

R E V I E W

May footwear be a predisposing factor for the development of hallux rigidus? A review of recent findings

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Abstract. Hallux rigidus (HR) is the clinical manifestation of osteoarthritis of the first metatarsophalangeal (MTP1) joint and affects about 2.5% of people older than 50 years. The condition may significantly impact patients' quality of life, leading to debilitating pain and limited range of motion (ROM). Numerous hypotheses have been postulated about contributing factors to the development of the disease, but with poor proven association. Some types of footwear over others may transmit altered pressure and stress toward the forefoot and this can significantly contribute to development of the condition. The purpose of this review is therefore to analyze the importance of correct footwear and if an incorrect shoe can influence the development and/or worsening of symptoms in patients affected by HR. From the results of the studies, it appears that symptoms improve with rigid-soled low-heeled shoes such as boots and worsen with flat flexible-soled shoes such as sandals and tennis shoes, which should therefore be avoided. Despite this, although incorrect footwear increases symptoms, a direct correlation with the development of the condition has not been detected but rather an improvement in comfort in some types of shoes than in others. In predisposed patients, incorrect footwear is more a way to increase symptoms than a real risk factor for the development of the disease, remaining in a very low risk percentage to be considered indicative. (www.actabiomedica.it)

Keywords: Hallux rigidus; Hallux limitus; Shoes; Footwear; Risk factor

Introduction

Hallux rigidus (HR) is the clinical manifestation of osteoarthritis of the first metatarsophalangeal (MTP1) joint and affects about 2.5% of people older than 50 years. The condition may significantly impact patients' quality of life, leading to debilitating pain and limited range of motion (ROM) (1). The pathology was first defined by Davies-Colley (2) in 1887 as “hallux flexus”, then Cotterill (3) described the term HR to characterize the painful limitation of motion of the

MTP1 joint. DuVries (4) and subsequently Moberg (5) noted that immediately after hallux valgus, HR is the most common problem of the MTP1 joint with a higher incidence of female involvement (6).

The terms “hallux rigidus” and “hallux limitus” are used indifferently, though hallux limitus (7) should be understood as a limitation of dorsiflexion, while HR, which is characterized by ankylosis, is a total absence of movement (8) (Fig. 1)

Etiopathogenesis of the disease is still not entirely clear (9); anatomy of the MTP1 is unique and

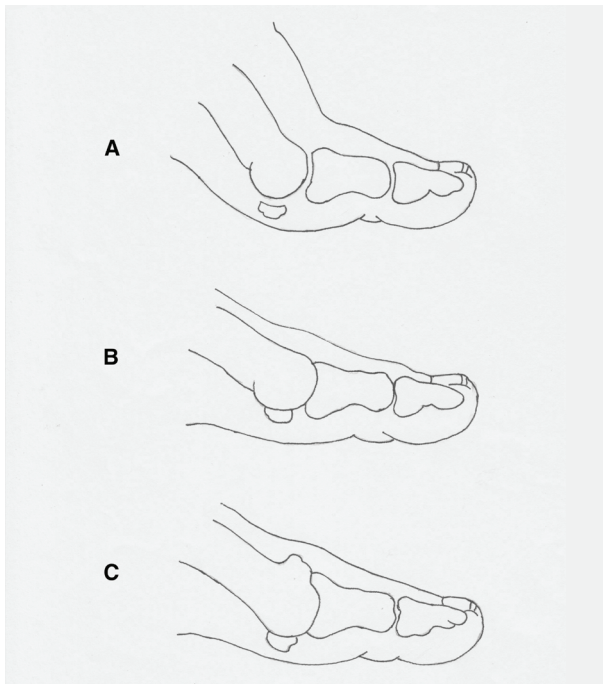


Fig. 1 A schematic drawing of the development of hallux rigidus: normal anatomy at the hallux metatarsophalangeal joint (A); hallux with a reduction of the joint space and a limitation of dorsiflexion (B); advanced hallux rigidus with dorsal osteophyte, narrowing of the joint space, and subcortical irregularities (C).

its configuration may play a significant role in the HR development (10) as it transfers about 119% of an individual's body weight with each step (1).

