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# The effect of good and poor walking shoe characteristics on plantar pressure and gait in people with gout

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ABSTRACT

*Background:* Previous research has shown that good footwear characteristics may reduce foot pain and foot-related disability in people with gout. The aim of this study was to determine the effect of good and poor footwear characteristics on plantar pressure and spatiotemporal parameters of gait in people with gout.
*Methods:* Thirty-six people with gout participated in a cross-sectional repeated measures study. Plantar pressure and spatiotemporal parameters were recorded in two shoe conditions: (1) the participants own footwear, and (2) either a new pair of walking shoes with good footwear characteristics ($n = 21$) or poor characteristics ($n = 15$). Differences between good and poor shoe groups compared to participants own shoes were also determined.
*Findings:* Compared to participant's own shoes, footwear with good characteristics significantly reduced peak pressure at metatarsal 3 and 5, reduced pressure time integrals beneath the heel and metatarsals 3 and 5 and increased pressure time integrals beneath the midfoot. The footwear with poor characteristics significantly increased peak pressure beneath the heel and lesser toes, reduced peak pressure at metatarsal 3 and reduced pressure time integrals in the midfoot compared to participants own shoes. Both good and poor footwear significantly increased walking velocity, step length, and stride length compared to participants own shoes.
*Interpretation:* Walking shoes with good footwear characteristics can influence plantar pressure values and encourage a more efficient heel to toe gait pattern in people with gout. These changes may contribute to the reduction in foot pain and foot-related problems in this population.



## 1. Introduction

Gout is a form of inflammatory arthritis caused by the deposition of monosodium urate (MSU) crystals in joints and soft tissue. The disease is characterized by painful acute flares and may progress to a tophaceous disease and erosive arthritis. Gout has a predilection to affect the feet, with the knee and smaller joints of the feet the most commonly affected (Dalbeth et al., 2013). Involvement of the first metatarsophalangeal joint (1MTP) is regarded as a discriminatory diagnostic feature of the disease (Prowse et al., 2013). In a recent study using dual-energy computed tomography to examine bones and tendons in patients with gout, Dalbeth et al. (2013) found the first metatarsal head was the most commonly affected by MSU deposition (38%), followed by the lateral malleolus (25%) and proximal calcaneus (25%). MSU deposition was also observed frequently at the Achilles tendon (39%) and the peroneal tendons (20%). The clinical relevance of this is currently unknown despite the important role that tendons play in musculoskeletal function and gait.

People with gout report significant foot pain, impairment and disability during acute flares which cause severe restrictions in activities related to daily living and recreation (Rome et al., 2012a,b). Importantly, more than half of patients still report moderate foot-related problems during intercritical periods (Rome et al., 2012a). Furthermore, everyday tasks such as walking are rated very highly by people with gout as a discriminatory feature of the disease (Prowse et al., 2013). Our previous work has shown that people with gout have a significantly reduced walking speed compared to healthy controls, which emphasizes the extent of walking disability in this population (Rome et al., 2012b).

Emerging evidence suggests that footwear to be an effective non-surgical and non-pharmacological intervention in inflammatory disease (Dufour et al., 2009). However, poorly fitting shoes have also been linked to foot pain in rheumatoid arthritis (Silvester et al., 2010) and poor footwear characteristics that include inadequate stability, and poor cushioning have been reported to exacerbate foot pain, disability and impairment in people with gout (Rome et al., 2011a). Furthermore,

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we have recently reported that poor footwear may contribute to the development and delayed healing of ulceration in people with gout (Rome et al., 2014). Previous plantar pressure studies in other chronic conditions such as diabetes and rheumatoid arthritis have focused on relieving areas of high pressure through footwear in order to reduce pain and the risk of tissue damage (Bus et al., 2009; Hennessy et al., 2007; Kastenbauer et al., 1998; Lavery et al., 1997; Mueller, 1999; Perry et al., 1995). Interestingly, people with gout have been shown to exhibit high pressure patterns in the midfoot and heel only, when compared to controls, while pressure values beneath the hallux are reduced (Rome et al., 2012b). Coupled with the reduced walking speed also observed in this population, these pressure patterns may reflect inefficient propulsion and forward load progression (Rome et al., 2012b). The role of footwear in gout may therefore be to encourage normal heel to toe loading and gait efficiency in order to reduce abnormal strain on areas of the foot prone to crystal deposition including the first metatarsophalangeal joint and Achilles tendon.

