Dynamic Chiropractic

SPORTS / EXERCISE / FITNESS

Foot Biomechanics during Weightbearing

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Why is it that the adjustments we perform sometimes fall short of our expectations? Why do they not always "hold" as well as we expect? The weightbearing foot (so often the "smoking gun" behind disorders of the knees, hips, pelvis, and back) may be the source of the problem. When the foot hits the ground, a series of events extending throughout the body is set into motion. This complex interaction of bone and soft tissue can cause or contribute to a number of conditions frequently seen in the chiropractic office. Flexible, custom-made orthotics help support and encourage normal foot function, which in turn helps protect the body from the harmful effects of faulty biomechanics. When the feet provide a balanced foundation for the body, its components can work together most effectively. A house with a flawed foundation may stand for years, but problems (leaks, cracked walls or sagging windows) will eventually develop. The effects of foot imbalance on the body can be just as insidious.

Anatomic Review

The foot functions as one link in a biomechanical kinetic chain, where movement at one joint influences movement at other joints in the chain.[1] As the base of this chain, the foot is subject to the forces of ground contact with every step, cushioning the body on landing and launching the frame forward immediately thereafter. This seemingly simple maneuver is accomplished through a series of complex biomechanical motions within the foot. These motions are collectively called the "stance phase" of the gait cycle, when ground contact occurs.[2] Stance presents the greatest risk to musculoskeletal integrity, because the foot is subjected to dual forces: the ground shock of heel strike and the vertical stress of weight from above.

What exactly happens when the foot hits the ground? Three distinct responses occur, each evoking change within the pedal structure.

1. Contact. The foot lands at the posterolateral aspect of the heel, with most of the weight on the outer edge. A gradual shifting of weight to the inner edge follows as the foot moves down and inward to a position of pronation. This is accomplished by internal rotation of the subtalar joint. The arch flattens to distribute the force of heel strike and midfoot arches unlock, relieving tension and encouraging flexibility of arch ligaments to facilitate shock absorption and adaptation to uneven terrain. The ball of the foot makes initial contact with the ground.

2. Midstance. This is the period when weight shifts from the posterior to the forefoot. Pronation ends as the foot begins to roll upward and forward to a position of supination. The subtalar joint and midfoot structures that had relaxed become rigid, preparing the foot to act as a lever that will launch the body forward. Body weight moves directly over the foot.

3. Propulsion. The foot effectively becomes a lever with the posterior structures providing force and the ball serving as a fulcrum. With weight shifted to the outer edge, the foot effectively

> moves downward and away from the leg. Toeing off brings the foot away from the ground and launches it to the swing phase, when no weight is borne until the stance phase repeats at the next ground contact. Structures above the foot undergo equally extensive changes during stance, as demonstrated by the tibia. At the moment of heel strike, it is in external rotation. As the foot moves in and forward to pronate, the tibia begins an internal rotation that concurrently evokes slight movement of the femur. In effect, the leg is moving forward and reducing the distance to the toes.

As body weight shifts forward and the foot begins to supinate, the tibia resumes its external rotation and the femur responds accordingly. This external rotation continues through the propulsive stage and is maintained until the gait cycle repeats itself at the next heel strike.

Movement of the tibia and femur affects structures of the knee. The patellofemoral complex is especially vulnerable to disorders when faulty biomechanics occur.[3] Likewise, because the femoral heads are instrumental in supporting the spine, leg movement also affects spinal stability and alignment. The body normally responds with hip rotation, pelvic tilt and compensatory lumbosacral subluxations.

Weightbearing Problems

The body's orderly response to ground contact and locomotion can be disrupted by alterations in foot biomechanics.[4] The patient may not experience pain in the feet, but may complain of discomfort in the knees, hips or back and exhibit poor posture.[3]

One of the most common causes of biomechanical disturbance is excessive pronation, which occurs when contact accounts for more than 27% of the stance cycle.[5] Understanding the effects of excessive pronation may be helped by considering a "snapshot" of the healthy foot in midstance, the period of transition from pronation to supination. Rear-foot structures lock to form a rigid lever; the calcaneus is straight when viewed from the rear. As body weight moves directly over the foot, the longitudinal arch, toes and heel work together to provide balanced, firm support. There is no straining or gripping with the toes or sides of the feet to maintain balance.

Such balance cannot exist when the foot remains in pronation. The calcaneus continues to tilt inward, and the longitudinal arch remains relaxed and flattened. Soft tissues strain to achieve stability and, over time, may become permanently weakened by plastic deformation. Joints cannot lock to form a rigid lever, so propulsive force is reduced. Excessive pronation has been implicated in a range of musculoskeletal complaints. The following briefly summarizes how it can manifest throughout the kinetic chain:

Knee. The effect of pronation on the patellofemoral complex has already been noted. The patella can be displaced from its femoral groove, causing medial knee pain or leading to chondromalacia patella.

Leg length. Excessive pronation creates a functional inequality of leg lengths which affects muscular pull and the amount of weight borne by the joints. Strain on the body increases and endurance is reduced[6] so that routine movements require greater muscular effort and cause fatigue. Pain is a common response.

Spine/pelvis. A balanced pedal foundation promotes structural integrity that protects the spine from destructive torque, bending and shearing stresses.[7,8,9] Muscle fatigue brought on by postural instability can manifest as pain in the low back,[10] pelvis and sacroiliac joints.[10,11,12,13]

Orthotic Therapy

Research proves that flexible orthotics are helpful in promoting integrity of the pedal foundation.[14,15,16] One study documented a reduction in the degree and duration of pronation.[17] Another project involving members of a running club determined that 75% of those using orthotics eliminated or greatly reduced pain in the feet, ankles, shins, knees and hips.[14]

When structural or functional leg length inequality exists, orthotic therapy can be enhanced with the use of lifts. Functional scolioses, in particular, respond well to lifts.[18] Muscular imbalance and skeletal distortion that transmit directly to the pelvic ring may also be eliminated or reduced when orthotics and lifts are applied.[4,19,20,21,22]

Orthotic therapy has a place in modern chiropractic care because the feet are the foundation of the human frame. The interrelationship of the feet to overall musculoskeletal health cannot be overlooked. Be alert to the "smoking gun" that the weightbearing foot represents.

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