Course Objectives
Upon completion of this course the participant should be able to:

1. Discuss the multiple factors proposed to contribute to pre-arthritic hip disease, including structural and neuromuscular impairments, activity level and type, and abnormal movement patterns.
2. Describe the bony abnormalities associated with femoroacetabular impingement and structural instability.
3. Discuss factors proposed to contribute to bony abnormalities and ligamentous laxity.
4. Describe the importance of active performance of precise joint motion.
5. Differentiate the most common movement system diagnoses of the hip.
6. Discuss how impairments in muscle length, strength, stiffness, and pattern of recruitment contribute to movement system diagnosis.
7. Develop a corrective exercise program, and provide instruction in correcting the performance of daily activities for a given movement system diagnosis.

Course Description
Using lecture and demonstration, this course will provide an update of the concepts and principles used to determine a movement system diagnosis and to provide diagnosis-directed treatment of pre-arthritic hip disease. Bony and ligamentous abnormalities associated with femoroacetabular impingement (FAI) and structural instability will be presented. Muscle performance impairments in force production and activation will be discussed as they relate to movement system diagnoses of the hip. The course will emphasize the determination of a movement system diagnosis, based on a clinical examination to assess movements and postures observed during exam items and performance of functional activities. Selection and performance of corrective exercises and functional activities will be discussed and demonstrated.

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3. Washington University School of Medicine
   a. Program in Physical Therapy
   b. Clinical Center for Imaging Research
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Course Outline

1. Introduction
   a. Classification of Hip pain
   b. Challenges and Opportunities
   c. Current Treatment guidelines
      i. Osteoarthritis
         1. Orthopedic Section, APTA Hip Task Force
            a. Hip OA, *Cibulka MT et al. JOSPT 2009*
         2. American College of Rheumatology (ACR)
         3. Osteoarthritis Research International (OARSI)
               *Zhang W et al. Osteo & Cart 2010*
          ii. Intra-articular hip disorders
             1. Orthopedic Section, APTA Hip Task Force,

d. Importance of Physical Therapist
   i. Provide unique expertise
   ii. Movement system diagnosis/classification
      1. Understanding movement-related factors that contribute to musculoskeletal disorders
         a. Biomechanics - Knee adduction moment
         b. Movement patterns - Medial collapse/Dynamic Valgus
   iii. Multiple factors to consider
2. Structural and muscular characteristics of the hip joint and variations in people with pre-arthritic hip disease.
   a. Introduction
   b. Pre-arthritic Hip Disease, aka Intra-articular, Nonarthritic hip disease/disorder
      i. Associated Diagnoses
         1. Femoroacetabular impingement
         2. Structural instability (Hip dysplasia)
         3. Labral tears, chondral lesions, ligamentum teres tear
ii. Multidisciplinary approach to diagnosis

1. Structural (osseus) diagnosis
   a. Femoroacetabular impingement
   b. Structural instability

2. Soft tissue diagnosis
   a. Labral tear
   b. Ligamentum teres rupture

3. Movement system diagnosis/classification
   a. Femoral Hypermobility - Anterior Glide
   b. Femoral Hypomobility

c. Hip Joint Anatomy

   i. Stability and mobility
      1. Bony morphology
      2. Soft tissues
         a. Capsular ligaments
         b. Labrum, ligamentum teres
         c. Muscle (iliopsoas, intrinsic rotators, iliocapsularis)

3. Muscular Restraint on Anterior Hip Joint

4. Muscular Restraint On Posterior Hip Joint
d. Structural diagnosis - Bony abnormalities
   
i. Femoroacetabular impingement (FAI)
   
   1. Bony overgrowth: Acetabular overcoverage, aspherical femoral head, loss of concavity of femoral head-neck junction

   Standaert CJ Arch Phys Rehab 2008

2. Clinical presentation
   
a. Symptoms consistent with pre-arthritic or intra-articular hip disease
      
i. Localized anterior groin pain
      
   ii. Chronic – generalized joint pain
      
   iii. May report catching or locking
      
   iv. Aggravating factors
      
      1. Often related to increased activity level or specific activity, such as sitting

b. FAIR/FADIR test (anterior impingement)
   
i. Pain
      
      1. Sensitive, not specific
      
   ii. ROM
      
      1. < 20°IR (hip at 90°hip flexion) Wyss TF CORR 2007

   c. May have limited hip flex, abd
   
   d. Movement exam to identify Movement system impairment
3. Imaging findings
   a. Acetabular Retroversion
   b. Lateral Center Edge Angle (LCEA)
   c. Cam FAI - Alpha Angle

