Beliefs About and Use of Forefoot Lateral Wedging in Podiatric Medical Practice: A Survey of Podiatric Physicians in New Zealand

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Abstract

Background

There is currently limited evidence exploring the beliefs and application of forefoot lateral wedges in clinical practice by podiatrists. The study aimed to understand rationale and beliefs that guided the use of forefoot lateral wedges amongst podiatrists.

Methods

A cross-sectional study of New Zealand podiatrists was conducted between 31st May 2021 and 26th July 2021. Data were collected anonymously using a web-based survey platform. The 30-item survey included questions to elicit participant characteristics, why and when podiatrists used orthotic modifications, what biomechanical assumptions influenced clinical decision making, and how podiatrists fabricated and placed forefoot lateral wedging.

Results

Sixty-five podiatrists completed the survey. Most respondents were trained in New Zealand (91%), had over 10 years' experience (70%), and worked with a mixed case load (60%). Seventy-seven percent (77%) prescribed 0 to 10 pairs of foot orthoses per week, with forefoot lateral wedges used in 44% of prescriptions. Forefoot lateral wedges were likely to be used in the treatment of peroneal tendon injuries (70%) and chronic ankle instability (64%). The most common belief being that forefoot lateral wedges increase first metatarsophalangeal joint range of motion (86%). Forefoot lateral wedges were regularly manufactured from 3mm (74%), medium density ethylene vinyl acetate (91%) and positioned from the calcaneo-cuboid joint (53%) to the sulcus (77%).

Conclusion

NZ Podiatrists frequently use FLW. These were generally manufactured from 3mm, medium density EVA and positioned from the CCJ to the sulcus. The most common rationales for use were to increase first MPJ ROM, shift the COP medially, and balance the foot. A discordance was found between the theories of foot function upon which clinicians placed the greatest importance, and the biomechanical outcomes that they thought were being achieved. Survey data also highlighted inconsistency in the nomenclature used to describe FLW thickness and inclination.

Keywords

Podiatry, foot biomechanics, foot orthoses, valgus wedge

Background

Lateral wedging can be defined as material sloped uniformly to be thicker on the lateral side than the medial side.[1] These wedges are commonly added to foot orthoses or shoe insoles in the management of several lower limb pathologies.[2, 3] Lateral wedging has most commonly been investigated in relation to the biomechanical effects on knee motion, particularly for their role in the management of medial knee osteoarthritis.[4] In cohorts with medial knee osteoarthritis, lateral wedging of the foot has been shown to reduce knee adduction moments[2]; however, this effect is the subject of controversy.[5] With respect to lower limb kinetics and kinematics, lateral wedges have been shown to shift the centre of pressure (COP) laterally[6-8] and increase the external eversion moment of the sub-talar joint.[9, 10] However, current evidence investigating the effect is limited to a small number of observational studies.[1] Beyond this, limited evidence exists to inform how lateral wedges impact other variables such as kinematics of the forefoot or how the wedge design may affect function.

There are numerous theories of foot function proposed, many of which provide a theoretical link which can be extrapolated to suggest how lateral wedging may function. Four of the most widely cited theories are Root theory,[11, 12] Sagittal Plane Facilitation theory[13], Rotational Equilibrium theory,[14] and Tissue Stress theory.[15] Root theory has the most direct link to explain the functional effects of lateral forefoot wedging.[11] Focussing on the concept of sub-talar joint neutral, and the importance of maintaining this position, Root theory highlights several abnormalities which are said to result in compensation, and movement away from the desired position. Under this theory, forefoot position is important. Any deviation forefoot position is measured and subsequently balanced by a wedge of equal size placed under the appropriate part of the foot using a firm or rigid material.[11, 16] Sagittal Plane Facilitation theory also focuses on kinematics and proposes that lateral stability of the foot, along with two other key functions, are essential for efficient transfer of weight.[13] Evidence linking the Sagittal Plane Facilitation theory and lateral wedging proposes that lateral wedging increases lateral stability of the foot.[17] Rotational Equilibrium theory attempts to predict function of the foot according to the balance of forces around the sub-talar joint,[14] something that lateral wedging is known to influence.[1] Finally, the Tissue Stress theory is not proposed to be a model to understand foot function, but rather, how to manage it. According to this theory the focus is to reduce stress on injured tissues to allow healing[15]. There is currently no evidence linking lateral wedging to alteration in tissue stress in the foot.[1]

