Foot Overpronation
A Review of the Literature

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Abstract

The purpose of this manuscript was to review the current literate on foot overpronation in the attempt to identify key biomechanical changes associated with the condition as well as therapies used to treat it. Twenty-seven peer reviewed journal articles along with three textbooks were used in this investigation. The data showed that the majority of authors believed that overpronating the foot predisposed individuals to overuse injuries; although their data did not always support that belief. The investigation did reveal therapies such as orthotics, exercise, physiological therapeutics and manipulation as beneficial to the overpronated foot. It was determined that further research was needed to support quantitative analyses used in the measurement of foot pronation.

Introduction

Foot pronation is a series of movements which is intended to absorb shock by decelerating and cushioning the foot as is comes in contact with a surface. When this motion is exaggerated, the ankle rolls too far inward and the arch is flattened causing overpronation. This excess of pronation causes biomechanical changes that primarily affect the foot, ankle, and knee; with injury seen to a lesser degree in the pelvis and low back. Overpronation of the foot has been attributed to predisposing individuals to injury in these regions including plantar fascitis, shin splints, stress fractures, bunions, and patello-femoral knee pain[1, 2,3.] The treatment choices for these conditions range from orthotic devices for correction to exercise programs for stabilization.

Abnormally high pronation can be described as flat foot, pes planus, pronated foot, pes valgoplanus, valgus foot, calcaneovalgus foot, and talipes calcaneovalgus. The three main causes of abnormal pronation are congenital defects, acquired deficiencies, and overpronation secondary to neuromuscular disease [3]. The two most common types to present to a healthcare provider with the common overuse injuries mentioned above are acquired and to a lesser degree congenital.

Congenital pes planus is a result of a malposition of the fetus in the uterus or through genetic defects. It can be further classified as flexible or rigid depending on the deformity. The majority of cases related to significant congenital malformations will be diagnosed in the first three years of life as the child begins to ambulate [3].

The acquired form of overpronation can be caused by trauma, ligament laxity, rotational deformities of the lower extremity, and leg length discrepancies. This form develops after weight bearing begins and is compensatory in nature. The patient history along with physical examination helps to delineate the cause of the person's overpronation.

It has been estimated that 60% of the adult population overpronates to some degree. This overpronation accounts for 60-90% of all foot and lower extremity injuries classified as overuse conditions[4]. Its prevalence will continue to increase as the public becomes more health conscience and the population increases its exercise utilization that includes running and walking. Overpronation affects individuals ranging from the novice jogger to the world class Olympic athlete.

The problem with overpronation is that not only can it predispose a person to injury, but recovery from injury is diminished as well [1,5]. This leads to a chronic injury pattern that does not respond well to traditional therapy designed for that specific injury. Patients will therefore be caught in a cycle of nagging injury with minimal relief from treatment unless that treatment addresses the biomechanical alterations caused by their overpronation.

The health care provider therefore needs to be aware of not only the clinical presentation of overpronation, but the diagnostic criteria as well. Once the condition is diagnosed as being the underlying cause of the individual's condition, the doctor should be aware of the treatment options best suited for the patient.

The purpose of this investigation is to review the current literature on the etiology, diagnose, and treatment options for foot overpronation. Furthermore, this manuscript should be viewed as a potential resource for the health care provider to allow them a better understanding of the possible pathologies related to this biomechancial alteration and provide information on the most recent techniques used to correct it. Traditional medical therapies will be discussed as well as conservative measures in which the doctor of chiropractic can utilize for treatment of the hyperpronation as well as the common injuries associated with it.

Materials and Methods

On March 22, 2003 a literature search using Pub-Med was performed at the Logan College of Chiropractic Library. The phrase "foot pronation injuries" was entered with 92 results received. After reviewing the abstracts 8 articles were selected based on content and year of publication no earlier than 1995. On the same day another search of Pub-Med was performed searching "runners knee". This inquiry produced 171 results with 3 articles chosen based on the previous criteria.

A basic search of the Chiro-Mantis database gave 7 results with 4 accepted when using the phrase "foot pronation". The Bridges catalog was searched first with "running injuries" which yielded 1 result, this source however was not utilized. The search of "sports injuries" in the Bridges catalog produced 36 results however none of these results were found to fit the criteria as stated above.