Numerous hypotheses have been postulated about contributing factors but with poor proven association. Among the external factors, high-heeled shoes transmit increased pressure and stress toward the forefoot and this can significantly contribute to development of the condition (11).

The correlation between inadequate footwear and foot anomalies has been stressed several times in the literature (11); however, with conflicting opinions. Some authors argue that painful symptoms improve with stiff soled shoes such as boots and worsen with flexible soles such as sandals and tennis shoes (12). Others report that, in the subjects analyzed, the association between HR and footwear was not statistically significant (13, 14). However, it is not yet clear whether footwear is solely related to the worsening of painful symptoms or whether it is a real predisposing factor for the development of HR (2, 15).

The purpose of this review is therefore to analyze the importance of correct footwear and if an incorrect shoe can influence the development and/or worsening of symptoms in patients affected by HR.

Anatomy and kinematics of the first metatarsophalangeal joint

The MTP1 joint normally has a ROM of 110° , allowing a plantar flexion of 35° and a dorsal flexion of 75° (16). The center of rotation is stabilized by the three-dimensional geometry and the consistency of the articular surfaces, to which the plantar fascia, lateral ligaments, joint capsule and dynamic structures are added (17); the flexor hallucis longus, flexor hallucis brevis, extensor hallucis longus, hallucis adductor and hallucis abductor contribute as well (16).

In a normal foot, center of rotation is on the metatarsal head (18, 19) and is in constant movement; on the other side, in HR the center of rotation is located eccentrically to the metatarsal head or outside (20). Furthermore, the proximal phalanx moves gradually to a plantar position respect to the metatarsal head, resulting in gradual displacement of the center of rotation (16, 20).

Cartilage lesions mainly occur on the dorsal aspect of the first metatarsal head causing repeated compressions under severe biomechanical stress. These structural changes, over time, result in dorsal locking of the joint during dorsiflexion with consequent development of joint degeneration, dorsal osteophytes and possibly overall ankylosis. The sesamoids are also involved in the degenerative process following the retraction of the plantar structures, with displacement of the center of rotation and consequent compression of the articular surface throughout the ROM and stiffness (21).

The continuous extreme traction that occurs causes hypertrophy of the sesamoids with extension in the sagittal plane. The consequent retraction of the flexor hallucis brevis, over time, can also lead to proximal displacement of the sesamoids relative to the metatarsal head (22). Kinematic analyses of the MTP1 joint in HR reveal a decrement in the arc of motion, with relatively normal plantar flexion but reduced dorsiflexion (16, 23). Without dorsiflexion, there can be

increased plantar foot pressures to the hallux, so pressure in stance and propulsion may transfer laterally and distally, under the lesser toes (24). Bryant et al. (25) found that in HR patients an oblique axis is used in push-off, which subjects the lateral forefoot and toes to increased loading and results in hyperextension of the interphalangeal joint of the hallux (24).

Risk factors

There is inconsistency in the literature regarding the numerous causes of HR, not universally agreed and with little objective evidence (26, 30). Aetiology of HR reaches back to 1887, when Cotterill (3) believed rheumatoid diseases and infections as a major cause of the condition. Davies-Colley (2) and other authors (31, 32) hypothesized traumatic events to be a possible cause for this disease. On the contrary, Thomas (33) excluded singular traumatic lesions and rather regarded deforming osteoarthritis as aetiology of HR, while Jack (34) proposed a spontaneous onset. Ulterior investigations showed cartilage's defects as well as osteochondral lesions following injuries to be the cause of HR (26, 35).

