"HEY COACH/DOCTOR/ PHYSIO/PODIATRIST/ DAD/MUM: WHAT FOOTBALL BOOT IS BEST FOR ME"?

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A question every bit as hot a topic today with the 2022 football world cup in Qatar looming as it likely was at the inaugural world cup held in Uruguay in 1932. Any player who has since donned a pair of football boots to play the world's most popular game has an opinion on what makes a 'good football boot'. Yet surprisingly little research is available on how the player, shoe, and surface interact during football movements. Or what affect these factors have on injury risk, comfort, or even performance[1–3].

Modern football boots are the equivalent of a swiss army knife in the sports equipment stakes. Versatile. Players must interact with the ball, and playing surface, through the shoes on their feet. They perform more explosive sprints, successful passes, changes of direction, and greater running distances than ever before[3]. Not forgetting jumping, walking, shots on goal, blocks, tackles, cross-over steps, the occasional goal celebration, and hopefully some foot protection!

Evolution has ensured flexible, lightweight boot designs with various outsole (stud/cleat) options to match the ensuing climatic and playing surface conditions. Innovative material technology allows very thin football boot uppers to improve feel for the ball and aggressive blades or cleats to augment traction. However, with design evolutions being largely performance related there are downsides such as minimal protection from injury (both from being stepped on and possible foot fixation on the surface) and comfort issues[4,5–7].

According to the literature a 'good' football boot should improve performance, feel comfortable to wear, and protect the player from injury[4–9]. Yet, player motives for selecting boots are likely more complex (e.g., Foot shape/comfort, injury history, climatic conditions, artificial v hybrid reinforced grass v natural grass) and contextual (e.g., world cup final vs pre-season sponsor event, brand sponsorship, favourite colour, and superstitions).

In this article we ask; are there 'sensible' tips to aid football boot selection that apply universally? Second, do characteristics that make a 'good boot' for a male player align with those for a women's player or how about a youth player new to a football academy?

Our aim is to highlight some pillars of boot selection.

- Foot shape and fit.
- Matching the stud/cleat to the playing surface and climate.

- Women and youth player considerations.
- Bending stiffness.

ANATOMY OF A FOOTBALL BOOT

Before we delve into particulars, we need to understand the basic components of a football boot (Figure 1).

WHAT DO PLAYERS WANT?

Football players (n = 407 Men and 200 women) rank comfort, traction, feel for the ball, and stability as the most desirable features for football boots[8,9]. Remarkably, both sexes rank injury protection very low (not important to them). The authors' clinical experience and collaboration with 'athlete services' departments at the global boot manufacturing brands tells a different story. Especially for those players returning from injury. This population often look for boot customisation specific to an injury they might have had. Especially if the injury is career threatening and suspected to be provoked by their previous boots such as fifth metatarsal fracture or Anterior cruciate ligament rupture.

In a worldwide study of 1129 elite football players (n = 1018 men and 111 women) 91% of players believed the type or condition of the playing surface increases injury risk. Hard, bumpy, inconsistent, and high traction (grip) were some of the concerns[10]. International Women football players at the 2019 FIFA world cup (n= 196) ranked poor pitch quality and artificial turf as the second and third most important perceived risk factors for injury after low muscle strength[11]. Clearly players are concerned about surface types or conditions. Informed football boot selection is one of the few modifiable factors that a player can influence for training or matches to minimise injury risk and optimise performance once the playing surface properties are known[12].

DO THE TYPE OF STUDS/CLEATS MATTER?