The extent to which lateral wedges affect foot function is linked to the steepness (gradient) of the slope[18], a variable which is interchangeably described in millimetres (thickness) or degrees (inclination angle) of the wedge. For example, Telfer et al.[19] demonstrated that for every two degrees increase in lateral wedge inclination, peak plantar pressure in the lateral forefoot decreased by 0.74%. Considering the impact of this variable on biomechanical outcomes, clear terminology is important to ensure suitable design decisions are made. Also of relevance to design is the length of wedge. There is limited evidence linking the length of a lateral wedge to a biomechanical influence upon foot function.[8, 17] For the purposes of this study, the following terminology will be applied. A full length wedge will be defined as a wedge beginning from the most proximal aspect of the insole, under the calcaneus, extending to the distal end of the insole, past the apex of the digits. A FLW will be defined as a wedge beginning from the calcaneo-cuboid joint and extending distally to the sulcus of the foot.

Previous research has highlighted a difference in prescription habits of New Zealand (NZ) podiatrists compared to those from Australia and the United Kingdom.[20] Chapman et al.[20] reported that NZ podiatrists prescribe prefabricated orthoses more frequently than both their Australian and British colleagues, and conversely prescribe fewer custom orthoses than both groups. However, this data did not explore the application of full length lateral wedges or FLWs amongst NZ podiatrists.

There is currently limited evidence exploring the beliefs that guide the clinical application of FLWs amongst podiatrists practicing in NZ. Therefore, the current study aimed to understand the rationale of NZ podiatrists when they use FLWs, and to identify how lateral wedges are manufactured and applied in clinical practice. Data from this survey will be influential in the design of future lab based work, analysing the kinetic and kinematic effects of FLWs, as they are used in practice by NZ podiatrists.

Methods

This study used a cross-sectional observational design. Data collection was completed anonymously using the web-based survey platform (Qualtrics XM, Provo, UT). The survey was implemented over an eight-week period between May 31st, 2021, and July 26th, 2021. Participants were recruited via an email invitation sent to all members of the national society (Podiatry New Zealand), and a research flyer distributed to delegates at the 2021 New Zealand Podiatry Conference. Incentivisation to participate was offered in the form of five prizes of $100 shopping vouchers. Consent to participate was obtained through participants completing a yes or no question on the landing page of the survey. If participants did not consent to participate, they were unable to proceed to the survey questions. Ethical approval was obtained from the Auckland University of Technology Ethics Committee (AUTEC, reference number 21/118) prior to commencing data collection.

The survey was piloted through a two stage process. First, six NZ registered podiatrists with an average of 17 years' experience (SD 5.3) and expertise in biomechanical management and orthoses completed the survey online and provided written feedback. Following suggested amendments, a focus group with the same practitioners was held to finalise the survey questions. The focus group was facilitated by MC, who has previous experience in survey development. The final survey (Additional File 1) comprised 30 questions, divided into three sections. Participants were able to review responses to previous questions by using the back button at any stage until the survey was completed. The first section related to demographics and asked respondents about their experience, age, geographic region, qualification, type of work and frequency of orthotic prescription. Section two posed questions relating to when and why they used certain modifications, and what biomechanical hypotheses influenced their decisions. Section three contained questions about lateral wedge fabrication and placement. Twenty-three of the survey questions garnered categorical responses (3-10, 13, 14, 17-19, 22-27, 29-32). Questions 11, 12, 20 and 28 used percentage sliders, and questions 15 and 16 were Likert scales. Question 21 asked respondents to indicate what percentage of their FLWs were placed on the sock liner, an orthotic, or on the midsole of the shoe. Participants were required to assign a percentage of their total modifications to each category whilst the online platform created a sum which was required to equal 100.

