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Arthritis, Foot Pain & Shoe Wear: Current Musculoskeletal Research on Feet

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Abstract

Purpose of review—Both arthritis and foot pain are major public health problems.

Approximately 24% of adults have foot ailments, and the prevalence increases with age. Foot pain, particularly related to shoes, footwear and rheumatic disorders, may be an important modifiable factor. Surprisingly, this topic has received little attention in the rheumatology community.

Recent findings—Despite the major focus of structure and alignment in arthritis, remarkably little work has focused on the foot and non-surgical foot interventions that might affect lower extremity joint alignment, structure and pain in rheumatic diseases. Emerging research suggests that there may be a significant role for foot orthotics and footwear in the treatment of rheumatoid arthritis and osteoarthritis of the hip, knee and foot. This review highlights the current understanding on the topic of foot orthotics and footwear in adults with rheumatic diseases.

Summary—Biomechanical evidence indicates that foot orthotics and specialized footwear may change muscle activation and gait patterns to reduce joint loading. Emerging evidence suggests that orthotics, specific shoe types and footwear interventions may provide an effective non-surgical intervention in rheumatic diseases. Yet good data are sparse, and it is premature to recommend guidelines. As there are a limited number of studies that underpin the foot's role in arthritis etiology and progression, clinical trials and prospective studies are of utmost importance to unravel the links between foot pain, foot conditions and interventions that lessen the impact of rheumatic diseases.

Keywords

arthritis; pain; feet; osteoarthritis; orthotics; footwear; shoes; shoe modifications

Introduction

Both arthritis and foot pain are major public health problems with escalating trajectories. As the number of older adults in the population exponentially increase, so will the burden and proportions of society affected by these problems. A podiatric supplement to the US National Health Interview Survey estimated 24% of the population has at least one foot ailment, with older adults experiencing more troubles than younger adults[1]. Recent

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prevalence data from the Framingham Study reported that 19% of men and 29% of women reported foot pain on most days of the month, with prevalence of pain at specific foot locations ranging from 7% to 13% (figure 1) [2].

For persons with rheumatoid arthritis (RA), these site-specific prevalence reports of foot pain are approximately double those seen in the general population[3]. Foot pain, particularly as it relates to shoes, footwear and arthritis-related disorders may be an important modifiable factor, yet this topic has received little attention in the rheumatology community. Over the past few decades, knee bracing for knee osteoarthritis has garnered significant attention for its role in correcting joint malalignment and possibly reducing progression of knee osteoarthritis. In comparison, very little work has focused on the foot and non-surgical foot intervention that might benefit foot pain and related rheumatic diseases. However, emerging research suggests that there may be a significant role for foot orthotics and footwear in the treatment of rheumatic disease. This review highlights the current understanding on the topic of foot orthotics and shoe wear in adult populations with rheumatoid arthritis and osteoarthritis.

Popular belief is that foot orthoses and therapeutic footwear cause changes in kinematic and skeletal alignment; however, systematic reviews suggest these changes may be minimal[4]. In contrast, research suggests that the benefit of foot orthotics and specialized shoe wear is in changing the shank and foot muscle activation[5] and gait[6] pattern to reduce joint loading. Nigg et al.[7] proposed the “preferred movement pathway model,” hypothesizing that altering afferent signaling with foot orthotics leads to changes in muscle activity to reduce lower extremity stress[8]. These data, when taken together, provide evidence that the foot provides the “micro control” of gait[9] and suggests orthotics and specific shoe wear may provide an effective non-surgical and non-pharmacologic intervention in rheumatic diseases.

The foot in rheumatoid arthritis

Over 85% of patients with rheumatoid arthritis (RA) have painful feet or ankles during the course of the disease, and within the first year of diagnosis up to 57% of patients report foot or ankle symptoms[10]. In patients with RA, inflammation and changes in bone and ligament integrity cause hindfoot instability leading to forefoot deformity[11–12]. The hindfoot instability can be insidious, leading the forefoot to present symptoms first. These ailments include hallux valgus, subluxation, dislocation or erosion of the metatarsophalangeal (MTP) joints as well as hammer toe or claw toe in the lesser toes. Both the hindfoot and forefoot adaptations lead to altered foot and ankle motion, higher forefoot plantar pressure loading, and increased pain during weight-bearing and locomotor activities [13–15].

