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Before Bikefit
Addressing Foot/Pedal Asymmetry: Part 2

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Graduate Sports Therapists Nick and Nicola Dinsdale, father and daughter team, run NJD Sports Injury Clinic in Clitheroe, Lancs. UK. The family clinic is recognised for its strong evidencebased approach to the management of sports related musculoskeletal injuries and its keen interest in working with competitive cyclists. Patients include professional cyclists from across the various disciplines, in addition to British Nick Cycling officials. Nicola

Nick specialises in foot dysfunction and how it impacts on cycling performance. This article contains unique findings taken from his own research recently carried out at Manchester Metropolitan University. Nick has worked with The Great Britain Cycling team both domestically and overseas and is a past National CycloCross Series winner.

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Introduction

BGN INT XTP MSR MTB

This two-part article will hopefully provide the competitive cyclist with an opportunity to acquire those all too elusive marginal-gains which can represent the difference between success and failure. Both parts closely examine the role of the foot/pedal interface arguably the most common source of pedalling asymmetry. Part 1 highlighted key aspects of biomechanical / anatomical screening before Bikefit from a clinician's perspective. We (authors) strongly believe screening is an area often neglected, undervalued, or misunderstood.

In Part 2, we now investigate different approaches to address the common problem of asymmetry arising from the foot/pedal interface. Although limited published robust research exists, we will apply what does exist, in an attempt to provide sound reasoning to justify our claims. Different approaches include the controversial issue of In-The-Shoe Wedges versus Cleat Wedges; and the emotional topic of Wedges (shims) versus Musculoskeletal Rehabilitation strategies.

The Foot

The human foot comprises 26 bones, 19 muscles, and 107 ligaments, these musculoskeletal structures work together with the neurovascular elements to provide support, balance and locomotion during gait, and power transfer during cycling. Most appropriately, the foot was once admirably described by Leonardo da Vinci as "a master piece of engineering and a work of art".

The foot/pedal interface, arguably the main source of pedalling asymmetry, is the mechanical link between the leg and the cycle and according many authors, including Paul Swift (**www.Bikefit.com**) the foundation for a great Bikefit. As highlighted in Part 1, reduced power output and overuse injuries, particularly knee related, are frequently linked to the anatomic structure of the foot and/or lowerlimb alignment problems (i.e. excessive pronation). This is because the structure and function of the foot and lowerlimb alignment dictate how effectively pedal forces are transmitted via the foot/pedal interface down to the cranks, and potentially, how deleterious forces are transmitted up the kineticchain.

However in an attempt to provide an open and comprehensive approach, we wish to point out that excessive foot pronation,

especially unilateral, can be a compensatory mechanism for faulty biomechanics in the pelvis, hips, and a consequence of unilateral anatomical leglength difference (LLD), thus appropriate screening is crucial before attempting to address foot/pedal interface issues.

Modern Technology Increases Foot/Pedal Pressures and Pronation

While modern cycling technology and rider strength has made rapid advancements over the last couple of decades, the human foot has remained unchanged. Rigid carbonfibre frames and carbon wheelsets have improved stiffness and power transfer. Consequently, there is less flex for energy to dissipate. Jarboe and Quesada (2003) demonstrated that carbonfibre shoes are 42% stiffer in longitudinal bending and 550% stiffer in threepoint bending compared with plastic shoes. While these rapid improvements in modern technology, compounded by everimproving rider fitness/strength provide more efficient power transfer, they have come at the expense of increased forefoot pressures at the foot/pedal interface. Past studies have demonstrated increasing power outputs lead to higher peak forefoot pressures, (causing the foot to collapse inwardly), which in turn, can lead to forefoot problems and increased foot pronation.

Forefoot Varus or Forefoot Supinatus

Before examining the different approaches of addressing pedalling asymmetry arising from the foot/pedal interface; it is important we define, or at least consider forefoot varus and forefoot supinatus. The forefoot varus versus forefoot supinatus is a widely debated topic within the field of podiatry. Forefoot varus is a congenital osseous (bony deformity), whereas forefoot supinatus is an acquired soft tissue contracture that holds the forefoot more inverted (supinated position) during nonweightbearing examination. Forefoot supinatus is considered to be a result of foot posture/position related to excessive foot pronation that occurs over time, probably over many years. When addressing the two conditions for gait activities, the consensus of literature, although very limited, suggests they require distinctly different interventions, failure to do so, can exacerbate the problem. However in cycling, since there is no requirement for the first metatarsophalangeal joint to dorsiflex to provide forward propulsion via the action of the windlassmechanism, differentiation between forefoot varus and forefoot supinatus is unlikely to be such a problem. Therefore, like the vast majority of Bikefit organisations, we (authors) believe that when fitting wedges for cycling the need to differentiate between forefoot varus and forefoot supinatus becomes unnecessary. However, this is not the case when considering approaches that rely on musculoskeletal rehabilitation strategies.