A player's ability to accelerate, decelerate, and change direction is largely influenced by the available traction between the football shoe and playing surface[13]. Two important components of traction exist: translational traction (straight line grip linked to better performance); and rotational traction (torque required to release studs through the playing surface in a rotational manner)[14]. Higher levels of rotational traction are linked to greater risk of lower limb injury due to foot fixation or the boot

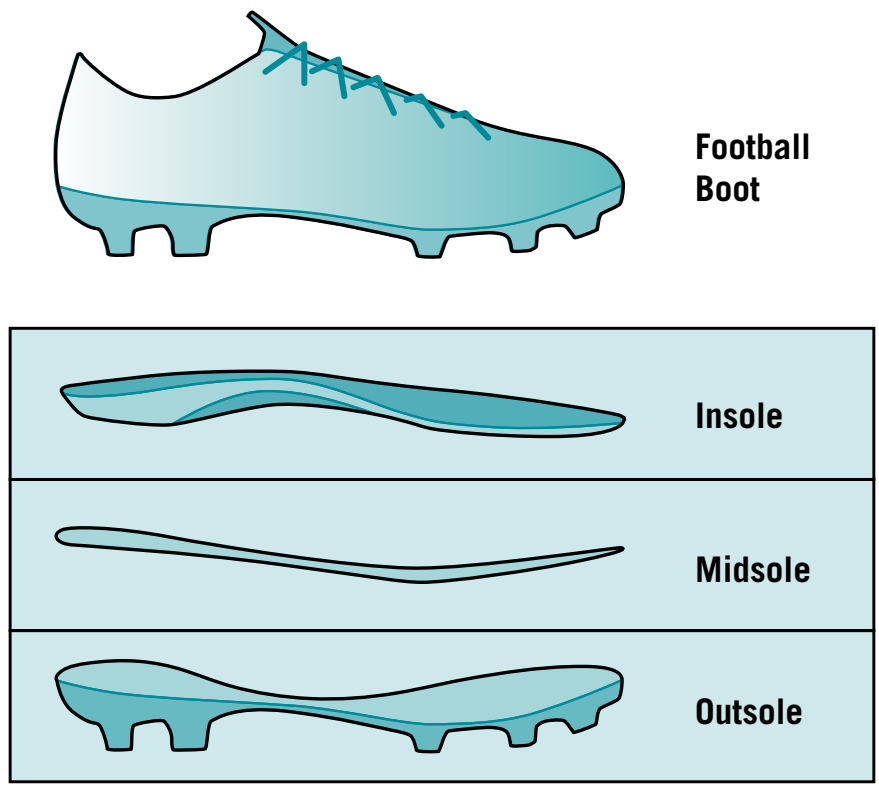

Figure 1: Anatomy of a Football Boot.

'getting stuck' on the surface. Rotational traction causes torque, which if excessive, is then transferred to proximal structures such as the ankle syndesmosis or anterior cruciate ligament at the knee[6,7].

It is pragmatic to advise players returning from these injuries to look for outsole options that decrease rotational traction (or chance of foot fixation) yet not cause any performance or slip issues. Our research suggests short, round, and many studs will decrease rotational traction compared to longer, metal screw-in, blade style, and fewer cleats/studs[6,7,12,14].

Stud/cleat length or arrangement on the outsole can increase plantar pressures at the foot[1,5]. It is important to achieve full stud penetration on the penetrable playing surface to decrease high regional plantar pressures that may give rise to an increased risk of metatarsal stress fractures or foot discomfort[15,16]. This means the type of shoe outsole should be matched to the playing surface conditions. Shoes are sold in "silos" with players expected to choose an outsole type that best suits the surface and climatic conditions[12] (Figure 2).

Artificial grass (AG) shoes have several small, short, round moulded studs that are generally used on very firm pitches or artificial turf. Firm ground (FG) shoes have moulded cleats, blades, or round studs (not screw-in metal studs) that are used on firm dry surfaces. Soft ground (SG) shoes have fewer, longer, conical (or tapered) metal "screw-in" detachable studs for wet, muddy, or low traction conditions. The length of these detachable studs can be changed to suit conditions (longer studs to gain more traction).

