Introduction to Movement Dysfunction & Kinetic Chain Assessment

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Objectives

1. Define common human movement imbalances
2. Explain the evidence for common imbalances
3. Define Corrective Exercise
   a. What is it?
   b. Why is it used?
   c. How do you apply it?
Paradigm Shift

• Injury prevention is the primary goal of all performance enhancement programs
  – The primary emphasis of traditional “Sports Conditioning” programs has been on concentric force production (how much can you lift) primarily in the sagittal plane, in a controlled environment
    • This may not be the best way to prevent injuries
  – Also, many athletes have pre-existing injuries that must be addressed prior to advanced performance enhancement training
Foot and Ankle Imbalances

- Lateral ankle sprains are the most common injury suffered in sports during sports participation (Safran, 1999)
  - Denegar, et al 2002 in a retrospective study demonstrated altered arthrokinematic movement of the talus (decreased posterior glide) even though range of motion was restored
  - This is very important because limited posterior glide of the talus may lead to decreased dorsiflexion
    - Limited dorsiflexion may lead to other compensations
Foot and Ankle Imbalances

- Bullock-Saxton et al 1994 demonstrated decreased gluteus maximus muscle activation post ankle sprain
- Beckman et al 1995 demonstrated decreased gluteus medius muscle activation post ankle sprain
  - If an athlete begins an integrated training program and has muscle imbalances in the hip complex secondary to an ankle sprain, then further compensations and possible injury may occur
Knee and Hip Imbalances

• It has been recognized that the patellofemoral joint may be influenced by the segmental interactions of the lower extremity (Fredericson, Powers)
  – Abnormal motions of the tibia and femur in the transverse and frontal planes are believed to have an effect on the patellofemoral joint (Ford, Nyland)
  – This abnormal motion may be caused by weakness in the hip abductors and external rotators (Ireland)
Knee and Hip Imbalance

- Recent kinetic analysis of running reveals that, although the knee joint primarily moves in the sagittal plane, the knee is also subject to significant frontal and transverse plane moments (McClay)
  - In the absence of sufficient proximal hip strength, the femur may adduct and internally rotate, further increasing the lateral patellar contact pressure (Lee)
  - (Fredericson) demonstrated that distance runners with ITB Syndrome had weaker hip abduction strength than the control group and their unaffected leg
  - (Ford and Hewett) demonstrated that female athletes landed with greater total valgus (femur adduction and tibia abduction) than male athletes and may lead to ACL Tears
Lumbo-Pelvic-Hip Complex Imbalance

- Low back pain is very common in the active population (Nadler)
  - In a cross-sectional study of 100 patients (Cibulka) demonstrated unilateral hip rotation ROM asymmetry in patients with SI joint regional pain
  - Hodges and Richardson 1996 reported that slow speed of contraction of the transverse abdominus during arm and leg movements was well correlated with LBP
  - O’Sullivan et al 1997 found that synergist substitution of the rectus abdominus for the agonist transverse abdominus during the abdominal drawing-in maneuver suggesting less efficient intersegmental stabilizing mechanisms and greater shear forces at the intervertebral joints
  - Hides et al 1994 demonstrated unilateral atrophy of the multifidus in patients with low back pain
Current Concepts in Human Movement Science

- Two distinct yet interdependent muscle systems
  - Stabilization System (Stabilizers)
    - Primarily involved in joint support
    - Broad spectrum of attachments
    - Prone to inhibition and weakness
  - Movement System (Mobilizers)
    - Superficial muscles associated with extremity movement
    - Prone to overactivity and tightness
    - Categorized into four common sub-systems
Understanding Muscle Function

• Stabilizers
  – Gluteus Medius
  – Transverse Abdominus
  – Internal Oblique
  – Multifidus
  – Lower Trapezius
  – Serratus Anterior
  – Rotator Cuff
  – Deep Neck Flexors

