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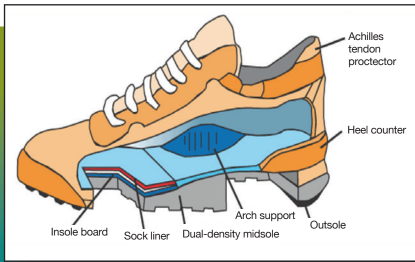

Fundamentals of Care in Biomechanics—Part 2

Understanding this science is the key to prevention and treatment.

BY MARK MENDESZOON, DPM

Goals and Objectives

After the completion of this CME, the reader will:

1) Appreciate the different scientific fields that are applicable to biomechanics

2) Appreciate anatomy and physiology of the lower extremity

3) Recognize and appreciate closed and open chain kinetics

4) Understand the role of the midtarsal joint and pathomechanics

5) Understand the different lower extremity deformities and their impact on overuse injuries

6) Realize the impact of pathomechanics and overuse injuries

7) Understand the impact and role of running shoes

8) Appreciate how performing thorough biomechanical exams can improve a physician's practice

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*Following this article, an answer sheet and full set of instructions are provided (pg. 140).—**Editor***

Evaluating the Back

When evaluating the back, it is important to evaluate for a scoliosis by having the patient stand up straight, then bending over and reaching for their toes. This examination should not be impeded by constrictive clothing. Run your fingers along the spine and inspect for any spinal irregularities or curvature. Have the patient perform a lumbar twist and inspect for any weakness, stiffness, and imbalances. Evaluate the patient for any lumbar radiculopathy by performing the straight leg raise test. Typically, an electrical shooting pain would be elicited if there is a lumbar issue such as nerve impingement, herniated disc, or stenosis. Further evaluate any neurological issues by checking deep tendon reflexes, pinpoint sensation, and balance. If these tests are positive, rec-

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ommend that the patient be seen by a back specialist and be worked up accordingly.[18]

Hip Range of Motion

When evaluating the hips for normal range of motion in the supine position, hip flexion should be between 110-120 degrees. Hip abduction should be 30-50 degrees and hip adduction 20-30 degrees. Generally, the ratio of external hip range of motion to internal range of motion should be a 2-1 ratio in adults. Strength testing of the hips can be examined by having the patient sitting upright and raising the knee to the sky. Evaluate for equal strength. Also, doing a single leg stance can determine if there is any weakness of the gluteus muscle as there will be a pelvic tilt on the weak side. It is also important to evaluate the greater trochanteric bursa and proximal iliotibial band to rule out external hip issues, or the groin to evaluate the adductor muscles.[19]

Leg Measure

While examining the leg, it is crucial to understand the normal anatomy of the femur as it connects the hip to the knee, and many overuse lower extremity conditions can be related to the structure of this bone. Various important measurements are critical to understand in order to appreciate the source of mechanical and anatomical pathology.

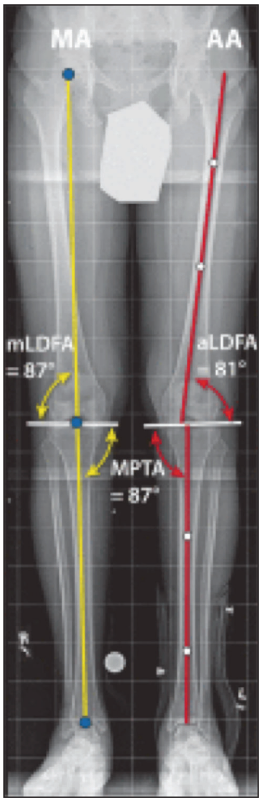

Figure 11: Long-leg standing radiograph demonstrating the mechanical axis of the lower extremity (MA), mechanical axis of the femur (MA)

Coxa vara is a deformity in which the angle is less than 120 degrees.

On normal weight-bearing anteroposterior radiographs, a vertical line that extends distally from the center of the pubic symphysis is known as the vertical axis. This axis is used as a reference axis/line from which the other axes are determined (Figure 11).

The normal relationship of the neck of the femur to the femoral shaft is 160 degrees at birth and decreases to 125 degrees at skeletal maturity (Figure 12). Coxa vara is a deformity in which the angle is less than 120 degrees. Coxa valga is a deformity when the angle is greater than 135 degrees.