Our group has previously undertaken an 8-week prospective intervention study comparing the effect of four different participant-selected walking shoes on patient-reported foot pain and disability in gout (Rome et al., 2013). The shoe with good characteristics (ASICS Cardio Zip; RRP US$225) was both acceptable to patients in terms of comfort, fit and support. This resulted in significantly greater improvements in pain, impairment and disability at the 8-week follow-up compared to the three low-cost shoes classed with poor footwear characteristics (Helix Viper, Dunlop Apollo, and Dunlop Asteroid; RRP US $30-35). A number of features in the Cardio Zip shoe, which were lacking in the other three shoe types, may have been responsible for the reduction in pain and disability (Rome et al., 2013). The medial size zip closure in the Cardio Zip shoe enhances the ease of putting on and taking off the shoe. The Cardio Zip shoe also uses a dual-density midsole system to control motion (Rome et al., 2013). Barton et al. (2009) reported that the motion control properties of footwear are considered an important shoe feature in the management of patients with rheumatoid arthritis and musculoskeletal injuries. Another feature of the Cardio Zip shoe that may have reduced foot pain was the use of gel cushioning in the heel and forefoot regions to improve shock attenuation. This shoe element was not present in the other three shoe types. Dufour et al. (2009) reported that shoes that have softer outsoles and midsoles, or insoles that use elements of gel, foamed polyurethane or air chambers can smooth (low pass filter) the shock wave associated with foot-strike. Finally, the Cardio Zip shoe midsole/outsole has a 'rocker' type system to create a smoother heel to toe transition during the gait cycle while maintaining both stability and comfort. Previous studies have reported that the toe rocker-soled shoe is thought to reduce pain by decreasing forefoot loading and promoting a normal heel-toe motion during gait (Bagherzadeh et al., 2013; Cho et al., 2009; Fong et al., 2012); Cho et al. (2009) reported that rocker-soled shoes with comfortable insoles may be enough to reduce foot pain and increase foot function for people with rheumatoid arthritis. It is unknown how good and poor footwear characteristics influence the functional and biomechanical characteristics of the foot and whether this may contribute to the improvement observed in patient outcomes. The aim of this study was to determine the effect of shoes with good and poor footwear characteristics on plantar pressure and gait parameters in people with gout.

## 2. Methods

### 2.1. Study design

This study was conducted at the start of a larger prospective intervention study in which 36 participants with gout selected one of four pairs of new commercially-available walking shoes which they wore for an 8-week period (Rome et al., 2013). At the baseline visit, all participants tried each of the shoes in a randomly determined order. Randomization involved the presentation of one of a series of sealed envelopes, indicating the order in which the footwear was to be assessed by the participant. Participants were blinded to footwear brands and logos during their selection to ensure they based their choice on comfort, fit, style, sole and weight. Brand names and logos were concealed using small lengths of black masking tape, which did not cover any of the design features of the shoe. At the baseline visit, patients participated in this repeated-measures study, in which each individual walked in two different conditions: (1) their own footwear, and (2) their chosen new study footwear. For the purpose of this analysis, participants were stratified into two groups based on their chosen study footwear: (1) the good shoe group (Cardio Zip) ($n = 21$) and (2) the poor shoe group (Viper, Apollo, Asteroid) ($n = 15$) (Fig. 1).

### 2.2. Participants

Participants were recruited from the rheumatology clinics based at the Auckland and Counties Manukau District Health Boards, Auckland, New Zealand. As previously reported (Rome et al., 2013), participants were included if they were (i) over 18 years of age, (ii) had a history of gout according to the 1977 ACR preliminary classification criteria (Wallace et al., 1997) and (iii) were able to walk a minimum of 10 m without the use of a walking aid. They were excluded if they had (i) received any treatment for foot pain in the previous 4 weeks, (ii) an acute gout flare at the time of assessment, (iii) a history of surgery to the foot or (iv) received treatment with foot orthoses or footwear within the previous 3 months. The Northern Regional X Ethics approved this study and local institutional approval was also obtained. All participants provided written informed consent. The trial was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12612000735853).


**Fig. 1.** Cross section of study shoes. (A) Shoe with good footwear characteristics (Cardio Zip). (B) Shoe with poor footwear characteristics (Dunlop Asteroid). (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)