   Harris-Hayes and Royer PMR 2011
   Clohisy JC JBJS 2008

4. Proposed risk factors
   a. Genetics
   b. Activity level
      i. Early participation in sport
      Gerhardt et al AJSM 2012
      1. High physical demand during stage of development
      ii. Cumulative effect of selected sport
      iii. Reduction of multiple sport
      iv. Cumulative effect of repetitive load in general
      v. Supporting studies – CAM lesion
         Siebenrock KA et al. CORR 2011

5. Activity level/type – Interact with bony abnormality present
   a. Deformity + Demand = Risk of injury
   b. Slight deformity + Wide amplitude motions
   c. Large deformity may require less motion

   Nogier A et al. Ortho and Traumatol. 2010

6. Extra-articular impingement
   Anterior Inferior Iliac Spine Impingement
   Hetseroni et al. Arthroscopy 2011

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Rehabilitation Factors in Pre-arthritic Hip Disease
7. Clinical implications for rehabilitation
   a. Regarding FAI, consider
      i. Does the person participate in activities that repetitively place them in the position of impingement?
      ii. Do the functional activities associated with the pain involve a position of impingement?
      iii. How does the magnitude of the abnormality relate to the magnitude of the hip motion required for activity?
   b. Education
      ii. Structural instability
         1. Shallow acetabulum, Ligamentous laxity
         2. Clinical presentation
            a. Symptoms consistent with pre-arthritic or intra-articular hip disease
               i. Localized anterior groin pain
               ii. Chronic – generalized joint pain
               iii. May report catching, locking or feelings of instability
               iv. Aggravating factors
                  1. Often related to increased activity level or specific activity (direction specific)
            b. FAIR/FADIR test (anterior impingement)
               i. Pain
                  1. Pain may occur at greater range
               ii. ROM
                  1. May be increased
            c. Excessive ROM other planes
            d. Movement exam to identify Movement system impairment
3. Imaging findings
   a. Lateral Center Edge angle
   b. Acetabular Depth Index
   c. Caution: Acetabular retroversion
      i. May be apparent due to insufficient posterior wall

4. Ligaments
   a. Ligamentum teres tear
      i. Associated with insufficient acetabular coverage
      ii. Shallow acetabulum were 1.7 times more likely to have a LT tear
         1. 60% vs. 34%  \textit{Domb BG et al. Arthroscopy 2013}
   
      i. High energy injury
      ii. Hip subluxation or dislocation
      iii. Posterior most often reported

      \textit{Philippon MJ et al. Oper Tech Orthop 2005}
      i. Connective tissue disorder
      ii. Repetitive loading leading to chronic capsular injury
         1. Rotation with axial load
      iii. Anterior or Posterior
      iv. Shallow acetabulum may or may not be present
      v. Anterior hip instability
         1. Clinical presentation
            a. Supine: Rests in excessive ER
            b. Abd/Ext/ER: Pain/apprehension
2. Imaging (MRI)
   
   a. Insufficient iliofemoral lig
   
   Blakely CM et al. Hip Int 2010

   vi. Movement exam to identify Movement system impairment

5. Proposed risk factors
   
   a. Genetics
   
   b. Ligamentous laxity

6. Clinical implications for rehabilitation
   
   a. Regarding structural instability, consider

   i. Repetitive subtle instabilities of hip joint

   ii. Do they participate in activities that facilitate flexibility of the soft tissues?