Coughlin and Shurnas noted that HR is associated with hallux valgus interphalangeus, and bilateral condition is associated with female gender and a family history (13). Development of degenerative changes can also be secondary to repetitive stress or inflammatory or metabolic conditions such as gout, rheumatoid arthritis and seronegative arthropathies (13, 36). Damage of the articular surface of the MTP1 joint due to osteochondritis dissecans has been proposed as well (37). Structural and biomechanical factors, such as metatarsus primus elevatus, long first metatarsal and metatarsus adductus may also lead to increased risk of HR (37, 38). Poor footwear (2), pes planus (39), ankle equinus (15), and functional hallux limitus (40) has also been cited. However, most cases are likely idiopathic (8).

Body Mass Index (BMI) seems not considered to be a predisposing factor for HR (41). However, reducing weight-bearing and starting a regular physical activity appears to be useful not only in these cases but in the vast majority of pathologies (42-45).

Footwear and foot anomalies

The link between poor footwear and foot anomalies has been underlined several times in the literature (11, 46). Bradford (47) in 1897 noted several alterations caused by shoes through an analysis of historical art, including medieval civilizations and art of ancient. Nowadays, contemporary shoe styles, especially for women, continue to cause deformity and predispose to damage, even more than in the past.

Badly fitting footwear are a major contributing factor to the difference in incidence of foot disorders in both sexes (48). Traditionally, men's shoes bring to be larger and have lower heels than women's typology and this could be related to some disorders, especially in the forefoot.

In effect, both high heels and a narrow toe box have been involved in the development of such forefoot abnormalities as metatarsalgia, Civinini-Morton syndrome, Freiberg infraction, hallux valgus with bunions, callosities and HR (46, 49).

Nowadays, it is therefore widely accepted that high-heeled shoes transfer increased pressure and stress toward the forefoot (Fig. 2) and even raise also the risk for post traumatic fracture during falls from above (50-52). Moreover, shoes with heels as short as 1.5 inches have been shown to significantly increase knee torque and can have implications for knee osteoarthritis (53).

Dancers and athletes should be considered separately, as they belong to particular populations; in these cases marked alterations in load result in specific injury patterns (11).

Footwear as a predisposing factor

The correlation between HR and inadequate footwear has a long history. In 1887, Davies-Colley (2) analyzed a young man in which he noted the pressure of short rigid boots upon an abnormally long great toe. Hoffmann et al. (54) in 1905 made a comparative study of barefooted and shoe-wearing subjects and noted that abnormal biomechanics of the foot may predispose to disorders of the first MTP1 joint and that footwear may further compound these abnormal biomechanics.



Fig. 2 High-heeled shoes transfer greater pressure and stress to the forefoot and this can increase the conflict on the dorsal aspect of the first metatarsophalangeal joint and therefore painful symptoms.

Similarly, McMurray (55) in 1936, identified ill-fitting shoes as the cause of this adolescent condition when he wrote, “In adolescence the condition is usually found in association with a long foot which is narrower than normal, and examination of the great toe shows that the power of dorsiflexion is lost.” Then, Bingold (15) and DuVries (4) mentioned footwear that is too short, Lorimer et al. (56) footwear that is too loosely fitting and Cracchiolo (57) footwear that induces hyperextension of the big toe as a cause of HR. Some authors referred that HR patients even exhibited an intolerance to footwear (58, 59).

Unluckily, the vast majority of evidence over the years resulted in mixed results. The few studies that have addressed the condition found that the association between HR and footwear was not statistically significant (13,14).

Discomfort during ambulation seems to get worse during the heel-rise and toe-off. Patients refer that symptoms get better with stiff sole shoes such as boots and worse with those with a flexible sole such as sandals and tennis shoes (Fig. 3) (60).