The first question of section three screened respondents to identify those who made their own FLWs. To ensure that those responding to the questions had some experience in wedge fabrication, the final section of the survey was only shown to respondents who reported manufacturing their own FLWs. Any respondents who indicated using prefabricated FLWs bypassed the fabrication questions and were taken to the end of the survey. All survey data were reported in accordance with the Checklist for Reporting Results of Internet E-Surveys (Additional file 2).[21]

Data analysis

All categorical data were described as number (n) and percent (%). Likert scale data from question 15 were combined for final analysis. ‘Very unlikely’ and ‘unlikely’ responses were recorded as ‘unlikely’. ‘Likely’ and ‘very likely’ responses were recorded as ‘likely’. Percentage sliders were represented as a mean (out of 100) and standard deviation (SD).

Results

Participant characteristics

In total, 88 survey responses were received, representing 25% of Podiatry New Zealand members and 18% of registered podiatrists within NZ (based on 481 podiatrists who hold annual practicing certificates). Twenty-three surveys were incomplete and therefore excluded (a 74% completion rate), leaving 65 which were included for final analysis. Characteristics of the respondents are detailed in Table 1. Most respondents had greater than 10 years' experience (70%, *n* = 46), were trained in NZ (91%, *n* = 59), reported working with a variety of clinical presentations (60%, *n* = 39) and prescribed between 0 and 10 orthotics per week (77%, *n* = 51). Almost three quarters (70%, *n* = 46) of the respondents practiced in the more populated North Island of NZ, and one quarter (25%, *n* = 16) held a post-graduate qualification.

INSERT TABLE ONE NEAR HERE

The use of lateral forefoot wedges

In relation to the total number of orthotics prescribed, participants reported including a FLW in 44% (SD 26.76) of cases. When asked what modifications they routinely used, 79% (*n* = 52) reported using FLWs. Only metatarsal domes (80%, *n* = 53) were more widely used.

Respondents were asked about their likelihood of using a FLW in the management of various lower limb conditions (Figure 1). The four conditions for which FLWs were most frequently used included peroneal tendon issues, chronic ankle instability (CAI), plantar heel pain and medial knee osteoarthritis. Conversely, of the list presented to participants, first MPJ joint sprain was the diagnosis which least often led to the use of FLWs.

INSERT FIGURE 1 NEAR HERE

Figure 2 presents data from the question, “How important do you think it is to consider the following, when using a lateral forefoot wedge”. The most important factors for consideration when prescribing FLWs were *forefoot alignment* and *rearfoot pronation/supination*. These were deemed 'important' by 88% (*n* = 58) and 73% (*n* = 48) of participants, respectively.

INSERT FIRGURE 2 NEAR HERE

The biomechanical function of lateral forefoot wedging

In answer to the question '*How influential do you think each of the following podiatric theories/paradigms are in your orthotic prescription?*', the Tissue Stress theory (81.2/100, SD 20.4) was reported to be the paradigm which most significantly affects orthotic prescription. This was followed by Sagittal Plane Facilitation theory (69.0/100, SD 21.1), Rotational Equilibrium theory (55.4/100, SD 28.6) and lastly, Root theory (50.2/100, SD 28.4).

The primary reason that NZ podiatrists prescribed lateral forefoot wedging for both running and walking gait was to increase first MPJ ROM. Whether selected as their main reason for use or not, most participants (86%, *n* = 56) agreed that this is an expected biomechanical function of lateral forefoot wedging. Figure 3 contrasts the reasons that FLW are prescribed, for both running and walking gait. The majority of respondents (68%, *n* = 45) indicated that the biomechanical effect of lateral forefoot wedging is different in running gait, compared to walking gait. However, the three most common reasons for the use of FLWs were the same for both walking and running gait.