Correcting plantar loading and stabilizing the foot and ankle may reduce the likelihood of foot deformities and walking disability for patients with RA[11, 15–16]. Commonly this is thought to be accomplished through orthotics or custom shoe wear. However, critical reviews of controlled studies in shoe wear and foot orthotics in persons with RA have shown limited evidence to support their use[17–18], leading a Cochrane review to report only a “silver level of evidence” for prescribing custom-made foot orthoses in patients with RA [19].

Foot orthotics for patients with RA

As the primary reason people use orthotics is to facilitate movement[20], understanding the effects of foot orthotics on gait is paramount. Kavlak et al.[21] noted that using a custom-made foot orthotic for three months reduced pain, increased step and stride length, and

lowered energy expenditure during gait relative to the pre-orthotic condition in patients with RA. A similar study by Mejjad et al. [22] concurred that custom-made orthotics reduced pain, but they concluded that the orthotics were not adequate in improving gait as only step length improved. There was, however, a two month difference in acclimation periods, with participants in the Mejjad study only using the orthotics for one month prior to retesting. While persons without RA may have an acclimation period as short as two weeks[23], research in study participants with RA suggests six weeks with an average of 6 hours per day of use is needed to see a treatment effect[24–25]. The longer acclimation period in the clinical RA studies points to the need for further research to understand differences in orthotic use and gait adaptations in patients with RA.

In addition to treatment time, the type of orthotic (e.g., rigid or soft) relative to foot structure is important as well[25]. In general, rigid orthotics are used to control excessive pronation (pes planus or flat-footedness), reduce forefoot loading [24] and decrease forefoot and rearfoot pain[25]. Rigid orthotics may also reduce the risk of subsequent deformities such as hallux valgus[16]. In one of the few prospective studies, Budiman-Mak et al.[16] showed that using a custom-molded hard foot orthosis led to a 73% decrease in the incidence of hallux valgus over a three-year period. Conversely, soft orthotics are typically used in conjunction with rigid foot ailments, such as pes cavus[26], and reduce both forefoot and generalized foot pain in patients with RA [21–22, 27]. As both rigid and soft orthotics provided adequate comfort in these patients[24–25, 27], the recommendation is that foot orthotics should be custom-designed to meet the individual's unique needs to reduce pain[19, 25].

Shoe wear for patients with RA

In persons with RA, shoes, like their orthotic counterparts, should reduce plantar pressure and stress while stabilizing the foot and ankle. Heat-moldable, customizable shoes or shoes with extra-depth may improve ambulation and reduce pain in patients with RA[28–29]. A study of 25 participants with RA reported that wearing heat-moldable shoes for three months increased walking ability for 80% of the participants[28]. To increase foot and ankle stabilization, extra-depth orthopaedic shoes, especially when aligned with a foot orthotic, may be effective[24].

While current evidence suggests that therapeutic and orthopaedic footwear can improve gait in persons with RA[24, 28–30], there tends to be large resistance in wearing these types of footwear[20, 31]. Many studies have reported that people with RA find the size, aesthetics, design, weight and comfort of orthopaedic shoes to be unacceptable [20, 30, 32].

As orthopaedic and therapeutic footwear tend to have increased bulk, running shoes may provide some of the comforts without the extra size and weight [33]. In a recent single-blind comparison with participants unable to see the type of shoe (control shoe, running shoe or orthopaedic shoe), the participants chose the running shoe over the others based on comfort and weight[33]. It is important to note that the running shoes also provided better attenuation of forefoot plantar pressure and foot loading relative to the orthopaedic and control shoe. These findings suggest that there is an increased need for exploring lightweight alternatives to the traditional therapeutic shoe.