On October 18, 2003, at the Logan College of Chiropractic Library, a search of the keyword "pronation" in the Bridges online catalog produced 11 results with 3 books selected for their content and year of publication. A Pub-Med search of the phrase "overpronation" produced 34 results with 9 papers being selected based on the same criteria. A Chiro-Mantis search of "overpronation" yielded 3 sources. The information used in the current investigation was based on 27 peer-reviewed journal articles and 3 books recovered by the above listed methods.

Results

Although the majority of the research supports overpronation as a causative agent for injury and delayed healing, some authors have not found that to be the case. In 1995 Perry and Lafortune found there was no reduction in the impact loading of the foot comparing normal pronation and overpronation [6]. The increase in impact forces thought to occur in overpronation had been hypothesized to contribute to increasing injury susceptibility. Hargrave et al performed research which supported Perry and Lafortune's conclusion. They investigated subtalar pronation and its' influence on impact forces during a single-leg landing. They found no significant differences among excessive pronators and those individuals considered "neutral" [27]. The authors concluded that there should be a de-emphasis on the role of subtalar pronation and impact loading.

Nigg, in 2001, stated that even when impact forces are increased, these forces are not important factors in the development of overuse injuries, both chronic and acute, in running [7]. The author hypothesized that impact forces act as input signals that cause muscle activation shortly before contact is made on the next sequence of movements. His conclusion was that any attempt to "align the skeleton" to minimize pronation would actually be counterproductive in terms of increasing muscle fatigue or reducing its activity. In 1997, Wen et al found no association between overpronators and normal individuals when examining 355 athletes training for a marathon. The authors did however state that overpronation causing overuse injury makes too much intuitive sense to discount it altogether [8].

Another hypothesis explaining overpronation-causing injury has been the medial/internal rotation of the tibia seen with excessive pronation. During normal gait, some degree of normal subtalar pronation is produced which internally rotates the tibia and permits the femur to flex. This mechanism "unlocks" the knee and allows for shock absorption. When the individual begins extension the tibia must externally rotate to allow for the extension of the femur to occur. The hypothesis that internal rotation of the tibia as a result of overpronation is capable of causing injury is that theoretically the increased internal rotation would delay the external rotation needed to complete the mechanics of the motion [4].

In 1999, however, Reischl et al found that there was a lack of evidence linking foot pronation and the rotation of the tibia on the femur [9]. They stated that although the tibia may rotate on the femur during gait, it does not do so consistently. Furthermore, the investigators believed that because there is no correlation between rotation of the tibia and femur, the knee joint cannot be considered a rigid link that would be abnormally affected by loads during overpronation; thus rotary stress is not transferred up the lower extremity chain. The authors concluded that the relationship between pronation and rotation of the lower segments, namely the tibia, should be examined on a patient by patient basis.

In a 2002 investigation Powers et al studied foot pronation with lower extremity rotation and their association with patellofemoral knee pain. Their results showed there was no data to link individuals with patellofemoral knee pain with excessive pronation or tibial internal rotation [28]. Surprisingly the subjects in their study showed a decrease in tibial rotation, a finding the authors link to a compensatory mechanism to reduce the quadriceps angle.

There is literature supporting the link between overpronation and injury [1-5, 10-12,14-16,19,20,22-27]. McClay and Manal, in 1997, found significant kinematic differences at both the rearfoot and knee when comparing normal runners with overpronators. The authors found that although some of the angular measurements were "subtle", these differences would be magnified with the repetitive nature of running/walking and would result in clinical significance [10]. They also concluded that these minor deviations repeated over time would result in cumulative abnormal stresses to the musculoskeletal system.

In 1999 Stergiou et al examined asynchrony between the subtalar and knee joint during running [11]. The authors found that abnormal tibia rotation, as seen with overpronation, causes a lack of coordination between the subtalar and knee joint. The investigators link the lack of coordination with greater impact forces seen at the foot. They suggest this as a mechanism for various running injuries and that its' measurement may have a predictive value in determining susceptibility to injury.