• Mobilizers
  – Gastrocnemius
  – Quadriceps
  – Hamstrings
  – Adductors
  – Hip Flexors
  – Rectus Abdominus
  – Erector Spinae
  – Latissimus Dorsi
Understanding Muscle Function

• Stabilizers
  – Delayed recruitment
  – Reacts to pain and pathology with inhibition
  – Loss of joint stabilizations
  – Leads to synergistic dominance

• Mobilizers
  – Become overactive
  – Reacts to pain and pathology with spasm
  – Develops myofascial adhesions which alter (LTR, ATK)
Lateral Sub-System

- **Muscles Involved**
  - Gluteus Medius
  - Tensor Fascia Latae
  - Adductor Complex
  - Quadratus Lumborum

- **Function**
  - Frontal plane stability
Posterior-Oblique Sub-System

• Muscles Involved
  – Latissimus Dorsi
  – Thoracolumbar Fascia
  – Gluteus Maximus

• Function
  – Transverse plane stabilization
Anterior-Oblique Sub-System

- **Muscles Involved**
  - Internal Oblique and Hip Adductor Complex
  - External Oblique and Hip External Rotators

- **Function**
  - Transverse plane stabilization
Deep Longitudinal Sub-System

• Muscles Involved
  – Erector Spinae
  – Thoracolumbar Fascia
  – Gluteus Maximus
  – Biceps Femoris
  – Peroneals

• Function
  – Force transmission from the ground to the trunk
Kinesiopathological Model

- If one component of the human movement system is not functioning optimally, than PREDICTABLE PATTERNS of dysfunction will develop and initiate the cumulative injury cycle.
Kinetic Chain

- Myofascial
- Articular
- Neural

  Sensorimotor Integration

  Neuromuscular Control
Length-tension Relationships

• There is a direct relationship between tension development in a muscle and the length of the muscle
  – There is an optimum length at which a muscle can generate maximum tension
Force-couple Relationships

- Muscles work synergistically to reduce force, dynamically stabilize and concentrically produce force in all three planes of motion.

- The CNS is designed to optimize the selection of muscle synergies.
Arthrokinematics

- Articular partners have predictable movement patterns
  - Roll
  - Slide
  - Glide
  - Translation

  - These patterns are controlled by the CNS and the surrounding muscles of the kinetic chain
DYSFUNCTION

- Altered Length-tension Relationships
- Altered Force-Couple Relationships
- Altered Arthrokinematics
  - Altered Sensorimotor Integration
  - Altered Neuromuscular Efficiency
    - Tissue Fatigue
      - Initiation of the Cumulative Injury Cycle
Results from Human Movement System Impairment

• Reciprocal Inhibition
• Synergistic Dominance
• Arthrokinetic Inhibition
• Relative Flexibility
• Pattern Overload
Reciprocal Inhibition

- Increased neural drive or decreased extensibility of an agonist will decrease the neural drive to the antagonist
  - Leads to synergistic dominance
Synergistic Dominance

- The NMS phenomenon that occurs when synergists and stabilizers compensate for prime movers during functional movement patterns
Arthrokinetic Inhibition

- The process of inhibition that occurs from lack of proper joint arthrokinematics
Relative Flexibility

• The Human Movement System will take the path of least resistance
Pattern Overload

• Repetitive recruitment of the same muscle fibers, in the same ROM/Plane of motion and at the same speed creates tissue overload and eventually injury
Kinesiopathological Model

Low Back Extension

- Lengthened
  - Gluteus Maximus
  - Abdominal Complex

- Shortened
  - Erector Spinae
  - Hip Flexors

- Joint Dysfunction
  - Lumbar SI-Joint
Integrated Training

General Guidelines:

• Identify all kinetic-chain imbalances.

• Correct all kinetic chain imbalances

• Develop proper structural integrity of the kinetic chain before activity-specific training.

• Integrate functional movements in the plane of motion, range of motion and speed of motion that replicates the training activity.
What is the Solution?