   iii. Neuromuscular re-education/Proprioception

   b. Education

   iii. Other bony abnormalities

   1. Femoral version

   a. Influences ROM

   b. Excessive anteversion

   i. ↑ IR  ↓ ER ROM

   ii. may be associated with structural instability

   c. Retroversion

   i. ↑ ER  ↓ IR ROM

2. Femoral neck-shaft angle

3. Normal value: 125°- 135°

   a. Coxa Valga: Increased angle

   i. May be associated with structural instability

   ii. 5% prevalence in young adults with hip pain
iv. Update on current research findings related to bony structure

v. Summary – Rehabilitation implications related to structural (osseus) abnormalities

1. Intense focus leading to surgical procedures to correct bony morphology

2. Is surgery the right treatment?

3. Many Limitations
   a. Bony structure is highly variable.
   b. Little is known about the general population.
   c. Values to indicate pathology have not been agreed upon.
   d. We don’t know which bony abnormalities are pathologic.
   e. Surgeons are debating the definitions.

4. Epidemiologic studies are needed.

5. Factors other than bony abnormalities may contribute to development or persistence hip pain
   a. Activity participation
   b. Movement related factors
   c. Psychosocial factors

6. Physical therapist expertise is needed and appreciated
   a. Movement system diagnosis/classification

7. Clinical exam findings and relationship to pain and function
e. Movement related factors
   i. Neuromuscular performance
      1. Provides stability and mobility
      2. Force production
         a. Strength
      3. Activation
         a. Timing
         b. Recruitment
      4. Poor performance
         a. Due to the pain
         b. Potential contributor
            i. Influence lower extremity kinematics
               Sahrmann SA 2002
               Casartelli NC et al. Osteo Cart 2011
   
   ii. Update on current research findings related to neuromuscular performance

f. Femoral acetabular impingement and osteoarthritis
   i. Limited (weak) evidence suggests bony abnormalities, cam and pincer, are associated with OA
      Harris-Hayes and Royer PMR 2011
      1. prospective case control and cross-sectional studies
   ii. Limitations
      1. Cross-sectional studies
         a. Measures of FAI affected by OA (alpha angle, lateral center edge angle)
            i. Changes in the bone due to OA may result in larger values of FAI measures
      2. Inconsistent definitions and measures of bony abnormalities and OA
   iii. Cam
      1. Chingford Study – United Kingdom
         a. Nested Case-Control with 19 year data
         b. Women aged 44-67 years
         c. 1° increase Alpha angle increased risk of THA by 5.8%
            Nicholls AS et al. Arthrit & Rheum 2011
2. CHECK cohort – The Netherlands
   a. Prospective cohort with early symptomatic OA
   b. 80% Women
   c. End-stage OA at 5 yr follow up
      i. \( \alpha \) angle > 60°: 3.67 aOR
      ii. \( \alpha \) angle > 83°: 9.66 aOR
      iii. Hip IR (90°) \( \leq \) 20°: 7.13 aOR
      iv. \( \alpha \) angle > 83° + Hip IR \( \leq \) 20°: 25.21 aOR


iv. Preliminary findings suggest FAI associated with Hip OA
   1. Additional research needed to confirm
      a. Longitudinal studies
         i. Valid and reliable measures (FAI and OA)
      b. Proposed mechanism underlying OA development
      c. Relationship with other factors
         i. Movement-related factors
         ii. Activity-related factors
   2. Across studies – some subjects with bony abnormalities do not develop or progress OA

Hartofilakidis G. JBJS 2011
Bardakos and Villar. JBJS 2009

a. Hartofilakidis 2011
   i. 96 asymptomatic hips with FAI by imaging
   ii. 18.5 (10-40) year follow up
   iii. 79 (82.3%) = no OA
b. Allen 2009 – people with cam impingement
   i. 88/113 had bilateral cam by radiograph
   ii. 23/88 had bilateral pain
   iii. Smaller cam on uninvolved?
   iv. Activity participation?
v. Consider other factors

