70 °
Radial deviation	20°
Ulnar deviation	30°

Client in sitting, hands on a table or pillow on lap

- Forearm pronation
- Forearm supination
- Wrist flexion
- Wrist extension
- Radial deviation
- Ulnar deviation
- Flexion/extension of IP and MCP joints

Resisted Tests

- Note pattern of pain, strength. Keep each joint in mid-range position, start light, progressively increase to maximum strength or limitation due to pain.

Client in sitting, hands on a table or pillow on lap

- Forearm pronation
- Forearm supination
- Wrist flexion
- Wrist extension
- Radial deviation
- Ulnar deviation
- Squeeze therapist's fingers (dynamometer more accurate)
- (individual fingers/thumbs)

Special Tests

Phalen's test

- confirmation of carpal tunnel syndrome
- flexion of the client's wrists one against the other at maximum ROM
- hold position for 1 minute
- positive finding: tingling in median nerve distribution (note time of onset of symptoms to determine irritability)

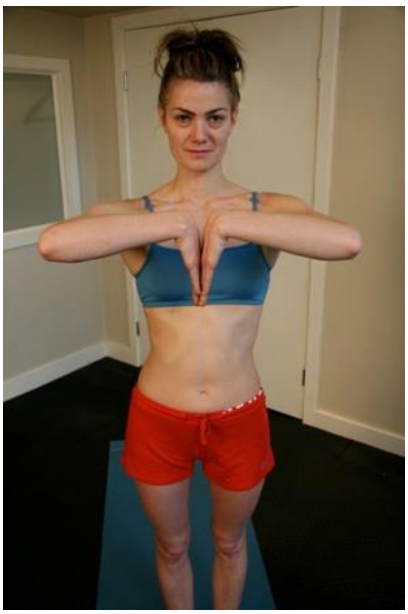


Figure 40. Phalen's Test

Tinel's sign

- confirmation of carpal tunnel syndrome
- therapist taps over the median nerve at the carpal tunnel
- positive finding: tingling in median nerve distribution

Finkelstein's test

- confirmation of De Quervain's tenosynovitis
- client makes fist with thumb tucked inside fingers
- therapist passively deviates hand ulnarly
- positive finding: pain over EPB or AbPL tendons

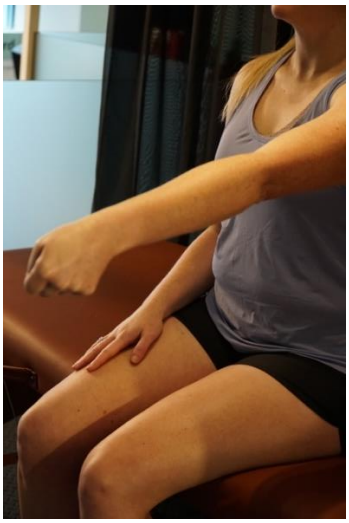


Figure 41. Finkelstein's Test

Allen capillary refill test

- tests the integrity of the radial and ulnar arteries supplying the hand
- client opens and closes fist rapidly and repeatedly, then squeezes hand in fist
- therapist presses thumbs over radial and ulnar arteries to occlude blood flow
- client opens hand while therapist still occluding arteries
- palm will appear pale
- therapist releases one of the arteries.
- hand should flush immediately
- repeat test, this time releasing the other artery first
- positive finding: slow flushing of hand (more than 2 seconds)

Palpation

- localize the lesion by reproduction of pain.
- feel for pulses, temperature changes, altered muscle tone, ganglion cysts, scar adhesions.

Case Study #1: Wrist Assessment

History:

Age: 32
Pain Location: base of left thumb
Nature of Pain: intermittent
Aggravated by: weight bearing, most wrist activities
Relieved by: rest
Duration: 1 month
Mechanism of injury: FOOSH at home (tripped over child's toys)
Occupation: homemaker
Investigations: none
General health: excellent
Medications: insulin

Objective:

Observation: guarded position, warm over base of thumb, slight swelling noted
Neuro: pain and slight decrease ROM on ULNT1 on left
C-sp ROM: WNL
ROM: all movements about 1/3 of normal, limited by pain
Resisted tests: painful weakness of EPL, EPB, hesitant in all wrist directions with pain on radial deviation
Special tests: Positive Finkelstein's; unable to test Phalen's due to pain
Palpation: tenderness over base of thumb

