



Short Communication

Aviation footwear – Influencing biomechanics

Margaret Grace¹

¹Flying Feet, Glasgow, Scotland, United Kingdom.



***Corresponding author:**

Margaret Grace,
Senior Aviation Podiatrist,
Flying Feet, Scotland,
United Kingdom.

magsayr@rocketmail.com

Received: 07 June 2024

Accepted: 18 September 2024

Published: 25 November 2024

DOI

10.25259/IJASM_14_2024

Quick Response Code:



ABSTRACT

The effect that footwear has on lower limb mechanics has been widely documented over the years. Considering the nature of their role, commercial cabin crew is deemed to be at an increased risk of sustaining an occupational injury, in particular, to the lower limbs. Mitigation of such injuries can, in part, be achieved through careful consideration of an individual's biomechanics and the wearing of particular footwear styles that are more conducive to their needs.

Keywords: Biomechanics, Kinematics, Lower extremity, Musculoskeletal system, Occupational Health, Podiatry

INTRODUCTION

Common lower limb mechanical problems can often exist among cabin crew populations. Many of such problems can either contribute to or be the sole cause of an industrial injury resulting in long-term absence or failure to perform designated duties.^[1-5] Management of such injuries can sometimes be complex, largely due to expectations from various individuals. In all instances, a holistic approach must be taken, involving the patient, and since many crew industrial injuries are lower limb related, an aviation specialist podiatrist and physiotherapist should be called upon to assist with rehabilitation.^[3,6,7] While orthotic therapy is often a preferred treatment option in improving lower limb mechanics and helping to either rehabilitate or avoid injury in the first place, footwear considerations are often overlooked.^[8-11] Aviation podiatrists must, therefore consider footwear, orthotic therapy, physical therapies, and also education when dealing with such issues.

COMMON PROBLEMS AND FOOTWEAR

Often, a misconception exists that “flat shoes are best.” Too often, the female cabin crew is granted permission to wear a flat shoe both on and off the aircraft, in the belief by all parties (including the patient) that their donning a flat shoe is aiding their recovery. In many instances, however, certain biomechanics actually benefit from wearing shoes that have a small heel.^[8-14] Considering the common mechanical problems encountered [Box 1], an overview of suggested shoe styles [Box 2, Figure 1] and orthotic interventions is detailed along with the rationale below. Such footwear recommendations are given based on the assumption that the cabin crew has to wear a higher heeled court shoe off the aircraft and a flat shoe on board the aircraft. This advice given is, therefore, subject to the uniform standards of the airline in question.

This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 License, which allows others to remix, transform, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

©2024 Published by Scientific Scholar on behalf of Indian Journal of Aerospace Medicine

Box 1: Description of biomechanical lower limb issue.

Biomechanical lower limb issue	Description
Lisfranc injury or fracture	The Lisfranc complex describes an area in the mid-foot where the proximal aspect of the metatarsal bones joins the tarsal region at the mid-foot. Typically, injuries tend to occur between the 2 nd and 3 rd metatarsals and cuneiform joints.
Forefoot or ankle equinus	This describes an early heel lift during gait. A forefoot equinus tends to be due to soft-tissue changes causing a plantar flexed forefoot, whereas an ankle equinus tends to be due to a fixed plantarflexion at the ankle joint.
Over-pronation with associated plantar fasciitis	Over-pronation refers mainly to excessive eversion of the foot at mid-stance during the gait cycle. Pronation also includes both abduction and dorsiflexion movements. Excessive eversion at mid-stance can cause the plantar fascia to become inflamed.
Achilles tendonitis	Achilles tendonitis occurs when the part of the tendon that inserts into the calcaneus becomes inflamed.
Hypermobility	Hypermobility refers to an excessive range of motion within the lower limbs that is out of expected parameters. It is associated with over-pronation.

Besides considering style and, more specifically, heel height, other considerations should be given to footwear with a view to having an impact on lower limb biomechanics. Such considerations are as follows:

- **Size/fit** – it is important to note that not only do shoe sizes vary between both genders and from country to country, but there are also inconsistencies among a particular size and even between shoes manufactured by the same manufacturer. For example, a U.S ladies' size 7 may not be the same as another ladies shoe labeled U.S size 7. The best practice is, therefore, to always try a pair of shoes on before purchasing them or selecting them from the uniform department.