Generally longer studs will increase traction if they can penetrate the surface completely to the sole plate of the shoe. Shorter studs (and more of them) should decrease traction and decrease plantar pressure. Our advice is to NOT use a high traction shoe (metal screw-in studs and some blade configurations) on a high traction surface (warm season grass, dry conditions, firm pitch, or artificial grass) or vice versa. Studs that are too long for the surface conditions may feel uncomfortable as they fail to fully sink into the playing surface. Studs that are too short for the given surface conditions may feel slippery due to a loss of traction.

IF THE SHOE (BOOT) FITS... WEAR IT!

Football footwear is known to increase plantar loading at specific anatomical

Artificial grass outsole (AG) | **Firm ground outsole (FG)** | **Soft ground outsole (SG)**

Figure 2: Outsole silos.

areas of the foot during movements like running, cutting, and kicking[3,16,17]. Plantar loading (pressure = force/area) is related to the narrow cut design causing a small surface area and a hard outsole with little cushioning or protective structures[1]. Pressure is commonly located under stud placements – especially when outsoles are of a thin, lightweight design. This may contribute to repetitive load-related injuries such as metatarsal stress fractures. For example, the fifth metatarsal, which has a stud placed right below it, sustains higher plantar loads especially during cross-over cutting and at the stance leg when kicking[3,16,17]. Male players load the lateral margin of the foot more than female football players during side-cut, cross-over cut, and acceleration tasks when using firm ground football boots[16]. The outsole plate provides some protection but only if the shoe fits well (Figure 3).

Players rate comfort as the number one priority and this aligns with lower injury risk[2]. It is therefore important to have the shoe fit properly. This can be difficult as many different footwear manufacturers have their own sizing metrics which may vary between footwear companies but also within footwear companies (two shoes labelled as size 9 may not fit the same - even from the same manufacturer). Aside from length and width, having a boot that suits your foot shape is paramount.

At present there is limited assistance available for proper fit evaluations, some newer technologies are being developed, such as footscan-to-shoe-scan matching, but these systems are in their infancy. Until then we recommend trying several brands and models of shoes on to see which feels most comfortable for you. This will likely be the one that also matches your foot shape the best. A simple method is to remove the insole and stand on it to see if your foot shape and the insole roughly mirror each other in shape - without too much of your foot spilling over the margins of the insole.

Football boot fit is an independent predictor of injury and performance yet boots currently available on the market are only designed and shaped for adult Caucasian males. An explosion in women's football participation and established age and ethnic diversity renders this approach vastly outdated.

WOMEN AND YOUTH FOOTBALL BOOTS FIT - FEMALE

Whether a 'shoe fits' is easier to determine for a male senior football players – especially of Caucasian descent. This is because footwear moulds/lasts used by manufactures are based on Caucasian male foot shapes when designing football boots. This neglects known ethnic, sex, or age-related diversities in foot shape[18–21]. The adult female foot is anatomically different to the adult male foot. It is on average smaller. However, women generally have a wider forefoot relative to their foot length, a greater ankle circumference, a different ankle shape, and a more proximally placed fifth metatarsal (located on the outside of the forefoot)[22–24]. To increase this complexity further, ethnical variations in foot morphology and loading characteristics also exist[18,21].

Finding a boot with a good fit can therefore be a challenge for women football players and something they are yet to experience as most companies are still working on designing football boots for female players. The good news is women's specific football boots are beginning to be available on a small scale (one start-up