INSERT FIGURE 3 NEAR HERE

Fabrication of lateral forefoot wedges

Sixty-three percent (*n* = 42) of the respondents in this survey choose to construct their own FLWs. Respondents who reported using prefabricated FLWs most often used wedges manufactured by FootBionics (FootBionics®, Christchurch, NZ) (52%, *n* = 12) and Formthotics (Foot Science International Ltd, Christchurch, NZ) (22%, *n* = 5).

Wedge placement

Placement of FLWs was considered to have a large impact (81/100, SD 15.9) on their outcome. Seventy-seven percent (*n* = 33) of respondents reported not always using the same design of FLWs, with patient symptoms highlighted as the most common reason for adjusting design. The most common FLW design reported began at the calcaneo-cuboid joint (CCJ) and finished at the sulcus of the foot (Figure 4). Beginning this modification at the CCJ was standard for 53% (*n* = 23) of participants, whilst 40% (*n* = 17) used the styloid process as their landmark. Less variation was reported regarding the distal border with 77% (*n* = 33) agreeing on ending the FLW in the sulcus of the foot. A small number of respondents reported finishing the FLW proximal to the metatarsal heads (19%, *n* = 8) or at the end of the insole (5%, *n* = 2).

INSERT FIRGURE 4 NEAR HERE

Wedge material

Respondents considered that material density (82/100, SD 12.4) and thickness (82/100, SD 13.7) were important when constructing FLWs. When asked what materials they have used in the past 12 months, 91% (*n* = 39) reported using ‘medium density’ ethylene vinyl acetate (EVA), whilst ‘low density’ EVA (51%, *n* = 22) and felt (51%, *n* = 22) were also widely used. The most commonly used FLW material thickness was 3mm EVA, 74% (*n* = 31) of respondents reported having used this in the last 12-month period. Fifty-two percent (52%, *n* = 22) used 4mm EVA, 33% (*n* = 14) used 5mm EVA and 21% (*n* = 9) used 6mm EVA in this time period. Eight-millimetre EVA was used by four respondents (10%) and 10mm EVA, by three (7%). However, no respondents reported using 6, 8 or 10mm EVA as their primary choice of thickness.

Discussion

This is the first study to investigate the frequency of application for a range of forefoot orthotic modifications amongst NZ based podiatrists. These findings highlight the regular use of FLW within this cohort, with FLWs reportedly included in almost half of all orthotic prescriptions. This makes them the second most widely applied orthotic modification. This survey identified the majority of respondents prescribed between 0 and 10 orthotics or modified insoles per week. A similar frequency of prescription was reported by Chapman et al.[20], who found that NZ podiatrists on average prescribed 12 orthoses, per week.

Peroneal tendinopathy and CAI were the diagnoses that most frequently lead to FLW prescription. Both diagnoses have been linked to patients whose COP is laterally deviated.[22, 23] Therefore, if the widely held assumption revealed in this survey is true, and FLWs do shift the COP medially, this is likely to have a positive impact on these clinical presentations. However, this assumption contrasts current research which suggests that lateral wedges shift the COP laterally.[1, 6] There is currently limited evidence investigating this function of FLWs, or any positive outcome effect when managing peroneal tendinopathy. It has been postulated that orthoses have a positive impact on CAI due to heightened input to mechanoreceptors, although limited work has been completed exploring the role of FLWs in this scenario.[24] Kakihana et al.[3] compared full length lateral wedges in people with and without ankle instability and concluded that in those with unstable ankles, the change in sub-talar joint moments is the same as age-matched controls. Plantar heel pain was the third most likely diagnosis to be managed with FLW. The in vitro study by Kogler et al.[17] provides the only evidence regarding lateral wedging configurations and their impact on the plantar fascia with data indicating that FLW reduced plantar fascial strain. The limitation of this work was the use of cadaveric limbs.