In terms of fit, it is important to note specific advice with regard to ladies' court shoes (which are worn by most female cabin crew). Since most cabin crew court shoes tend to be "slip-on," such footwear lacks the preferred straps and laces that a podiatrist would normally recommend^[8,15] as being a necessary feature in a sensible shoe. Without such straps/support, the foot has to work harder to keep the shoe on. This is often achieved by contracting the intrinsic muscles within the foot and clawing the digits. Any foot placed under such unnecessary stress is more likely to develop soft-tissue

skin and nail problems (corn, ulcers, ingrown toenails, etc.) and intrinsic soft-tissue issues (neuromas, sprains, strains, etc.).^[8-10,15]

Whilst it is obvious that footwear should not be too tight, equally, it should not be too big. Both factors will contribute to the soft-tissue problems previously mentioned. It is often noted that female cabin crew, conscious of the fact that their feet will swell whilst over 10,000 ft altitude, will opt for a uniform shoe which is bigger than that which they would normally require. Considering the fact that, in most instances, an individual's foot will swell less than expected and that a leather shoe, once worn a few times, will stretch, many cabin crew end up wearing a shoe that is too big and consequently place additional stress on their lower limbs thus increasing their risk of developing symptoms. It is therefore advised that the female cabin crew, on choosing leather court shoes, should select a pair that are slightly snug (on the understanding that they will stretch). They should then wear their shoes at home for short periods until they are comfortable.

- **Male cabin crew/pilots** – assuming that both male and female pilots can select their own footwear, they should all be encouraged to select lace-up shoes that are of a good fit, good quality and have a round toe box.
- **Quality of leather** – generally speaking, the more expensive a shoe, the better quality it is. However, this is not always the case. To select a good quality shoe, one must consider the shoe's outer. In most instances, the shoe outer tends to be comprised of a leather mix. The higher the percentage of leather, the better the quality. Outers that are of better quality tend to have a "gritty" feel under the thumb.
- **Different sized feet** – often, individuals have different sized feet. Differences up to half a U.S./UK size can be dealt with relatively simply. In this instance, it is advised to select a pair of shoes to fit the bigger foot. The shoe accommodating the smaller foot should have a simple, thin insole (not an orthotic) added to it. This will make the shoe a ¼ size smaller and is often sufficient in dealing with any fitting issues with the smaller foot.
- **Wearing orthotics** – the latest technological advances, the utilization of ethyl vinyl acetate (EVA) and other newer materials and adopting sub-talar axis methods in orthotic production allow orthotics to be made thinner than some traditional ones. However, no matter how sleek a device is, it will still take up additional room within a shoe. If a cabin crew member is required to wear orthotics, they must only consider getting a new pair of shoes after wearing a new pair of orthotics for at least three months (This will give the orthotics a chance to compress). Then, when selecting new shoes, they must try them on with the orthotics in them.

Box 2: Recommended shoe styles.