Case Study #2: Wrist Assessment

History:

Age: 30
Pain Location: right wrist
Nature of Pain: constant but fluctuates (also occasional neck/shoulder pain bilaterally)
Aggravated by: nursing, holding children, typing, opening jars, lifting and carrying objects, pain at night
Relieved by: rest, heat, painkillers
Duration: 6 months
Mechanism of injury: new mom (nursing twins)
Occupation: Homemaker
Investigations: none
General health: good, no formal exercise regime
Medications: none

Objective:

Observation: guarded movement, protecting hand
Neuro: mildly reduced ROM on ULNT1, slightly weak grip strength on right
C-sp ROM: slightly reduced in all directions, neck pain with neck flexion
ROM: elbow flexion/extension WNL; wrist ROM slightly decreased all movements due to pain
Resisted tests: pain and slight weakness in wrist flexion; (weak thumb abduction)
Special tests: Positive Phalen's – reproduces symptoms after 5 seconds; positive Tinel's over carpal tunnel
Palpation: tight forearm flexors and extensors on right

Answers to Case Studies

Case Study #1: Cervical Spine

Right C6 nerve root involvement, mechanical pain with postural changes, should refer to a physician

Case Study #2: Cervical Spine

Mechanical neck pain secondary to poor ergonomic setup at work

---

Case Study #1: Thoracic Spine

Contusion to soft tissues around right ribs 9-10

Case Study #2: Thoracic Spine

Functional scoliosis brought on by leg length discrepancy

Case Study #1: Lumbar Spine

Likely a disc injury affecting the S1 nerve root, should refer back to physician

Case Study #2: Lumbar Spine

General deconditioning, mechanical low back pain relating to many years of repetitive work involving slight sustained forward bending; x-rays later revealed Grade II spondylolisthesis

---

Case Study #1: The Hip

This client had a Grade II muscle strain to the adductor muscles, subacute phase. Query possible OA of the hip joint.

Case Study #2: The Hip

This client had greater trochanteric bursitis and Grade 1 gluteal tendinopathy.

Case Study #1: The Knee

This client had an acute Grade II MCL sprain with query for ACL sprain, meniscus.

Case Study #2: The Knee

This client had a Grade II quadriceps muscle strain.

Case Study #1: The Ankle

This client had a Grade II ATFL ligament sprain, acute/subacute phase.

Case Study #2: The Ankle

This client had a Grade II muscle strain of the medial belly of gastrocnemius muscle, acute phase.

Case Study #1: The Shoulder

This client had poor posture and lifestyle factors (job requires significant overhead work) that led to an overuse type injury. Essentially this client had developed supraspinatus tendonitis/impingement.

Case Study #2: The Shoulder

This client is likely presenting with referred pain from a whiplash-type neck injury that seems to be affecting C4 and C5 nerve roots.

Case Study #1: The Elbow

This client seems to have a Grade I medial collateral ligament sprain with irritation to the ulnar nerve as well as irritation to the forearm flexors. The irritation could be secondary to an actual overstretching of the ulnar nerve and local musculature (i.e. strained muscle) or it could be secondary to the inflammation that followed the valgus stress to the MCL. Difficult to determine at this time due to pain limitations during assessment.

Case Study #2: The Elbow

This client had an extensor tendinopathy**.**

Case Study #1: The Wrist/Hand

This client had a scapholunate ligament sprain. Differential diagnoses could include:

- De Quervain's (EPL would not be weak and painful, and tenderness would be over tendon's only, not the bones as in this case)
- Carpal Tunnel Syndrome (thumb abductors would be weak, also history not consistent with this condition)
- 1st CMC OA (though unlikely to have acute heat/swelling)
- Tendonosis
- Scaphoid fracture (send for X-rays to rule out?)

Case Study #2: The Wrist/Hand

This client had carpal tunnel syndrome.