Similar to the running shoe shape is the toe rocker-soled shoe. The toe rocker-soled shoe is thought to reduce pain by decreasing forefoot loading and promoting a normal heel-toe motion during gait[34–35]. With disease progression, patients with RA move from a heel-toe rolling gait to a more shuffled step with a delayed heel lift[10, 36], and the toe rocker-soled shoe may slow this progression[37]. A randomized controlled trial of patients with RA examined the effects of extra deep forefoot-rocker shoe with either a custom-made semi-

rigid insole or a ready-made simple soft insole [37]. Pain was found to decrease in both treated and untreated groups, and between groups there were no clinically identifiable differences. Cho et al.[37] concluded that rocker-soled shoes with comfortable insoles may be enough to reduce foot pain and increase foot function for patients with RA.

The foot in lower extremity osteoarthritis

The role of the foot has been limitedly explored with regard to lower extremity osteoarthritis (OA). While there are no prospective studies available, cross-sectional studies show a strong and notable association between foot alignment and hip and knee OA[38–40]. These findings suggest that patients with hip OA are more likely to have a high-arched foot, whereas patients with knee OA are more likely to be flat-footed[38–40]. These studies do not provide a causative mechanism between foot structure and OA development, but they do provide justification for exploring the role of the foot in lower extremity OA. Further, the known progression between primary hip and knee OA to subsequent joint OA development (see Figure 2) necessitates research exploring the role of the foot in lower extremity OA.

Foot orthotics and shoe wear in knee OA

The most common knee osteoarthritis is medial compartmental knee OA[42]. Though the cause non-traumatic medial knee OA is unknown, two mechanisms of disease are thought to be a high rate of loading and a high external adductor moment during walking. As such, studies often focus on the effects of shoe wear and foot orthotics on these biomechanical markers in medial compartmental knee OA. Most research on foot orthotics focuses on lateral wedge orthotics in this population as lateral wedge orthotics are thought to reduce the knee adductor moment to reduce medial-compartmental knee stress (see Figure 3).

Butler et al.[44] reported 12 of 20 participants with medial knee OA had a 10% reduction in the first peak knee adduction moment and five of the 20 exhibited a 10% reduction in the second peak knee adduction moment when using lateral wedged insoles during walking. A long-term study confirmed these results, showing that using lateral wedged insoles for two years showed decreased adductor moments during gait with and without the insoles (i.e., when walking barefoot)[6]. These latter results suggest that transient effects of foot orthotics can lead to long-term gait adaptations that reduce adductor moments. The researchers concluded that “as excess loading of the knee is associated with OA progression, these sustained reductions may have a beneficial impact on the disease course”[6].

Though this conclusion may be valid, a similar two-year prospective randomized controlled trial of lateral wedge orthotics for patients with knee OA showed no structural radiographic difference between patients who used the lateral wedge insoles relative to neutral insoles[45]. They did find, however, patients who used lateral wedged orthotics had lower NSAID (nonsteroidal anti-inflammatory drug) usage and better compliance compared to those with the neutral-wedged insole. The authors concluded that the decreased NSAID use and better compliance provide evidence of beneficial effect of lateral wedge insoles in patients with knee OA. A subsequent 1-year randomized controlled trial by Barrios et al.[46] confirmed these results, while also noting that patients in the lateral wedge orthotic group showed earlier improvements relative to the neutral orthotic.

By convention, lateral wedged orthotics are typically placed in the shoe, but a 2007 study examined the effectiveness of this practice. In this study Kuroyanagi et al.[47] assessed the short-term effects of insole orthotics versus subtalar strapped orthotics. They found that while both reduced loading relative to walking barefoot, the subtalar strapping had a greater reduction in medial knee loading in patients with moderate, but not severe, knee OA.

In addition to orthotics, shoes may play a role in the treatment of knee OA. Erhart et al.[48–49] explored variable-stiffness shoes in patients with medial knee OA. In this work, the variable-stiffness shoe reduced pain during walking while lowering the knee adductor moment. With six months of use patients improved function and had less pain with the variable-stiffness shoe. Other studies corroborate these findings, as Shakoor et al.[50] reported that patients with knee OA showed a decreased knee adductor moment when walking with the “mobility shoe” relative to both the control and the patient’s self-selected shoes.