Biomechanical lower limb issue	Footwear suggestion
Lisfranc injury or fracture	<i>Lower block heel court shoe:</i> wearing a small heel locks the midfoot into a supinated position during gait, therefore offering some degree of protection to the structures that make up the Lisfranc complex. Figure 1a <i>Orthotics:</i> addressing underlying foot mechanics, over-pronation or hypermobility with specialized top-coat materials to reduce shearing stress must be prescribed
Forefoot or ankle equinus	<i>Wedge cabin shoe:</i> Individuals who have an early heel lift, tight posterior chain and an equinus type foot, often experience lower back pain when standing in bare feet or in a very flat shoe. Female flight attendants who have this foot type would benefit from wearing a wedge type shoe. Figure 1b <i>Narrow high heel court shoe:</i> Tolerated also. Figure 1c <i>Orthotics:</i> Male crew should be given orthotics with a heel raise
Over-pronation with associated plantar fasciitis	<i>Flat cabin shoe:</i> Only worn with orthotics since wearing a very flat shoe allows the foot to pronate excessively, if it is inclined to do so, and thus irritate the plantar fascia. Figure 1d <i>Wedge cabin shoe:</i> Preferred option. Figure 1b <i>Lower block heel court shoe:</i> Preferred option <i>Orthotics:</i> If plantar fasciitis is diagnosed – ethyl vinyl acetate (or similar) orthotics must be worn with rear foot medial posting (added parallel to a sub-talar axis)
Achilles tendonitis	<i>Flat cabin shoe:</i> Later choice as well as initial choice. Figure 1d <i>Wedge cabin shoe:</i> Initial choice - not to be confused with Achilles tendinopathy, Achilles tendonitis is sometimes referred to as Insertional Achilles Tendonitis. Early rehabilitation of Achilles tendonitis must include the wearing of a shoe with a small heel. Figure 1b <i>Lower block heel court shoe:</i> Initial choice. Figure 1a <i>Orthotics:</i> Male crew should be given orthotics with a heel raise – used initially at all times, then interchanged with periods of not wearing them
Hypermobility	<i>Wedge cabin shoe:</i> Most hypermobile feet are inclined to pronate excessively at mid stance. Wearing a small-heeled shoe will help fix the foot into a supinated position. Figure 1b <i>Lower block heel court shoe:</i> Tolerated also. Figure 1a

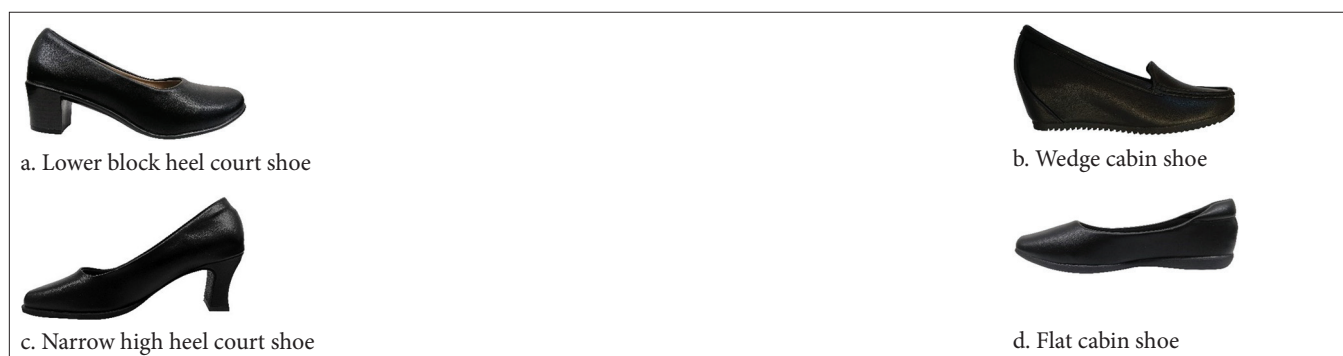


Figure 1: (a) Lower block heel court shoe. (b) Wedge cabin shoe. (c) Narrow high heel court shoe. (d) Flat cabin shoe.

SAFETY SHOES

Safety shoes present other issues besides those of fit. The steel toe cap can create some restrictions in the forefoot motion required for gait. This can create soft-tissue skin lesions or intrinsic symptoms. Too often, wearers also report issues with comfort. Airfield workers who don personal protective equipment (PPE) in warmer climates sometimes experience overheating of the feet – this is partly due to the fact that safety shoes tend to be

quite heavy and cover most of the foot (and ankle) and also due to heat being transferred into the shoe through the shank or sole. Such issues are particularly of concern to those wearers who have underlying conditions such as diabetes mellitus.