Femoral antetorsion is an inward twisting of the thigh bone. The condition causes the knees and feet to turn inward and have a "pigeon-toed" appearance.

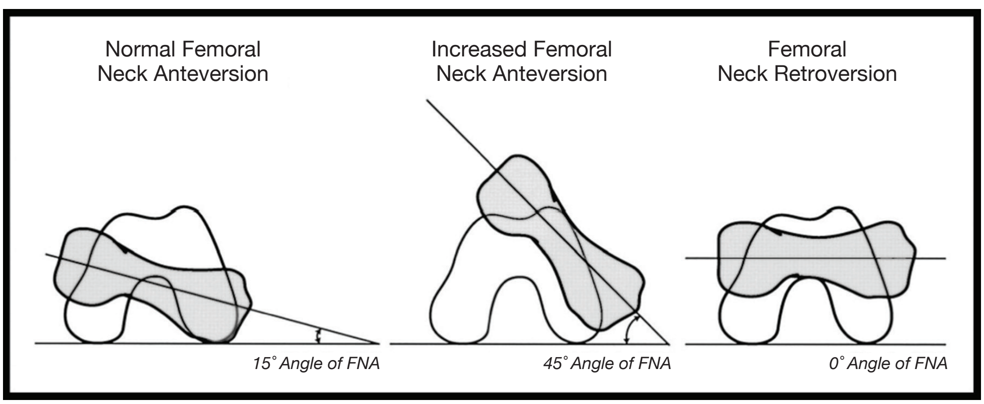

Figure 12: Femoral Anteversion & Torsion

Femoral anterversion relates to the femoral neck's angular orientation to a line that connects the femoral condyles. As such, it describes a bony or structural twisting or torsion of the bone. Over the years, these terms have become interchangeable but the take home point is that if a person's knee is inward facing or 'squinting', then the deformity is in the femoral segment. Parents should strongly discourage the child from sitting in the reverse W position as this can accentuate deformity of the femur.[20]

Q Angle

The quadriceps angle, Q angle, is the angle formed by a line drawn from the anterior superior iliac spine of the hip (ASIS) to the center of the patella. The second line is drawn from the center of the patella to the tibial tubercle (Figure 13). Generally, the Q angle will be greater in females due to their wider pelvis. Even the subtlest of femoral deformities may lead to overuse conditions such as patella tendonitis, chondromalacia, distal iliotibial band syndrome, and even meniscal injuries of the knee.[21]

Knee Range of Motion

As a hinged joint, normal knee range of motion should be 0 degrees of extension to 135 degrees of flexion. The knee should be in a rectus alignment but deformities may affect its mechanics. The mechanical axis is measured on full-length weight-bearing radiographs by drawing a line from the center of the femoral head to the center of the ankle. Normally, it should bisect the knee, with the joint horizontal and parallel to the ground. Genu varum is defined by medial displacement of the mechanical axis. Genu valgus is defined by lateral displacement of the mechanical axis. Genu varum and genu valgum are frontal plane deformities that can impact knee range of motion which could lead to improper tracking of the patella or chondromalacia. Excessive wear and tear could cause for meniscus injuries, plica syndrome or pes anseurinus syndrome. It is imperative that a thorough knee examination be performed to assess any chronic injury or

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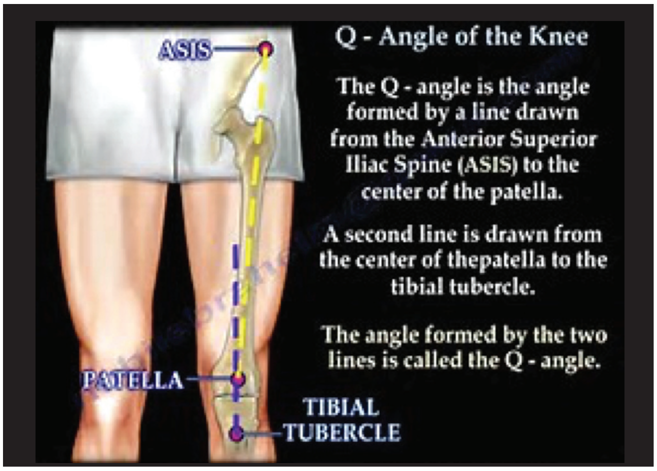

Figure 13: Q angle

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acute injury such as ACL or PCL tears (Figure 14).