Interestingly, Shakoor et al.[51] also found that when comparing clogs, stability shoes, flat walking shoes, and flip-flops, in patients with knee OA peak knee loads were greatest in the clogs and stability shoes and least in the flat walking shoes and flip-flops, as well as when walking barefoot. These data suggest that footwear is an important treatment consideration in patients with knee OA. They concluded that shoe flexibility and heel height (small height is better) may be important differentiating characteristics of shoes that affect knee loads. Together these studies suggest that footwear can affect knee joint loads and that clinicians should evaluate the patient’s shoes when exploring treatment strategies in patients with knee OA.

Foot orthotics and shoe wear in hip OA

Few studies have attempted to evaluate shoe and orthotic treatment for hip OA. Overall, the evidence for or against the orthotics is weak and no randomized controlled trials have evaluated their efficacy.

Gélis et al. [52] aimed to develop clinical practice guidelines for the use of foot orthotics in the treatment of knee and hip OA but found weak evidence for the use of foot orthotics. Lee et al. [53] agreed, stating that with the lack of controlled trials on foot orthotics their effectiveness is unknown. Despite this lack of evidence, particularly with regard to hip OA, the OARSI (Osteoarthritis Research Society International) recommendations state that “Every patient with hip or knee OA should receive advice concerning appropriate footwear” [54]. It is stated, however, that this recommendation concerning footwear is based on expert opinion given the lack of controlled trials in patients with hip OA.

Foot orthotics in midfoot OA

A lesser-known osteoarthritis is that of the midfoot. The etiology of midfoot OA is poorly understood. It has been linked to trauma, inflammatory arthropathy, mechanical stress and idiopathic osteoarthritis. Like other forms of non-traumatic OA, midfoot OA may be a result of abnormally high mechanical stress. Davitt et al.[55] hypothesized that aberrant loading may be the result of toe length abnormalities, as patients with idiopathic midfoot OA were more likely to have a second toe longer than the great toe. Yu et al.[56] suggested that the aberrant loading may be a result of past shoe use or footwear, noting that chronic high-heel use increased the risk of midfoot OA.

Promising non-invasive treatment of midfoot OA is a full-length orthotic, which decreases pain and increases foot function by reducing both the magnitude and duration of medial midfoot loading[57] as pointed out by Rao and colleagues. The orthotic intervention may promote a “stiffening” strategy[58], which may increase the mechanical advantage of the great toe and reduce the stress at the medial midfoot. However, future work is needed to understand the mechanical effects of orthotics on this population and the optimal time needed for treatment effect.

The role of footwear in arthritis and foot pain

As footwear is an important treatment strategy for reducing pain and improving function in population with arthritis, it is plausible to believe that footwear may be implicated in the disease etiology (as is the case with midfoot OA[56]).

As women tend to be at a greater risk of hip and knee OA, differences in shoe wear have been implicated, particularly with regard to high heel use. However, a retrospective analysis of factors affecting knee OA reported that wearing high heels did not increase the risk for developing this OA[59], dispelling the belief that high-heeled shoes are a major factor that promotes joint degeneration in women.

Moreover, wearing high heels has shown mixed results with the development of foot pain. A 2009 study by Dufour et al.[2] examined factors associated with foot pain, including current and past shoe wear. They found that women who regularly wore “poor shoes” (e.g., high heels, sandals, slippers) in their past were more likely to experience foot pain in their later years compared to those who wore average shoes.

Contrary to these results, a 2010 study by Paiva de Castro et al.[60] examined the prevalence of current pain among older Brazilian men and women when wearing shoes, and the relations between foot pain and high-heeled shoes. Women had a higher prevalence of foot pain compared to men. Approximately 50% of women and 30% of men reported foot pain when wearing shoes, and in this study current high-heeled shoe use was not associated with pain.

Though the long-term effects of wearing high heels are inconclusive, research has implicated shoes in general with poor foot development and alignment. A study investigating the current[61] and past[62] shoe wear in over 4000 adults and children in India concluded that wearing shoes, particularly during the “critical age in the development of the medial longitudinal arch” (up to 6 years of age), may increase the incidence of flat-footedness. In their sample, the longer a child waited before regularly wearing shoes, the less likely he or she was to have flat feet and foot ligament laxity as an adult[62]. They concluded that prospective long-term studies are needed to evaluate the possible link between shoe use and development of flat footedness. Further, with the known associations between foot structure and OA development[38–40], the role of past footwear and foot structure will certainly be an important component in understanding the etiology of joint degenerative diseases.