References

1. Cyriax JH. *Diagnosis of soft tissue lesions*: Baillière Tindall, 1978.
2. Clarkson HM. *Musculoskeletal assessment: joint range of motion and manual muscle strength*: Lippincott Williams & Wilkins, 2000.
3. Magee DJ. *Orthopedic physical assessment. Sixth Ed.*: Elsevier Health Sciences, 2014.
4. Kendall FP, McCreary EK, Provance P. Muscle testing snd function: Philadelphia: Lippincott Williams & Wilkins, 1993.
5. Page P, Frank C, Lardner R. *Assessment and treatment of muscle imbalance: the Janda approach*: Human kinetics, 2010.
6. Goodman CC, Fuller KS. *Pathology: implications for the physical therapist*: Elsevier Health Sciences, 2014.
7. Damjanov I. *Pathology for the health-related professions*: WB Saunders Company, 2000.
8. Snell R. The ANS: Clinical neuroanatomy for Medical Students: Washington DC: Lippincott Williams & Wilkins, 2001.
9. Moore KL, Agur AM, Dalley AF. *Essential clinical anatomy*: Lippincott Williams & Wilkins Philadelphia, 2002.
10. Hertling D, Kessler RM. *Management of common musculoskeletal disorders: physical therapy principles and methods*: Lippincott Williams & Wilkins, 2006.
11. Hoppenfeld S. *Physical Examination of the Spine and Extremities*. East Norwalk, CT: Prentice Hall, 1976.
12. Waddell G, McCULLOCH JA, Kummel E, Venner RM. Nonorganic physical signs in low-back pain. *Spine* 1980;5(2):117-25.
13. Reiman MP, Goode AP, Hegedus EJ, Cook CE, Wright AA. Diagnostic accuracy of clinical tests of the hip: a systematic review with meta-analysis. *British Journal of Sports Medicine* 2013;47(14):893-902.
14. Reiman M, Goode A, Cook C, Hölmich P, Thorborg K. Diagnostic accuracy of clinical tests for the diagnosis of hip femoroacetabular impingement/labral tear: a systematic review with meta-analysis. *British Journal of Sports Medicine* 2014:bjsports-2014-094302.
15. Reiman MP, Mather RC, Cook CE. Physical examination tests for hip dysfunction and injury. *British Journal of Sports Medicine* 2015;49(6):357-61.
16. Brukner P, Khan K. *Brukner & Khan's Clinical Sports Medicine: Injuries*: McGraw-Hill

Education Australia, 2016.

17. Ratzlaff C, Simatovic J, Wong H, Li L, Ezzat A, Langford D, et al. Reliability of hip examination tests for femoroacetabular impingement. *Arthritis care & research* 2013;65(10):1690-96.

18. Décary S, Ouellet P, Vendittoli P-A, Roy J-S, Desmeules F. Diagnostic validity of physical examination tests for common knee disorders: An overview of systematic reviews and meta-analysis. *Physical Therapy in Sport* 2017;23:143-55.

19. Speziali A, Placella G, Tei MM, Georgoulis A, Cerulli G. Diagnostic value of the clinical investigation in acute meniscal tears combined with anterior cruciate ligament injury using arthroscopic findings as golden standard. *Musculoskeletal surgery* 2016;100(1):31-35.

20. Abulhasan JF, Snow MD, Anley CM, Bakhsh MM, Grey MJ. An extensive evaluation of different knee stability assessment measures: A systematic review. *Journal of Functional Morphology and Kinesiology* 2016;1(2):209-29.

21. Cook C, Mabry L, Reiman MP, Hegedus EJ. Best tests/clinical findings for screening and diagnosis of patellofemoral pain syndrome: a systematic review. *Physiotherapy* 2012;98(2):93-100.

22. Sweitzer BA, Cook C, Steadman JR, Hawkins RJ, Wyland DJ. The inter-rater reliability and diagnostic accuracy of patellar mobility tests in patients with anterior knee pain. *The Physician and sportsmedicine* 2010;38(3):90-96.

23. Hegedus EJ, Cook C, Hasselblad V, Goode A, Mccrory DC. Physical examination tests for assessing a torn meniscus in the knee: a systematic review with meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy* 2007;37(9):541-50.

24. Cook C, Hegedus E, Hawkins R, Scovell F, Wyland D. Diagnostic accuracy and association to disability of clinical test findings associated with patellofemoral pain syndrome. *Physiotherapy Canada* 2010;62(1):17-24.