As with the femur, the lower leg could have structural abnormalities that could have a direct impact on biomechanics. The first deformity to recognize is a leg length discrepancy. Ideally, there should be no leg differences between the legs but more often than not, there is a difference in length. In the average person, a 1/4 inch differential is the threshold before biomechanical flaws develop. In athletes, that threshold reduces to 1/8". When measuring for a leg length discrepancy, two clinical measurements are recommended. The first measurement is the anatomical leg length, which is measured from the ASIS to the medial malleolus in the supine position.

This measurement concentrates on the structural components of the lower extremity. The second measurement is functional leg length. This measurement is from the umbilicus to the medial malleolus. This measurement varies as it is related to the soft tissue components. Full-length radiographs of the lower extremity will provide absolute measurements. When treating leg length discrepancies, it is important to realize that maximal height of an internal insert or lift will max out at 1/2 inch as anything larger will make the heel pop out of the shoe. Anything requiring greater than a 1/2 inch should require accommodations to the external portion of the shoe, specifically the midsole of the shoe.[22]

As with the femur, there is a physiologic torsion of the tibia. Typically, when infants are born, their extremities are externally rotated and as they progress to adults, the tibia will rotate inward. The measurement typically is a line bisecting the tibial tuberosity inferiorly, and bisecting the line connecting the medial and lateral malleolus. Another angle to help assess tibial torsion is the thigh foot angle. The thigh foot angle is assessed by the following method.

In the average person, a 1/4 inch differential is the threshold before biomechanical flaws develop.

Patient Position—Prone

Joint position—Knee flexed to 90 degrees, ankle in neutral position.

Procedure—Measure the angle between the thigh axis and the foot axis. The angle is negative if internally rotated, and positive if externally rotated. Normally, the angle is 10 degrees in adults. In the newborn, there is normally 5 degrees internal tibial torsion (Figure 15).

If the foot is not normal, then measure the angle of the transmalleolar axis.

Patient position—The patient is asked to lie prone on a couch with the knee flexed to 90 degrees.

Procedure—The center of each malleolus is marked. Connect these points by a line across the plantar surface of the sole. Draw a line perpendicular to it.

Interpretation—The angle between the thigh axis and a line perpendicular to the transmalleolar axis is measured, which is equal to the tibial torsion. At birth, this angle should be zero degrees and as skeletal maturity is reached, the angle reaches approximately 18 degrees. Clinically, the lateral malleolus is anterior to the medial malleolus. Absolute measurement of tibial torsion would require a CT scan. Unless the individual is tripping or having severe pain, treatment is conservative with shoes, orthotics, or bracing. If those measures do not help, then tibial osteotomy is the treatment of choice for deformity correction.[23]

Equinus

When examining the foot and ankle, it is imperative to recognize if there is an equinus condition. By performing the Silverskoid test, the clinician will be able to determine if there is an equinus condition of the gastrocnemius complex. When assessing this condition, it is mandatory that

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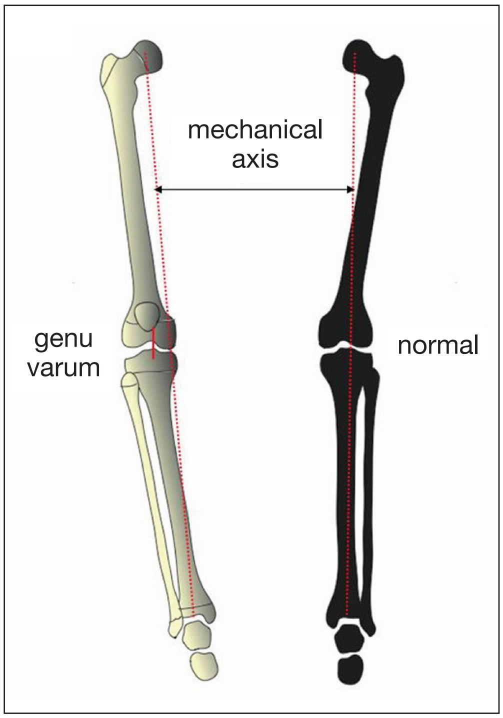

Figure 14: Genu Varum and Valgum

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the talonavicular joint be placed in a neutral and locked position so that there is no peri-talar motion which can give the appearance of adequate dorsiflexion.