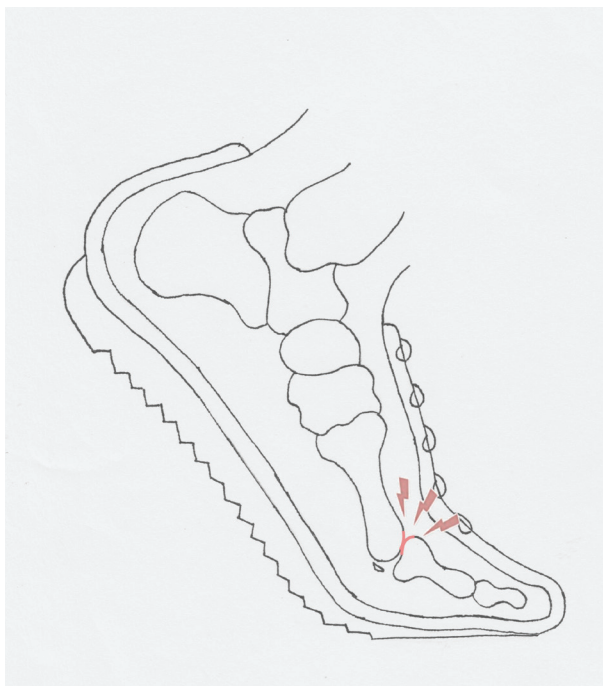


Fig. 3 Flat flexible-soled shoes, such as tennis type, increase the requirement for dorsiflexion at propulsion resulting in conflict on the dorsal aspect of the first metatarsophalangeal joint and painful symptoms.

Beeson et al. (41) in their study, footwear was not found to be a contributory causes but rather subjects reported a number of factors responsible for aggravating the symptoms of HR in which footwear was the most common (23% of which 67% women and 33% men).

Sim-Fook (14) examined 118 Chinese subjects who wore and 107 that not wore footwear. Only 17% of those wearing footwear and 10.3% not wearing footwear were affected by HR. This revealed a marked gender bias, as 84% of the unshod were female and 67% of the shod were male. In their study, Coughlin and Shurnas found that 16% of analyzed patients considered their footwear to be a predisposing factor of HR but they didn't find no statistically significant correlation between footwear and HR to confirm this ($r = 0.08$, $p > 0.1$) (13).

In another study (41) only 23% patients considered their footwear a contributory cause of their HR. Nevertheless, the frequency of MPT1 joint pain in HR associated with footwear was found to affect only 36% of them. In this study, different types of footwear were tested to highlight the most related type. High-heeled

shoes (31%) were the most common types of footwear restrictions reported by females, probably because the MTP1 joint is held in an extended position during the gait. An excessive overuse of flexor hallucis brevis may be caused by slip-on shoes (16%) and Wellington boots (3%) to maintain stability, with subsequent sesamoid suffering. Dress shoes compressed the forefoot in 14% of subjects, this because they can alter MTP1 joint biomechanics. In 5% of cases, flat shoes can predispose to HR cause they increase the requirement for dorsiflexion at propulsion. In 3% of patients it was found that shoes with a seam over MTP1 joint rub the joint, especially if dorsal osteophytes are present, and may this compress the dorsomedial cutaneous nerve resulting in numbness or dysesthesia along the medial border of the hallux. Walking boots and new footwear only contributed to HR in very few cases. No restrictions on footwear were reported in a quarter of the patients, most of them males.

Conclusion

Over the years, a fair number of studies have been published to highlight the correlation between footwear and the development of HR. Unfortunately, the vast majority of evidence has produced mixed results.

From the results of analyzed studies, it appears that symptoms improve with rigid-soled low-heeled shoes such as boots and worsen with flat flexible-soled shoes such as sandals and tennis shoes, which should therefore be avoided. Despite this, although incorrect footwear increases symptoms, a direct correlation with the development of the condition has not been detected but rather an improvement in comfort in some types of shoes than in others.

In conclusion, in predisposed patients combined with other risk factors, incorrect footwear proving to be more a way to increase symptoms than a real risk factor for the development of the disease, remaining in a very low risk percentage to be considered indicative.

Despite good quality of the articles analyzed, further studies with a longer follow-up period and high-quality randomized controlled trials are needed to provide more robust and accurate evidence.

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