g. Structural instability (acetabular dysplasia) and osteoarthritis

i. Conflicting evidence - limited
   1. 8 positive = an association exists
      a. 3 prospective cohort or case control
      b. 5 cross-sectional
   2. 12 negative = no association exists or there was a negative association between AD and OA
      a. 2 prospective case control
      b. 10 cross-sectional
   3. Positive studies - 1.1-10.2 higher risk of developing OA than those without AD
      a. Prospective
         i. Higher risk of developing OA
            1. aOR = 3.3 LCEA < 30°
            2. aOR = 2.8 ADI < 9mm
            Lane NE. Arthrit & Rheum 2000
            3. aOR = 2.4, 4.3 LCEA < 25°
            4. aOR = 1.7, 2.8 ADI < 9 mm
            Reijman M. Arthrit & Rheum 2005
ii. Limitations
   1. Cross-sectional studies (15/20)
   2. Measures of acetabular dysplasia – LCEA affected by OA
      a. Changes in the bone 2° to OA may result in larger values of LCEA measures
   3. 6 studies – radiographs taken for non-skeletal purposes, therefore did not control for rotation of the pelvis
   4. 6 studies – assumed a linear relationship between measures of AD and OA
   5. 2 studies found no association
   6. 4 studies finding a negative association

iii. Limited evidence to suggest that
   1. AD is associated with OA and may be a risk factor for OA
   2. Need prospective studies

3. Movement system impairments of the hip.
   a. Overview of basic concepts
      i. Mechanical pain
         1. Insidious vs. Trauma

   ii. Theories
      1. Movement System Impairment
         
         \textit{Sahrmann SA 2002, 2010}
         
         a. Kinesiopathological model of human movement

      2. Physical Stress Theory
         
         \textit{Mueller and Maluf. PTJ 2002}

   iii. Cause vs. Source of symptoms
      1. Cause = the mechanical factor (Movement System Impairment) that results in tissue irritation
         a. e.g. lumbar extension syndrome
      2. Source = the tissue or pathoanatomical structure that is symptomatic
         a. e.g. facet syndrome
3. Goal of examination is to determine the movement pattern that is causing increased stress to the tissue affected

iv. Contributing factors to Movement System Impairment

1. Physical impairments
   a. Neuromuscular
      i. Strength
      ii. Activation
      iii. Length
   b. Biomechanical
      i. Static/dynamic

2. Activities (daily, work, and sport)

b. Approach to examination

i. Subjective
   1. Clear report of pain location
   2. Activities that aggravate
      a. Clues to mechanical contributors
      b. Guide treatment

ii. Clinical examination
   1. Physical impairments (strength, length)
   2. Assess movements and effect on pain (think biomechanics)
      a. Key tests
      b. Functional activities
      c. Aggravating activities

iii. Evaluation
   1. Subjective and Clinical examination
      a. Identify movement pattern associated with pain
      b. Identify physical impairments that contribute to the movement pattern
iv. Treatment

1. Modify impaired movement pattern
   a. Functional activities
   b. Exercise

2. Focus on the impairments associated with movement pattern

3. Encourage continued physical activity to avoid producing fear avoidance behaviors

c. Movement patterns - Classification

i. Systematic exam – Visual appraisal
   1. Identify movement pattern associated with pain behavior
   2. Likely performed repetitively during functional activities
   3. May be contributor to pain or persistence of pain after injury

ii. Treatment approach
   1. Modify movement pattern
   2. Reduce stresses to tissues
   3. Reduce pain and improve function

iii. Examples
   1. Dynamic Knee Valgus (DKV)/Medial collapse (MC)
      a. Lower Extremity disorders
         i. Acetabular labral tear *Austin JOSPT 2008*
         ii. ACL injury *Hewett TE et al (multiple articles)*
Key movement system impairments of the hip joint (see grids provided for full detail)

i. Hip Adduction with Medial Rotation

1. Description
   a. Lack of posterolateral stabilization of proximal femur
   b. Exaggerated hip adduction/MR with functional activities
      i. gait, sit to stand and stairclimbing
   c. Associated with a variety of sources of pain
      i. Greater Trochanteric pain
      ii. Piriformis syndrome
      iii. Sciatic nerve
      iv. ITB

2. Symptoms
   a. posterior lateral hip pain
   b. sciatica (piriformis)
   c. pain along inner thigh
   d. lateral thigh pain
   e. pain on weight-bearing