Conclusion

This review presented our current understanding of musculoskeletal research that has focused on preventing or relieving foot pain and the effect of footwear and orthotics in adults. Non-surgical interventions may be important modifiable factors for the prevention of foot pain and slowing the foot-related progression of RA, osteoarthritis and perhaps other rheumatic diseases. Emerging evidence indicates that orthotics and perhaps footwear interventions play an important role in rheumatology-related foot health. Study design will be of utmost importance in unraveling the links between foot pain, foot conditions and interventions that lessen the impact of rheumatic diseases, as far too few prospective studies have been performed and more randomized clinical trials are needed. There is insufficient evidence to conclusively link footwear interventions with improvement in persons with RA and OA of various sites. Recent studies of interventions have been inconsistent.

Given the current status of arthritis, foot pain and footwear in the literature, good data are sparse and it is premature to recommend guidelines. More data focusing on rheumatic

conditions and specific foot conditions and possible interventions are desperately needed. In addition, there are massive holes in our current knowledge, particularly around pediatric foot issues as well as the biomechanical pathways. Both non-surgical and surgical interventions require more evaluation to add to our meager understanding of possible interventions to improve foot-related pain and dysfunction in rheumatologic conditions. Further studies of the etiology of foot pain and foot biomechanics are essential. Prospective studies are needed to explore the mechanisms by which foot conditions and foot pain operate and to make recommendations for those persons with rheumatic diseases. Longer-term prospective controlled intervention studies are needed to determine whether treatment with specific foot interventions or alterations in biomechanics can improve physical functioning, lessen the burden of disease or reduce severity of rheumatic diseases affecting the feet.

KEY BULLET POINTS

- Foot pain, particularly as it relates to shoes, footwear and arthritis-related disorders may be an important modifiable factor, yet this topic has received little attention in the rheumatology community.
- Emerging research suggests that there may be a significant role for foot orthotics and footwear in the treatment of rheumatoid arthritis and osteoarthritis of the hip, knee and foot.
- Biomechanical evidence indicates that foot orthotics and specialized footwear may change muscle activation and gait patterns to reduce joint loading.
- Clinical trials and prospective studies are needed to unravel the links between foot pain, foot conditions and interventions that lessen the impact of rheumatic diseases.