25. Kastelein M, Wagemakers HP, Luijsterburg PA, Verhaar JA, Koes BW, Bierma-Zeinstra SM. Assessing medial collateral ligament knee lesions in general practice. *The American journal of medicine* 2008;121(11):982-88. e2.

26. Benjaminse A, Gokeler A, van der Schans CP. Clinical diagnosis of an anterior cruciate ligament rupture: a meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy* 2006;36(5):267-88.

27. Wassinger CA, Williams DA, Milosavljevic S, Hegedus EJ. Clinical reliability and diagnostic accuracy of visual scapulohumeral movement evaluation in detecting patients with shoulder impairment. International journal of sports physical therapy 2015;10(4):456

Appendix A: History Taking Template (example)

Name:	**Date:**
Pain	
Location	Constant / Intermittent
Duration	Easing factors
Quality	Aggravating factors
Mechanism of injury Work / ADL's / Leisure / Sport	
Treatments to date Effect Investigations to date Medications Previous Surgeries General Health	
Red flags Y / N Recent unexplained weight-loss Y / N Night pains / night sweats Y / N Bladder or bowel function Y / N Saddle area paresthesia / anesthesia Y / N Bilateral / quadrilateral paraesthesia / anesthesia Y / N Neuro signs and symptoms (e.g. nystagmus, perioral numbness)	
Special questions e.g. Dizziness, Diplopia, Dysarthria, Dysphagia, Drop Attacks	

Appendix B: Goniometer Landmarks

Shoulder	
Flexion	**180°**
Axis	center of humeral head from lateral aspect
Stationary Arm	parallel to lateral midline of trunk
Moving Arm	parallel to longitudinal axis of humerus
Extension	**45°**
Axis	center of humeral head from lateral aspect
Stationary Arm	parallel to lateral midline of trunk
Moving Arm	parallel to longitudinal axis of humerus
Abduction	**180°**
Axis	posterior axis of glenohumeral joint
Stationary Arm	parallel to spine
Moving Arm	parallel to longitudinal axis of humerus
Horiz. Adduction	**45°**
Axis	on top of acromion process
Stationary Arm	perpendicular to trunk
Moving Arm	parallel to longitudinal axis of humerus
Elbow	
Flexion	**150°**
Axis	lateral epicondyle of humerus
Stationary Arm	parallel to longitudinal axis of humerus
Moving Arm	parallel to longitudinal axis of radius
Extension	**0°**
Axis	lateral epicondyle of humerus
Stationary Arm	parallel to longitudinal axis of humerus
Moving Arm	parallel to longitudinal axis of radius

Hip	
Flexion	**120°**
Axis	greater trochanter of femur
Stationary Arm	parallel to mid-axillary line of trunk
Moving Arm	parallel to longitudinal axis of femur
Extension	**30°**
Axis	greater trochanter of femur
Stationary Arm	parallel to mid-axillary line of trunk
Moving Arm	parallel to longitudinal axis of femur
Abduction	**45°**
Axis	ASIS on side being measured
Stationary Arm	along a line between both ASIS's
Moving Arm	parallel to the longitudinal axis of femur
Adduction	**30°**
Axis	ASIS on side being measured
Stationary Arm	along a line between both ASIS's
Moving Arm	parallel to the longitudinal axis of femur
IR	**35°**
Axis	over midpoint of patella
Stationary Arm	perpendicular to floor
Moving Arm	parallel to anterior midline of tibia
ER	**45°**
Axis	over midpoint of patella
Stationary Arm	perpendicular to floor
Moving Arm	parallel to anterior midline of tibia

Knee	
Flexion	**135°**
Axis	lateral epicondyle of femur/knee joint line
Stationary Arm	parallel to longitudinal axis of femur
Moving Arm	parallel to longitudinal axis of fibula
Extension	**10° (past horizontal)**
Axis	lateral epicondyle of femur/knee joint line
Stationary Arm	parallel to longitudinal axis of femur
Moving Arm	parallel to longitudinal axis of fibula
Ankle	
Dorsiflexion	**20°**
Axis	inferior to lateral malleolus
Stationary Arm	parallel to longitudinal axis of fibula
Moving Arm	parallel to 5th metatarsal
Plantarflexion	**50°**
Axis	Inferior to lateral malleolus
Stationary Arm	parallel to longitudinal axis of fibula
Moving Arm	parallel to 5th metatarsal