Hintermann and Nigg, 1998, stated that although some degree of pronation is physiologically needed, excessive amounts are potentially harmful. They found that with overpronation comes increased compensatory internal tibial rotation, which results in increased lower leg and knee problems [1]. The authors stated the amount of calcaneal eversion resulting from excessive pronation was directly related to the degree of internal rotation of the tibia. Thus the lower extremity, beginning at the foot up to and including the pelvis should be treated as one functional unit.

In 2000, Hreljac et al examined the stride characteristics of runners and the potential for injury [12]. They found that those runners who had rapid onset of pronation, without overpronation, and low impact forces had a reduced risk for overuse running injuries. With overpronation comes higher impact forces which can increase the chance for injury up the kinematic chain of the lower extremity.

In 2000, Vicenzino et al investigated the effect of antipronation tape and temporary orthotics on navicular height pre and post exercise. The authors stated purpose for the investigation was to reduce overuse injuries of the lower limb by removing excessive pronation [22]. The investigators reported that overpronation caused the soft tissues of the lower limb to be stressed beyond their elastic region which caused microfailure of the tissues. Thus, injury would be seen as a consequence of the amount of pronation present and the rate or amount of abnormal tissue loading produced.

Research of factors for recurrent stress fractures by Korpelainen et al in 2001 also supported hyperpronation as a causative factor in injury. The authors reported that overpronation was a biomechanical factor which predisposed an individual to lower extremity stress fractures [24]. The stated mechanisms by which the fractures would occur were muscle fatigue and excessive torsion of the tibia.

The stated mechanisms by which overpronation causes injury, i.e. impact forces and tibial rotation, need to be further examined. Impact forces result from the collision between the heel and the ground. The foot is designed to go through heel strike to toe off by a series of motions which absorb shock and cushion the foot's landing. As excessive pronation begins to occur this shock absorption is lost, the arch is stretched, and the foot rolls inward and everts. Impact forces increase as the cushioning effect of normal pronation is lost [7]. The increased forces are carried up the kinematic chain to the joints of the lower extremity. These joints not only have to handle increased forces but also compensate for the malalignment taking place because of the excessive pronation. Much of the compensation is directly related to internal rotation of the tibia.

As the tibia internally rotates in response to eversion the stress transfers up to the knee complex [10]. Not only does the amount of eversion correspond to the degree of tibial rotation, but the arch height can also be a factor. Individuals with higher arches introduced higher transfer load to the tibia during overpronation [1]. This internal rotation of the tibia alters the tibial-femoral joint biomechanics and is a contributing factor to the patello-femoral knee pain seen with foot overpronation.

The history and physical examination make the diagnosis of hyperpronation. Patients who present with lower extremity joint pain need to be examined for foot biomechanics. Patients will typically complain of pain originating at the big toe, heel, achilles tendon, anterior tibia shaft, or in the knee [2,4,13]. Many times these patients will have just begun a running program or recently made a significant increase in their mileage [16].

The physical exam should include an evaluation of the amount of pronation the patient has while weight bearing. This is simply done with the patient in the standing position and the doctor examining the foot from anterior and posterior. The doctor can also have the patient run or walk in the office to determine their foot biomechanics. The arch should also be evaluated with the overpronated foot showing a dramatically decreased or flattened arch [1,2,3,5]. The overpronated foot should demonstrate a valgus heel to achilles tendon alignment. A quantitative measure of pronation is the amount of navicular drop when weight bearing. The midpoint of the navicular is measured in the neutral position in its relation to the floor. It is then re-measured while weight bearing with a drop of greater then 10-mm possibly indicating hyperpronation [2]. Although the use of navicular drop has been found to be reliable, there has not been agreement on how much drop constitutes an abnormal finding [30]. Values ranging from 10-mm to 15-mm have been noted in the literature with some authors now investigating whether the amount of navicular height is as important as if the height is decreased into the propulsive phase of gait [30].