The Tissue Stress theory was found to be the most influential paradigm that guided orthotic modification and prescription. The Tissue Stress theory works on the premise that orthoses are used to reduce stress being placed on a tissue, to a tolerable level.[15] Therefore, based on the study data, the assumption made when using FLWs under the guidance of the Tissue Stress theory is that FLW will positively impact tissue stresses.

This survey has revealed incongruity between the surmised function of FLW and the inferred explanations of podiatric theories of foot function. This is highlighted in two examples related to the application of the Root and Sagittal Plane Facilitation theories. Regarding the Root theory, almost a quarter of respondents primarily use FLW to 'balance the foot', and most respondents identified the patient's forefoot position and rearfoot pronation/supination as 'important' when prescribing FLWs. These concepts are key pillars of the Root theory[11, 12], despite the Root theory being rated as the least influential paradigm by respondents. Regarding the Sagittal Plane Facilitation theory, almost all respondents believed that FLW increased the ROM in the first MPJ, and this was reported as the most common reason for FLW use in both walking and running gait. A recent scoping review, however, found no evidence relating to the impact of lateral wedging on first MPJ kinematics.[1] The Sagittal Plane Facilitation theory, ranked by participants as the second most influential paradigm, places a great deal of importance on first MPJ ROM.[13] This theory suggests that first MPJ movement to engage the windlass mechanism is essential for efficient forward transfer of weight. The Windlass mechanism was first discussed by Hicks[25] and relates to the association between MPJ position and the plantar fascia. This is said to cause the medial arch to rise and the forefoot to supinate. The contradiction in this case is that Hicks[25] described the irresistible supination of the forefoot as the windlass mechanics is engaged, yet over half of our respondents believe that FLWs both shift the COP medially and increase first MPJ ROM. Extrapolation of the original windlass mechanism description would suggest that first MPJ range of motion cannot increase at the same time as the COP shifts medially. However, recent data has shown the plantar fascia to be extensible[26], something that was not considered in the original explanations of the Windlass mechanism. What was previously thought to be a direct link between first MPJ kinematics and medial arch height appears to be an oversimplification of a complex interaction between the plantar fascia and intrinsic muscles of the foot.[26, 27] If extensibility of the plantar fascia also impacts the associated forefoot supination, then this could create the possibility of a concurrent medial shift in COP alongside an increase in first MPJ ROM, as participants in the current survey believe is true. However, there is limited evidence to support this supposition and further investigation is required.

Data indicated the respondents believed FLW functioned differently in walking gait versus running gait. Respondents also indicated that the biomechanical objectives for FLW prescription were entirely different when managing runners and that running gait enhances the effect of a FLW. Whilst research has indicated biomechanical outcomes derived from orthoses differ between walking and running gait[28], there is limited data supporting functional differences from FLW use between walking and running gait.[1] Given the differing use and the beliefs of clinicians that there are functional differences when using FLW in running versus walking gait, further investigation is warranted.

Full length lateral wedges have been the dominant design examined in research, notably for their biomechanical effect in the management of medial knee osteoarthritis.[1, 4] However, as indicated by the survey, full length wedges made up a small percentage of lateral wedges prescribed by respondents. Evidence contrasting the effect of varying wedge length (full length vs FLW) is limited.[1] Van Gheluwe et al.[8] compared the impact of lateral wedge length on plantar pressure and found FLW increased peak plantar pressure in the lateral forefoot, whereas rearfoot lateral wedges had no effect on forefoot plantar pressure. Further supporting the biomechanical impact of FLW, Kogler et al.[17] demonstrated that wedging under the lateral aspect of the forefoot provided the most significant reduction in strain in the plantar fascia.