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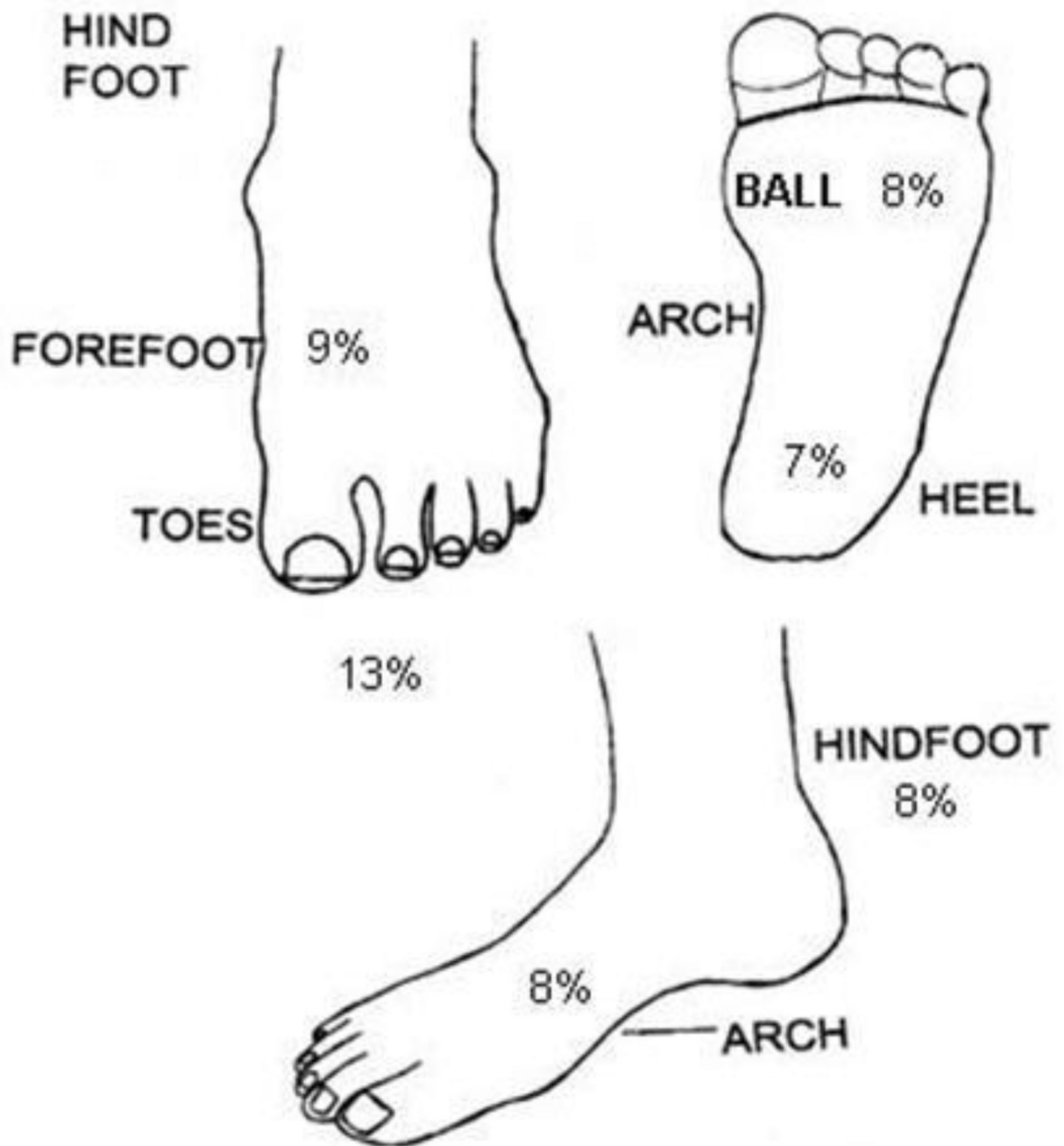


Figure 1. Diagram of the foot and prevalence of pain in each location as reported by the 3,372 men and women in the Framingham Foot Study, 2002–2008 [2].