ORTHOTICS

Practical considerations with regard to orthotics must be made. Such considerations are mainly concerned with the

patient's ability to tolerate them and also to fit them into their shoes. Experience with cabin crew podiatry patients has shown that orthotics made from medium density EVA in accordance with the sub-talar joint axis theory method are more likely to fit inside a lady's court shoe and are softer, allowing them to be tolerated better. Increased tolerance means that orthotics are more likely to be worn as advised and that rehabilitation goals are more likely to be achieved within a given time.^[11,12]

DISCUSSION

When it comes to the management and prevention of lower limb-related industrial injuries, footwear considerations must not be overlooked.^[2-4,8,15,16] Specific considerations with regard to heel height can allow for improved biomechanics, while changes in style, improved fit, and quality can reduce stresses that would otherwise have been placed on soft tissues. The wearing of better footwear from the outset can help to avoid injuries in the first place. Changes in footwear styles can be utilized as a rehabilitation aid post injury, along with other interventions, including orthotic therapy and physiotherapy.

CONCLUSION

Considering the increasing demands placed upon commercial cabin crew, and that there are recognised risk factors associated with the wearing of particular footwear styles; a requirement for the provision of footwear that is more conducive to the health needs of the uniform wearer holds great significance. Necessity for greater collaboration between aeromedical practitioners and key stakeholders exists to ensure that whilst image standards are not compromised, neither is safety and well-being.

Ethical approval

Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Agampodi SB, Dharmaratne SD, Agampodi TC. Incidence and predictors of onboard injuries among Sri Lankan Flight Attendants. *BMC Public Health* 2009;9:227.
2. Chen PH, Liu X, Dong L, Rau PL. Prevalence of musculoskeletal discomfort among female cabin crew in Taiwan. *J Occup Health* 2021;63:e12286.
3. Lee H, Wilbur J, Conrad KM, Miller AM. Risk factors associated with work-related musculoskeletal disorders among female flight attendants using a focus group to prepare a survey. *AAOHN J* 2006;54:154-64.
4. Mulay R, Gangwal A, Shyam AK, Sancheti PK. Prevalence and risk factors for work related musculoskeletal disorders in flight attendants. *Int J Community Med Public Health* 2019;6:2456.
5. Glitsch U, Ottersbach HJ, Ellegast R, Schaub K, Franz G, Jäger M. Physical workload of flight attendants when pushing and pulling trolleys aboard aircraft. *Int J Ind Ergon* 2007;37:845-54.
6. Nur NM, Salleh MA, Minhat M, Zuhudi NZ. Load lifting and the risk of work-related musculoskeletal disorders among cabin crews. *IOP Conf Ser Mater Sci Eng* 2018;370:012026.
7. Tyaryanas AP. Epidemiology of turbulence-related injuries in Cabin Crew, 1992-2000. *Aviat Space Environ Med* 2003;74:970-6.
8. Barnish MS, Barnish J. High-heeled shoes and musculoskeletal injuries: A narrative systematic review. *BMJ Open* 2016;6:e010053.
9. Merriman LM, Tollafield DR. *Assessment of the lower limb*. Edinburgh: Churchill Livingstone; 1995.
10. Yates B, editor. *Merriman's assessment of the lower limb*. 3rd ed. China: Elsevier Health Sciences; 2009.
11. Horwood A. Increasingly complex biomechanical theories and podiatric biomechanics. *Podiatry Now* 2017;75:26-31.
12. Horwood A. Foot function theories or paradigms: A quandry. *Podiatry Now* 2016;19:20-1.
13. Kirby KA. Rotational equilibrium across the subtalar joint axis. *J Am Podiatr Med Assoc* 1989;79:1-4.
14. Kirby KA. Subtalar joint axis location and rotational equilibrium theory of foot function. *J Am Podiatr Med Assoc* 2001;91:465-87.
15. Frowen P, O'Donnell M, Burrow JG, Lorimer D. *Neale's disorders of the foot*. 8th ed. Edinburgh: Churchill Livingstone; 2010.
16. Wen CC, Nicholas CL, Clarke-Errey S, Howard ME, Trinder J, Jordan AS. Health risks and potential predictors of fatigue and sleepiness in airline cabin crew. *Int J Environ Res Public Health* 2021;18:13.

How to cite this article: Grace M. Aviation footwear – Influencing biomechanics. *Indian J Aerosp Med* 2024;68:16-9. doi: 10.25259/IJASM_14_2024