Appendix C: Common Abbreviations & Their Meaning

Abbreviation	Definition
AbPL	Abductor Policis longus
ACL	Anterior Cruciate Ligament
ADL	Activities of Daily Living
AROM	Active Range of Motion
ASIS	Anterior Superior Iliac Spine
ASLR	Active Straight Leg Raise
ATFL	Anterior Talofibular Ligament
BID	Twice a Day
BMI	Body Mass Index
BP	Blood Pressure
C1-7	Cervical Vertebrae
CES	Cauda Equina Syndrome
CFL	Calcaneofibular Ligament
CHF	Congestive Heart Failure
CMC	Carpometacarpal
CNS	Central Nervous System
COPD	Chronic Obstructive Pulmonary Disease
CRPS	Complex Regional Pain Syndrome
C-sp	Cervical Spine
CT	Computed Tomography
CVA	Cardiovascular Accident
DOB	Date of Birth
Dx	Diagnosis
EPB	Extensor Policis Brevis
EPL	Extensor Policis Longus
ER	External rotation OR Emergency Room
ES	Extra Strength
FABER	Flexion, Abduction and External Rotation test
FADIR	Flexion, Adduction Internal Rotation test
FM	Fibromyalgia
FNST	Femoral Nerve Stress Test
FOOSH	Fallen on Outstretched Hand
FROM	Full Range of Motion
Fx or #	Fracture
GI	Gastrointestinal
GOOB	Getting Out of Bed
GP	General Practitioner
GRTW	Graduated Return to Work
HBB	Hands Behind Back
HBH	Hands Behind Head
HEP	Home Exercise Program
HFP	Head Forward Posture
HR	Heart Rate
Hx	History
IP	Interphalangeal

IR	Internal Rotation
IT	Iliotibial
Ⓛ	Left
l.	Ligament
L1-5	Lumbar vertebrae
LBP	Low Back Pain
LCL	Lateral Collateral Ligament
LCS	Lower-Crossed Syndrome
LMNL	Lower Motor Neuron Lesion
LOF	Loss of Function
m.	Muscle
MCL	Medial Collateral Ligament
MCP	Metacarpophalangeal joint
MFR	Myofascial Release
MI	Myocardial Infarction
MOA	Mechanism of Action
MOI	Mechanism of Injury
MRI	Magnetic Resonance Imaging
MS	Multiple Sclerosis
MVA	Motor Vehicle Accident
Mx	Management
n.	Nerve
NSAID	Non-Steroidal Anti-Inflammatory Drugs
OA	Osteoarthritis
PRICE	Protection, Rest, Ice, Compression, elevation
PCL	Posterior Cruciate Ligament
PNS	Peripheral Nervous System
PRN	As Needed
PROM	Passive Range of Motion
PSIS	Posterior Superior Iliac Spine
PTFL	Posterior Talofibular Ligament
QD	Once a Day
QID	Four Times a Day
QOL	Quality of Life
®	Right
RA	Rheumatoid Arthritis
ROM	Range of motion
RROM	Resisted Range of Motion
RTW	Return to Work
Rx	Prescription
Rx	Prescription drugs
S1-5	Sacral Vertebrae
SI	Sacroiliac
SLR	Straight Leg Raise
SOAP	Subjective, Objective, Assessment, Plan
Sx	Symptom
T1-12	Thoracis vertebrae
T1DM	Type 1 Diabetes Mellitus

T2DM	Type 2 Diabetes Mellitus
T3	Tylenol 3
TBI	Traumatic Brain Injury
TENS	Transcutaneous Electrical Nerve Stimulation
TFL	Tensor Fasciae Latae
TID	Three Times a Day
TOP	Tender on Palpation
Tx	Treatment
UCS	Upper-Crossed Syndrome
ULNDT1	Upper Limb Neurodynamic Test 1
UMNL	Upper Motor Neuron Lesion
VMO	Vastus Medialis Obliquus
WB	Weight Bearing
WNL	Within Normal Limits