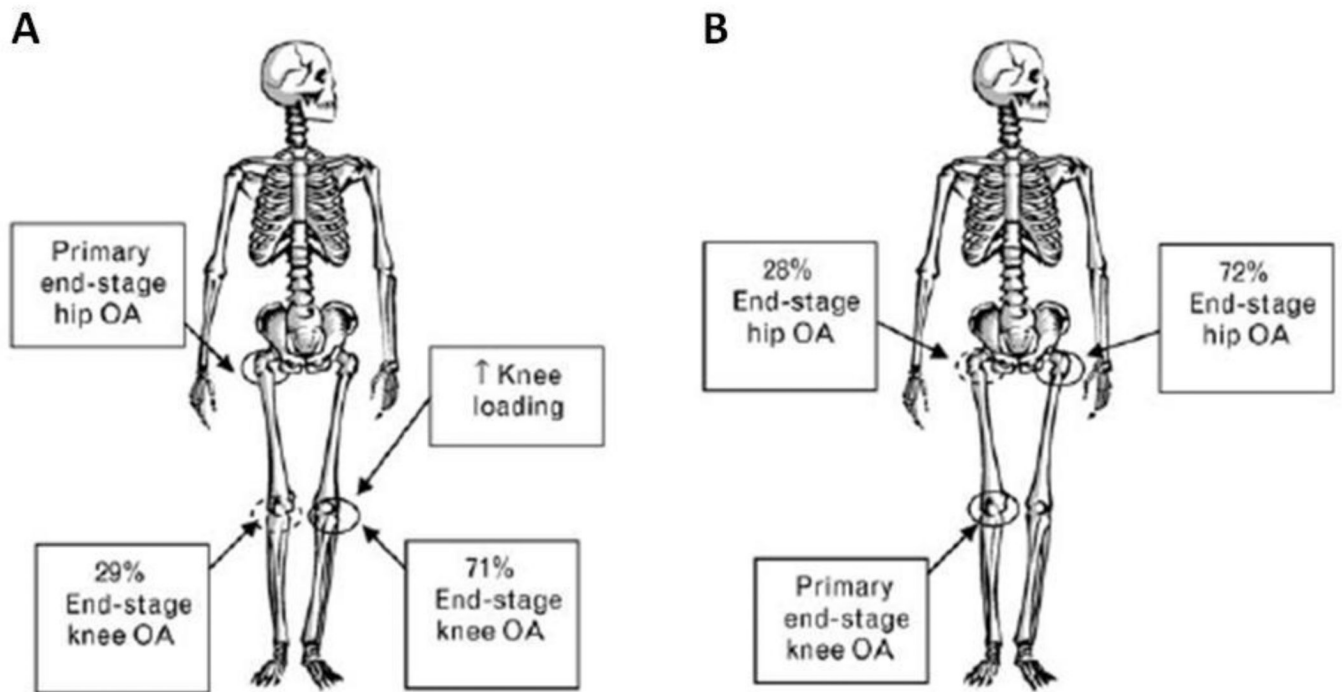


Figure 2.

There is a known relationship between hip and knee osteoarthritis (OA) progression [41]. Diagram A shows the progression of end-stage hip OA to the contralateral knee, and diagram B shows progression of primary knee OA to contralateral hip OA. Notably missing from these schematics is the foot's role in OA etiology and/or progression.

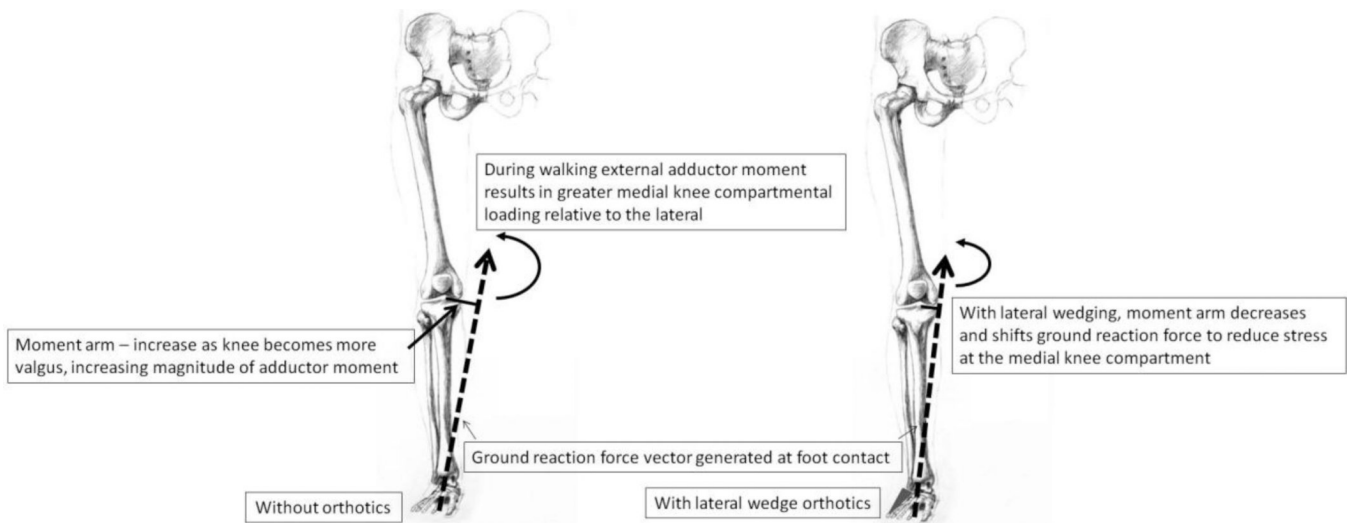


Figure 3.

During walking a ground reaction force (GRF) and an associated external adductor moment is generated. The external adductor moment is related to the GRF and the moment arm, defined as the distance from the knee joint axis to the GRF. With malalignment, either at the foot or knee, there is a higher external adductor moment at the knee joint. Lateral wedge orthotics is thought to decrease moment arm to reduce the external adductor moment and stress at the medial knee compartment. (Adapted from [43].)