The most common material thickness used to manufacture FLWs was 3mm. However, it is important that the difference between inclination angle and material thickness (in the case of wedges, referring to the thickest part) is clearly understood. Three-millimetre (3mm) material does not produce a consistent angle, as this depends on the width of the modification. Figure

5 displays the relationship between thickness and width, in which the width of a wedge entirely changes the inclination angle if the thickness remains constant. For example, 3mm material bevelled to 0mm over a width of 60mm (a relatively small FLW) produces an inclination angle of 2.9°, whereas that same material bevelled over 100mm (a large FLW) produces an angle of 1.7°. This difference means if the same material thickness is used regardless of modification width, patients with larger feet receive wedges with lower inclination angles. This is an important distinction as research has previously indicated that for a range of biomechanical outcomes, a larger inclination angle elicits a larger response.[19]

INSERT FIGURE 5 NEAR HERE

The survey data must be considered in the context of its limitations. Firstly, despite efforts to maximise recruitment, the sample size was lower than anticipated, which may limit the generalisability of the data. Whilst the response rate was low, recent NZ podiatry workforce data indicated only 19% of NZ podiatrists worked in the area of sports medicine.[29] Consequently, the survey may have only been of interest to a relatively small percentage of the NZ podiatry workforce. However, the study was the first to examine practice habits related to FLW. The responses allowed participants to select a range of common presentations, modifications and beliefs that underpin the prescription of FLW. This allowed space for reflection on their practice habits and established a benchmark for current clinical practice in NZ.

Conclusion

NZ Podiatrists frequently use FLW. These were generally manufactured from 3mm, medium density EVA and positioned from the CCJ to the sulcus. The most common rationales for use were to increase first MPJ ROM, shift the COP medially, and balance the foot. A discordance was found between the theories of foot function upon which clinicians placed the greatest importance, and the biomechanical outcomes that they thought were being achieved. Survey data also highlighted inconsistency in the nomenclature used to describe FLW thickness and inclination.

Abbreviations

CAI: Chronic ankle instability

CCJ: Calcaneo-cuboid joint

CHERRIES***:*** Checklist for Reporting Results of Internet E-Surveys

COP: Centre of pressure

EVA: Ethylene vinyl acetate

FLW: Forefoot lateral wedge

MPJ: Metatarsophalangeal joint

NZ: New Zealand

ROM: Range of motion

Declarations

Ethics approval

Ethical approval was granted by the Auckland University of Technology Ethics Committee (AUTEC). Application reference 21/118.

Consent for publication

Participants were advised in the participant information page at the beginning of the survey that anonymous, non-identifiable data would be published. Only data from those who consented has been included.

Availability of data and material

Request for further details of the data set and queries relating to data sharing arrangements may be submitted to Aaron Jackson (aaron.jackson@aut.ac.nz). The survey did not obtain consent for participant data to be shared, although the present data are anonymised with all personal identifiers not linked to individual responses.

Competing interests

All authors declare no competing interests.

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Authors' contributions

AJ, MC, DR, and KS conceived the study and developed the survey. AJ and MC coordinated the focus group, and analysed responses from the piloting process. AJ undertook the data analysis. AJ and MC the first version of the manuscript. All authors reviewed subsequent draft version and approved the final manuscript.

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Figures

Figure 1: Likelihood of FLW prescription, based on common lower limb diagnoses. Data above the line indicating the conditions where FLWs were more likely to be used. Data below the line indicates conditions where FLWs were more unlikely to be used

Figure 2: Importance of various considerations when prescribing forefoot lateral wedging.

Figure 3: The most common reasons respondents would prescribe FLWs for both running and walking gait (%).

Figure 4: Approximate FLW shape when placed from the CCJ to the sulcus of the foot.

Figure 5: The relationship between material thickness and width means that at a consistent material thickness (C) the inclination angle (b) will be smaller than (a) due to the modification being wider (B > A).