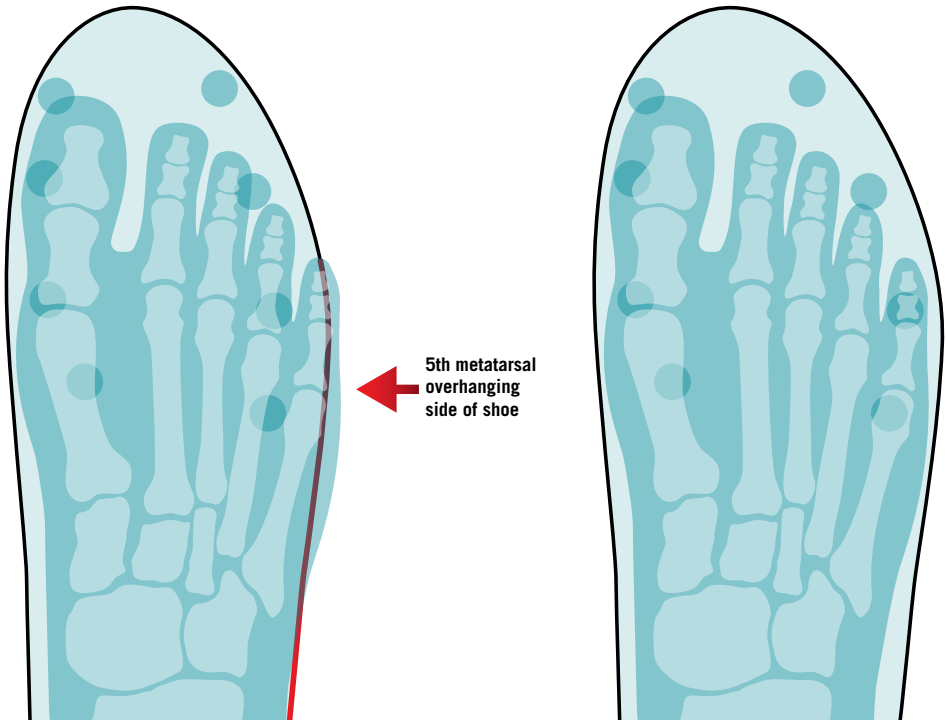

Figure 3: Boot fit with improper fit highlighted.

company and one Australian rules football boot). Many of the major manufactures are developing women's specific boots that should be available for the women's world cup in 2023.

WHAT ABOUT YOUTH OR ACADEMY PLAYERS?

Fit is also important for maturing athletes – male or female. Final foot length in boys and girls is commonly achieved at the age of 13-15 years and girls, although this is highly subjective[25–26]. Foot shape also changes throughout the time it takes for the foot to fully develop[27]. These natural developments make it challenging to ensure optimal (and long-lasting) football boot fit in younger academy players. Unfortunately, football boots can be a costly expense which may discourage or even prevent people from buying boots to adapt to these, at times, rapid foot shape changes. Medical staff and/or parents should monitor the change in fit of players as children and teens.

SELECTING APPROPRIATE OUTSOLES (STUDS) AS A FEMALE SENIOR OR ACADEMY PLAYER

Youth and senior female players do not generate the same muscle power and explosiveness as elite male players[28–30]. It is therefore worth considering whether a football boot outsole marketed for male players as a hard, firm, soft or artificial ground outsole truly reflects the best boot-surface match for other populations. Applying basic physics would make one question the generalisability of outsoles and their traction for populations needing less traction to play. Optimal traction is not only a performance requirement to make you accelerate faster or perform a cutting movement more efficiently. Optimal traction is very important to minimise injury[31-32]. Too high traction and your boot will get stuck in the ground. On the contrary, a low level of traction can cause slipping when trying to stop or change direction. As a general clinical guideline, players producing less power need less traction. Therefore, scaling down the level of traction of the outsole is advised. This can be done by selecting boots with more studs on the outsole and choosing shorter, round studs. Longer blades at the outer margins of the outsole should be avoided due to increased risk of ACL injury[33].

WHERE SHOULD A SHOE BEND? DOES BEDNING STIFFNESS MATTER?

Forefoot bending stiffness of a shoe is generally defined as the force required to bend the shoe, with a stiffer shoe requiring greater force to bend the shoe a set distance. Bending within a shoe will mostly occur at the metatarsophalangeal joint (MTP), which is the joint between the metatarsal bones of the foot and the proximal phalanges of the toes. Adding stiffness to footwear will reduce the range of motion of the toes during athletic movements and is understood to serve two purposes:

1. Reduce potential toe injury risk, commonly caused by hyperextension of the great toe, also referred to as turf toe.
2. Improve running, cutting, and jumping performance.