Identify Causative Factors

Correct Weak Links

Recondition

Bigger Engines or Better Brakes

Identify Causative Factors
ICE: Integrated Corrective Exercise

• Identify the kinetic chain Imbalance responsible for the movement inefficiency and the biomechanical overload

• Correct the Imbalance
  – Inhibit the overactive
    • Self-Myofascial Release
  – Lengthen the overactive
    • Static Stretching
  – Activate the under-active
    • Active-Isolated Muscle Activation
  – Integrate functional movement patterns
    • Integrated Isolation

• Empower your client
  – Give your client an individualized corrective exercise plan
  – Give your client an individualized Fitness and/or Performance Enhancement Program
Identifying the Weak Link:

- Posture
- Gait
- Flexibility assessment
- Neuromuscular assessment
- Overhead-squat test
- Single-leg balance excursion
- Single-leg squat test
- Multiplanar lunge test
- Multiplanar step-up test
- Push-up test
- Overhead medicine-ball throw

- Multiplanar vertical jump/hop
- Multiplanar horizontal jump/hop
- Shark skill test
- Multiplanar cone jump/hop test
- Speed tests
  - Straight-ahead speed
  - Lateral speed and agility
  - Sport-specific
  - Speed endurance
Transitional Movement Assessment
The Overhead Squat

1. Feet
2. Knees
3. Hips (Lumbar Spine)
4. Shoulders
5. Head
Normal Movement Assessment
Can You Guess the Chief Complaint?
What are Contributing Factors?
Foot & Ankle: Foot Turns Out

**Foot Turns Out:** Note the 1st MTP Joint in relation to the medial malleolus. In a normal foot the 1st MTP joint will appear along the same plane as the medial malleolus. However in a foot that is turned out the 1st MTP joint will appear lateral to the medial malleolus.
Foot & Ankle: Foot Flattens

Foot Flattens: Note the height of the longitudinal arch of the foot. It should be in a neutral position with a slight curve distinguishable and if the foot flattens it will appear to be flat along the floor. Another indicator of the foot flattening is the Achilles tendon. Note in the neutral picture how the tendon is straight, however when the foot flattens note the lateral angle that is produced by the Achilles tendon.
Foot & Ankle: Heel of Foot Rises

Heel of Foot Rises: Note the heel of the foot rising off of the floor. If the heel stays firmly planted on the floor then there is no abnormality. However any rise of the foot from the floor indicates an abnormal movement pattern.
Foot Flattens Single-leg: Note the height of the longitudinal arch of the foot. It should be in a neutral position with a slight curve distinguishable and if the foot flattens it will appear to be flat along the floor. Another indicator of the foot flattening is the medial malleolus will appear larger than the lateral malleolus. In the neutral picture both medial and lateral malleolus are even.
**Knee: Moves Inward**

**Normal**

**Abnormal**

**Knee Moves Inward:** Note a line drawn from the patellar tendon which bisects the ankle. This line should be perpendicular to the ground. If the line is leaning toward the midline of the body then the knee is moving inward.
Knee: Moves Outward

Knee Moves Outward: Note a line drawn from the patellar tendon which bisects the ankle. This line should be perpendicular to the ground. If the line is leaning away from the midline of the body then the knee is moving outward.
Knee: Single-leg Moves Inward

**Single-leg Knee Moves Inward:** Note a line drawn from the patellar tendon which bisects the ankle. This line should be perpendicular to the ground. If the line is leaning toward the midline of the body then the knee is moving inward.
Knee: Single-leg Moves Outward

Single-leg Knee Moves Outward: Note a line drawn from the patellar tendon which bisects the ankle. This line should be perpendicular to the ground. If the line is leaning away from the midline of the body then the knee is moving outward.
Low Back Rounds: Take notice of the area from approximately the mid back through the Sacral Complex. If the area is rounding then this area will appear as a thoracic or convex curve.
LPHC: Low Back Arches