Sigvard Hansen determined that over 90 percent of adult, chronic, and overuse conditions are due to the direct impact of equinus.[24] Once equinus is evaluated and recognized, stretching is paramount to improve the condition. If conservative measures fail, then either a gastroc recession or tendoAchilles lengthening procedure is advocated. Foot and ankle radiographs are a must; especially a lateral charger view is paramount to rule out any osseous deformity causing an equinus condition. The clinician must be astute in the history and physical to evaluate if there may be any neurological factors aiding in the equinus deformity.

When examining the foot and ankle, it is crucial that a non-weight bearing or open chain examination is performed by evaluating the patient from head to toe. If the patient is able to walk, then performing a weight-bearing, or closed chain examination, is mandatory before treatment is instituted. Performing both types of examinations will ensure a comprehensive evaluation so that proper treatment may be instituted.

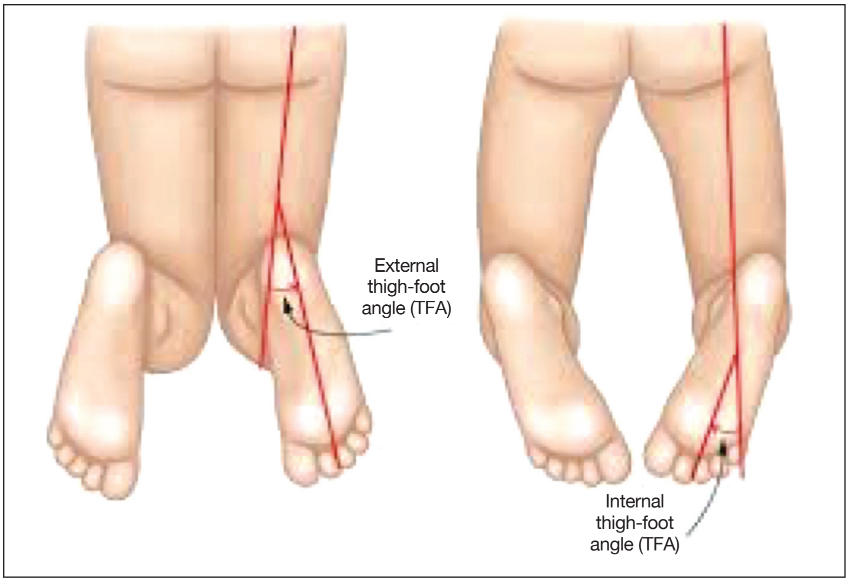

Figure 15: Thigh Foot angle

The main material of the midsole is EVA—ethyl vinyl acetate.

PRICE Treatment

Treatment of biomechanical overuse conditions may include the PRICE treatment: protection, rest, ice, compression and elevation. Non-steroidal and steroid medications must be given with caution and follow the local, state, national, international, and United States Anti-Doping Agency or World Anti-Doping Agency regulations. Appreciation of physical therapy modalities and establishing symbiotic relationships with therapists will ensure the best recovery program for patients. Treatment modalities include ultrasound, electrical stimulation, iontophoresis, strength and balancing, dry needling, cupping, massaging, active release techniques, and cross-training. Surgical intervention, when necessary, should take into account the biomechanical principles to restore balance and stability.[25]

Footgear

As the patient continues to return to activity, it is imperative that a thorough understanding of appropriate footgear is appreciated. Athletic shoes all have specific functions and indications, but running shoes are best equipped to provide proper support, cushioning, and function for the individual.