While the specific property of bending stiffness has been investigated for many years, conclusions on an ideal bending stiffness for both performance and injury prevention remain elusive (Figure 4).

WHAT CAN WE LEARN FROM OTHER SPORTS?

Limited data exists specific to football boots; however, data can be extrapolated from studies investigating other sports or movements such as running, sprinting, and cutting. These are all movements that are performed frequently in football[3]. From an injury perspective specific to toe injuries, having a stiff shoe that resists excessive bending at the MTP joint is ideal, as this has been thought to be preventative for toe hyperextension injuries[34,35]. If the stiffness of the shoe is substantially increased at bending angles in which damage to the internal toe structures are thought to occur (reported to potentially occur at 78° of toe bending[36]), this could offer some form of injury prevention. It is worth noting that this injury prevention mechanism has been proposed following the results of in lab studies; in-depth epidemiological studies to examine the efficacy of increased forefoot bending stiffness on reducing injury risk is lacking.

From a performance perspective, much data has been published indicating that some magnitude of increased bending stiffness of the shoe is ideal in terms of performance improvements during movements such as running, cutting, and jumping[37–39]. It should be noted that continual increases in stiffness do not result in continued increases in performance, as there appears to be a critical range, or 'sweet spot' for bending stiffness in which performance is optimized. Increases or decreases in stiffness from this optimal range result in decreased athletic performance. The overall conclusion is that

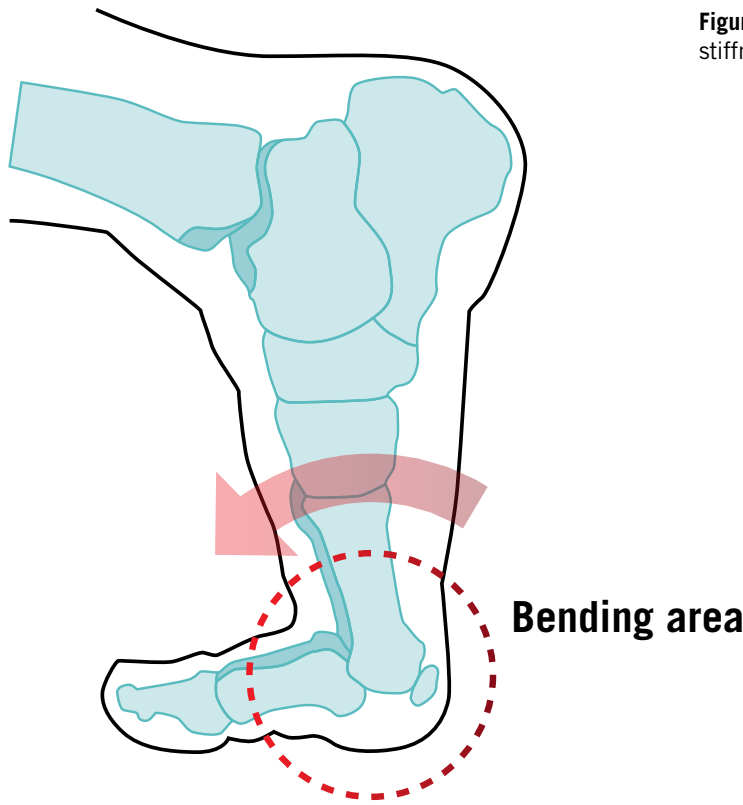

Figure 4: Bending stiffness.

some increase in forefoot bending stiffness results in improved performance, however, the exact stiffness for optimal athletic performance appears to be athlete specific, with some athletes performing better with high stiffness, some with low stiffness and some with moderate stiffness. A side effect of increased bending stiffness is that it is commonly perceived as uncomfortable by athletes[40,41].