Low Back Arches: Take notice of the area from approximately the mid back through the Sacral Complex. If the area is arched then this area will appear with an excessive lumbar or convex curve.
LPHC: Excessive Forward Lean

**Excessive Forward Lean:** Imaginary lines that are created by the shins and torso of the client if extended out should remain parallel. If these lines would cross immediately or shortly after extending them then the person does have excessive forward lean.
**LPHC: Weight Shift**

**Weight Shift:** Taking a line extending from the cervical spine through the thoracic and lumbar spine that is parallel to the ground should bisect the LPHC resulting in equal parts falling on either side of the line. If the LPHC is split unevenly resulting in a larger percentage on one side of the line then there is a weight shift on the side of the line that has the larger percentage of the LPHC.
Single-leg Lateral Hip Shift: Taking a line originating from the patellar tendon and bisecting the quadriceps should be parallel to the ground. If the line moves away from the midline then there is a lateral hip shift.
Upper Body: Arms Fall Forward

Arms Fall Forward: A line bisecting the torso and head should be noted. If this line travels parallel along the arms and the arms cover the ears of the subject then there are no abnormalities present. If the line does not parallel the arms and you can see the ears then the arms have fallen forward.
Dynamic Assessments

- Shark Skill Test
- Davies’ Test
- Vertical Jump
Valid and Reliable Tests

- Orthopedic Assessment (Magee)
- Muscle length assessment with Goniometer (Brosseau, Norkin)
- Single-leg Balance Excursion Test (Olmsted)
- Overhead Medicine Ball Throw (Stockburger)
- Vertical Jump (Manske)
- Single-leg Vertical Hop (Manske)
- Horizontal Jump (Manske)
- Single-leg horizontal hop (Manske)
So, once you find it... how will you address it?
ICE: Integrated Corrective Exercise

• **I**dentify the kinetic chain Imbalance responsible for the movement inefficiency and the biomechanical overload

• **C**orrect the Imbalance
  – Inhibit the overactive
    • Self-Myofascial Release
  – Lengthen the overactive
    • Static Stretching
  – Activate the under-active
    • Active-Isolated Muscle Activation
  – Integrate functional movement patterns
    • Integrated Isolation

• **E**mpower your client
  – Give your client an individualized corrective exercise plan
  – Give your client an individualized Fitness and/or Performance Enhancement Program
A Deeper Look at Dysfunction
ICE: Integrated Corrective Exercise

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Where are they going now?

- A comprehensive training approach that strives to improve all components necessary to allow each individual to achieve optimum performance (Clark 2000, Kraemer 2004)
  - Flexibility
  - Core Strength
  - Neuromuscular Efficiency
  - Power
  - Strength
  - Cardiorespiratory Efficiency
Summary

• Must appreciate movement as a whole when looking at postural & functional assessments
• Identify the weak link
• Provide isolated exercise to increase motor unit recruitment
  – Can only recruit motor units to the degree of dynamic joint stabilization
• Integrate to CNS by:
  – Multiplanar exercise selection
  – Variable speeds
  – ROM
  – Resistance (mode, frequency)
  – Acute variables (reps, sets, intensity, tempo, rest interval)
• Progress in training systematically to safely achieve goals
Further Reading Suggestions

• Professional Development
  – Kinesiology of the Musculoskeletal System (Neumann 2002)
  – Diagnosis and Treatment of Movement Impairment Syndromes (Sahrmann 2001)
  – Evidence-Based Medicine, 2nd ed (Sacket 2000)
  – Performance Enhancement Specialist (NASM 2001)
  – California University of Pennsylvania’s online, 12-month MS degree

• Personal Development
  – How Full is Your Bucket (Rath 2004)
  – The Leadership Challenge (Kouzes & Posner 2002)
  – Patch Adams (1998: 1 hr 56 min)