Despite the changes in materials of shoe engineering, the anatomy of the shoe remains the same (Figure 16). The midsole is a very critical portion of the shoe as this provides shock absorption. For over 40 years, the main material of the midsole is EVA-ethyl vinyl acetate. Recently, there has been a new midsole material that has been utilized as a midsole component and that is known as TPU—thermoplastic polyurethane. This material provides more individual air cell pockets and thus a much softer or cushioned feel. It has been very well received in the running shoe market, and in the near future different materials will be incorporated as midsole material. Other materials utilized for shoe construction

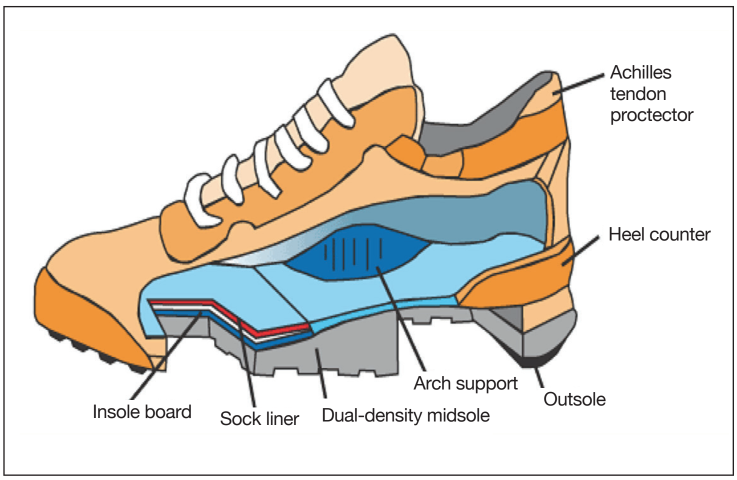

Figure 16: Running shoe anatomy

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are nylons, cardboard, and carbon blown rubber for the outer sole.

It is important that the care of running shoes be followed as instructed. All shoes are designed to break down, and the average life expectancy of a shoe is about 500 miles. If a patient has over-the-counter inserts or custom inserts, then adjusting the type of shoe is imperative so that the insole and shoe work in a symbiotic relationship. The design of running shoes has advanced so tremendously over the years that some patients may do well with the appropriate selection of shoes.[26]

In conclusion, the lower extremity specialist should acknowledge, respect, and understand the disciplines of anatomy, physiology, medicine, and biomechanics in order to ensure the best comprehensive program for his/her patients. This approach will not only benefit the patient, but also build a successful and thriving practice. **PM**

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CME EXAMINATION

SEE ANSWER SHEET ON PAGE 141.

1) When evaluating the hips for normal range of motion in the supine position, hip flexion should be between:

A) 50-60 degrees
B) 70-80 degrees
C) 110-120 degrees
D) 150-170 degrees

2) Coxa vara is a deformity in which the angle is less than ______ degrees:

A) 120
B) 140
C) 160
D) 180

3) Normal knee range of motion should be:

A) 60 degrees of extension to 120 degrees of flexion
B) 120 degrees of extension to 60 degrees of flexion
C) 135 degrees of extension to 0 degrees of flexion
D) 0 degrees of extension to 135 degrees of flexion

4) In the average person, a ______ differential is the threshold before biomechanical flaws develop:

A) 1/8 inch
B) 1/4 inch
C) 1/2 inch
D) 1 inch

5) By performing the __________ test, the clinician will be able to determine if there is an equinus condition of the gastrocnemius complex:

A) Hansen
B) Solomon
C) Silverskoid
D) Marshall

Continued on page 140

CME EXAMINATION

6) The PRICE treatment consists of all of the following EXCEPT:
- A) Protection
- B) Rest
- C) Heat
- D) Compression

7) Sigvard Hansen determined that over ______ percent of adult, chronic, and overuse conditions are due to the direct impact of equinus:
- A) 20
- B) 30
- C) 60
- D) 90

8) Ethyl Vinyl Acetate (EVA) is found in what part of the running shoe?
- A) Tongue
- B) Midsole
- C) Outer sole
- D) Toe box

9) Running shoes typically need to be replaced after how many miles?
- A) 100 miles
- B) 300 miles
- C) 500 miles
- D) 700 miles

10) The lower extremity specialist should acknowledge, respect, and understand the discipline(s) of:
- A) Anatomy
- B) Physiology
- C) Biomechanics
- D) All of the above

SEE ANSWER SHEET ON PAGE 141.

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(Mendeszoon)

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