The treatment of foot overpronation includes foot orthotics as the first line of treatment [1,3,4,5,14-18]. The goals in orthotic therapy include preventing a deformity, controlling undesired movement, correction of soft tissue deformities, controlling tone abnormalities, and protecting the weak stabilizer muscles [25]. Approximately 70% of runners who present with lower extremity injuries will improve with orthotic devices [1]. There are many types of orthotic devices available including custom made pieces to over the counter shoe inserts. A study comparing temporary orthotics and antipronation taping found that each device decreased the amount of pronation present, but the effects were reduced after only 10 minutes of exercise [14]. Shoe manufactures also produce corrective footwear with antipronation support built into the shoe itself. The type of orthotic device chosen will depend on the type of doctor sought by the patient and the degree to which that person overpronates.

Patellofemoral pain syndrome (PFPS) is commonly seen with overpronators [15]. Patients will complain of anterior knee pain that is most often times exercise dependent. The knee injures seen with hyperpronation often involve muscle strengthening in the treatment plan. The vastus medialis muscle is a key muscle to consider when a patellar tracking disorder has occurred in response to abnormal biomechanics [15,17]. Increasing the strength of this muscle has been shown to yield more consistent results in patients with foot orthotics being treated for a patello-femoral problem [17].

Shin splints resulting from hyperpronation need strengthening of the tibialis anterior and posterior muscle in the treatment regiment [2,13]. The patient will most often complain of pain near the lower half of the medial tibia that ranges from a dull tightness to a sharp pain. After X-ray analysis rules out stress fracture, treatment of shin splints can begin [13]. Physical therapy modalities including ice, heat, electrical stimulation, and massage should be used in conjunction with other therapies to decrease pain and facilitate healing [2].

Plantar fasciitis is a condition often seen with hyperpronation. Pain and tenderness will be seen beneath the anterior portion of the heel and at the anterior medial border of the calcaneus [4]. Treatment of this condition usually begins with orthoses or braces to decrease the stretch on the fascia. If conservative measures are ineffective, more invasive procedures such as injections of local anesthetic and surgical plantar fasciotomy are considered [4].

In some instances bunions may develop in an overly pronated foot. This condition results from abnormal shearing and compressive forces on the foot with hyperkeratosis and bursitis resulting. The diagnosis is made by the physical examination with treatment aimed at the underlying condition. Palliative agents such as hot soaks, pads, and broad-forefoot shoes can also be utilized [2,4].

Stress fractures are a concern with pain presentations in the lower extremity. The most common sites for stress fractures to occur include the distal tibia, fibula, metatarsals, and the neck or shaft of the femur. Because plain film x-rays may not detect the presence of a stress fracture, advanced imaging is warranted in some instances. If hyperpronation is the cause, an orthotic should first be used. The usual course of action following treatment of the underlying cause is 12 weeks of rest to allow for adequate healing [13].

Chiropractic manipulation can also be utilized in conjunction with the other techniques previously discussed [2,4,13]. By assessing the involved joints and restoring proper joint motion and biomechanics, chiropractic care can play a role in the recovery of patients with these injuries. Recent studies have also studied the use acupuncture and found it to be effective in decreasing pain in patients with patello-femoral pain as a consequence to hyperpronation [15].

Discussion

As the number of individuals who regularly exercise using running and walking increases, the number of overuse injuries involving hyperpronation should rise. It is vital that healthcare providers recognize the symptoms of this biomechanical problem and the treatment options available. The doctor should become proficient in assessing the foot for improper motion and link that finding with symptoms including great toe pain, heel tenderness, achilles tendon irritation, anterior tibial shaft pain, and knee pain. Orthotics are the first line of defense in terms of correcting the underlying problem, but they should be combined with other therapies to decrease healing time and preventing future injury. These other therapies include chiropractic manipulation, muscle strengthening, and physical therapy modalities. The combination of greater physician understanding with a complete treatment protocol will better help those who suffer from overuse injuries resulting from hyperpronation.

Conclusion

New research needs to be undertaken which further examines overpronation as a etiological factor in overuse injuries. Many of the authors who fail to find any significant link between pronation and injury remain convinced that in fact a correlation exists. The lack of reliability in the quantitative analysis of pronation leads to a reduction of power in studies that claim that a relationship exits between foot altering mechanics and injury. As new research backs the validity and reliability of tests such as navicular drop, researchers can attempt to better analyze foot pronation with more standardized and proven protocols. Research based on these standardized measuring protocols will better allow scientists and practitioners to judge the significance of overpronation as it relates to lower extremity injuries.

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