3. Incidence: W>M

4. Contributing factors
   a. Muscle weakness
      i. Hip abductors and hip lateral rotators
   b. Short TFL-ITB
   c. Contributing activities
      i. sleeping on side
      ii. sitting with legs crossed
      iii. stand with weight primarily on the involved limb
5. Treatment
   a. Education
   b. Modify Functional activities
      i. Support injured tissues
         1. Cane
      ii. Out of chair every 30 min (sciatica), symmetrical sit/stand, sleep, avoid excessive stretching
      iii. Avoid crossing legs
   c. Therapeutic exercise
      i. Shorten/Increase muscle performance of posterior muscles
      ii. Femoral Anterior glide with medial rotation (see grids provided for full detail)
         1. Description
            a. Excessive flexibility of anterior hip joint structures
            b. Result of maintained hip extension
            c. Excessive MR during hip flexion
            d. Associated with a variety of sources of pain
               i. Intra-articular hip joint structures
               ii. Iliopsoas
         2. Symptoms
            a. Groin pain d
            b. May be aggravated in hip flexion, extension and/or ext. rotation
            c. Pain may progress to aching of entire hip
         3. Contributing factors
            a. Alignment
            b. Poor muscle performance of iliopsoas and hip LRs(stabilizers)
            c. In some cases, stiffness of hip extensors and posterior hip joint contribute
d. Contributing activities
   i. running
   ii. dancing
   iii. martial arts
   iv. Soccer
   v. Rotation on fixed foot

4. Treatment
   a. Education
   b. Modify Functional activities
      i. Support injured tissues
      ii. Alignment, gait, sit & stand symmetrical
   c. Therapeutic exercise
      i. Improve muscle performance of iliopsoas,
      ii. Potentially improve muscle performance of gluteals.
      iii. Improve flexion motion
         1. Quadruped, supine hip/knee flexion (P→R), mob
      iv. Lengthen TFL-ITB
      v. Reverse altered hip flexor dominance of TFL over iliopsoas
   iii. Femoral Posterior glide (see grids provided for full detail)
      1. Description
         a. Imprecise spinning of the femoral head during hip flexion accompanied by excessive hip medial rotation (MR).
         b. Increased flexibility of the posterior hip joint structures (capsule and hip lateral rotator muscles)
         c. Individuals who develop this syndrome tend to be generally hypermobile or have performed a great deal of stretching exercises
         d. Hips more flexible than the spine
2. Symptoms
   a. Deep hip pain or aching of whole hip with sitting or sports
   b. Popping hip (active subluxation by sudden hip adduction/MR)
   c. May report feeling of dislocation when hip is in flexion and medial rotation
      i. Apprehension with FAIR test that decreases with posterior support.

3. Females > males

4. Contributing factors
   a. Poor muscle performance of the hip lateral rotator muscles and gluteals
   b. Long intrinsic hip lateral rotators
   c. Increased hip flexion and/or medial rotation
   d. Contributing activities
      i. Dancers, Yoga (emphasis on end range stretching)
      ii. Habit of sitting with legs crossed thigh over thigh
      iii. Habit of sleeping semi prone with hip in flexion/add/MR

5. Treatment
   a. Education
   b. Modify functional activities
      i. Alignment, sitting and sleeping position. ↓ sitting time
   c. Reverse altered hip flexor dominance of TFL over iliopsoas
   d. Improve performance of posterior muscles
   e. Lengthen TFL-ITB
   f. Quadruped is contraindicated

   iv. Multidirectional(see grids provided for full detail)
   a. Outcome measures
      v. The Hip Outcome Score (HOS)
      vi. Copenhagen Hip and Groin Outcome Score (HAGOS)
      vii. International Hip Outcome Tool (iHOT-33)
      viii. Modified Harris Hip Score (MHHS)
         1. Original vs. Modified
      ix. Hip Disability and Osteoarthritis Outcome Score (HOOS)
      x. Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)
   b. Demonstration of tests for movement system impairments using patient case
   c. Review tests for source of symptoms
      xi. May not be necessary
      xii. Only perform if uncertain of source
   d. Determine diagnosis and contributing factors
   e. Treatment based on movement system impairments.

5. Update on research

6. Discussion

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