While much information is known regarding bending stiffness in footwear, there is much information that remains unidentified. No peer-reviewed studies have investigated how to scale footwear properties depending on different shoe sizes (should a size 12 shoe be stiffer than a size 8 shoe?). Regarding gender, many differences exist between males and females, with women having different anthropometrics such as anatomical orientation, height, and lean body mass[42] as well as different movement patterns[43], muscle activation patterns[44] and different reactions to footwear[45]. It is therefore reasonable to assume that female athletes may require different forefoot bending stiffness from male athletes, however, no in-depth studies have investigated stiffness needs across males and females.

Current footwear mostly incorporates a linear bending stiffness profile[46], however, newer non-linear stiffness profiles, where the shoes are flexible at low bending angles but substantially increase in stiffness at large bending angles[47] ,may provide a shoe stiffness that reduces toe injury risk, while also optimizing performance. Additionally, the foot has both a transverse axis, through the first and second metatarsal heads and an oblique axis, extending from the second to fifth metatarsal heads. No studies have thoroughly investigated the orientation or location in which footwear should bend. Based on this lack of knowledge no recommendation on the location of where stiff footwear should bend can be made, however, it seems reasonable that the location of the bending of the shoe should be in close proximity to the individual athlete's MTP joint axis.

While research has shown that bending stiffness can influence both performance and injury, it is still challenging for athletes to select footwear with optimal stiffness for them. First, the specific stiffness values of each shoe are not provided so even if athletes had knowledge on what their optimal stiffness value was, finding a shoe would still be difficult. In fact, data is lacking on the range of stiffness that is commonly incorporated into football boots, but data from American football indicates a range of 0.10 to 0.35 Nm/deg[46], which may be able to be extrapolated to football boots.

Despite all these challenges some recommendations may be made when selecting football boots for forefoot stiffness. If toe injury is of concern, athletes should prioritize shoes with high stiffness, to potentially provide some mechanism of protection from toe hyperextension. If performance is to be prioritized, a general recommendation would be to select the stiffest boots that do not result in a substantial reduction in toe bending range of motion, which should provide athletes a stiffness value to provide sufficient performance, while also not negatively influencing the comfort of the athlete. For the general athlete, this would likely be a moderate magnitude of bending stiffness. In our opinion extremely flexible boots are likely to suit only a select few players and should be avoided especially by youth players or those with plantar fasciopathy and/or heel pain.

ALL GENERILISATIONS ARE FALSE, INCLUDING THIS ONE – MARK TWAIN

In conclusion, football boot preference is complex and contextual. We highlight some basic tips below with the caveat that these recommendations will not suit all situations.

- Choose a football boot that best mirrors your own unique foot shape – comfort is your number 1 indicator of this.
- Try on multiple brands or models to see what 'feels' most comfortable to you.
- There should not be an uncomfortable "wearing-in' period – let's break down this myth together.
- Look for multiple short, small, round studs such as an AG outsole if returning from injuries like fifth metatarsal fracture, ACL rupture, ankle syndesmosis injury and others. This will decrease rotational traction and allow more even plantar pressure distribution.
- There is an individual 'Sweet spot' for shoe bending stiffness that is specific to the individual. Too much or too little bending stiffness will affect performance, comfort, and likely injury risk.
- Too stiff may increase demand at calf muscle.
- Too flexible may increase demand at 1st MTP joint and plantar fascia. In general, very stiff plates are perceived as uncomfortable by players.
- Match shoe outsole group to surface type (AG for artificial pitch, SG for soft/wet pitch etc).
- Youth players should consider good heel counter support and heel contours due to high prevalence of heel pain.
- Women's specific football boots designed from women's foot shapes (lasts) are near non-existent at your local sports store. This is changing slowly with one start-up company and one Australian rules football boot currently available. The large brands are finally developing their own editions due out for the FIFA Women's' World Cup 2023™. Until then, women should consider a less aggressive outsoles and a fit you find comfortable.

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