Addressing Pedalling Asymmetry by Wedges

Wedges are designed to cant either the forefoot, or the entire foot, thereby address any misalignment of the foot and/or lowerlimb. Correct wedging permits the foot to be accurately aligned in a more neutral position. Wedges can instantaneously improve pedalling symmetry, which, in turn, can enhance pedalling efficiency, eliminating wasteful energy expenditure, thereby enhance comfort and power transfer. Essentially, there are two different types of wedge, namely the In-The-Shoe Wedge (ITS) shown if Figure 1a, and the Cleat Wedge as shown in Figure 1b. Both wedge types are made from plastic and can be used to address either varus or valgus tilts simply by reversing the wedge.

Figure 1a
In-The-Shoe Wedges

Figure 1b
Cleat Wedges shown in position

What Does the Research Say?

Many of the claims related to the benefits of both Cleat Wedges and ITS Wedges are anecdotal. Although little published research exists on their application and/or performance benefits; they remain widely used and appear to provide instant benefits at minimal expense. In a robust repeatedmeasures design study, Dinsdale (author) and Williams (2010) examined the effect of ITS Wedges on cycling performance in riders with varying levels of forefoot varus / forefoot supinatus. Unlike previous studies, this study reported forefoot varus measurements for each rider, and the corresponding number of ITS Wedges used in testing. Unique to this study, the results demonstrated a strong correlation between power output and cyclists with varying amounts of forefoot varus / forefoot supinatus. Consequently, those with the highest levels of forefoot varus / forefoot supinatus demonstrated increased anaerobic mean power outputs of approximately 10%.

Which Wedge Type Should I Use?

Wedge choice can be a very controversial topic. Unfortunately, like many aspects of cycling biomechanics there is limited published research to justify selection or preferred choice. Most Bikefit organisations tend to prefer the Cleat Wedge and report good results – but in some cases this may be achieved by default. We will now attempt to explain when and why each of the two different wedge types should be selected. Then we will discuss musculoskeletal rehabilitation strategies.

Cleat Wedge versus ITS Wedge

In our opinion, and logically, varus aligned Cleat Wedges should be used primarily to address the tibial varum factor which is common to the vast majority of people. Tibial varum is the natural bowing of the lower third of the tibia (bowlegged) represented

by a typical 3 to 4 degree angle (Figure 2). When the foot is unloaded (openchain) the inside aspect (bigtoe) of the foot is elevated in relationship to the outside of the foot. When the foot is loaded (closedchain) the inside of the entire foot must roll inwards (pronates) to make contact with the pedal platform. Pronation is a natural compensatory movement owing to the tibial varum factor. Cleat wedges accurately align (cant) the entire foot and hold it in a more neutral position. Where, ITS wedges should be used primarily to address forefoot varus. Forefoot varus is a forefootrearfoot alignment problem (Figure 3); the 1st MTP joint (big toe) is elevated from the pedal when the rearfoot is in a neutral position. ITS wedges are designed to address this alignment problem between the forefoot and rearfoot. Whilst most cyclists would benefit from Cleat wedges to address the natural tibial varum factor, for some unknown reason, many Bikefit organisations measure forefoot varus using a goniometer (Figure 4) and subsequently fit Cleat wedges. Furthermore, Pierrynowski and Smith (1997) report that the subtalar neutral position is the most widely used reference point for the clinical measurement of the relationship of rearfoot to forefoot (forefoot varus), yet this appears to be infrequent practice in many Bikefit scenarios.

In summary, we believe that the vast majority of cyclists would benefit from varus aligned Cleat wedges to address natural tibial varum. Ideally, ITS wedges should be used in combination with Cleat wedges, when and if, forefoot varus has been reasonably established. An indicative test for fitting varus wedges is; if your knee moves inwardly, and/or if your foot abducts (rotates outwardly) during the pedal downstroke when the foot is subjected to reasonably high pedal forces (Figure 5).

Figure 2

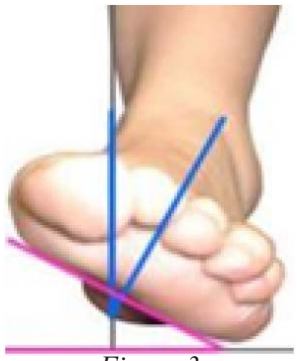

Figure 3

Figure 4

Figure 5

Arch Supports: Are They Necessary in Cycling?

Hannaford et al (1986) demonstrated that simple longitudinal arch supports are not adequate, as stand alone, to support the foot when high pedal forces move forwards directly over the forefoot during the pedal downstroke, especially during intense efforts. However, when ankling between 10 and 2 o'clock of pedal revolution, the ankle is often in a dorsiflexed position, the foot is then more susceptible to pronation, and therefore the longitudinal arch may collapse slightly, inwardly. Therefore, the use of a firm longitudinal arch support to complement varus wedges can be justified and is likely to prove beneficial, especially for short intense cycling events. A common problem with some commercial cycling insoles is that the longitudinal arch support is insufficiently dense/firm and incapable of providing support under high pedal loads. More importantly, if the longitudinal arch extends too far forward the arch will interfere with the 1st Metatarsophalangeal joint, preventing the metatarsophalangeal heads from grounding. This results in the pedal forces being transferred through the arch rather than the metatarsal heads of the forefoot.

Musculoskeletal Rehabilitation Strategies

While musculoskeletal strategies involving stretching and strengthening exercises have proved very effective in restoration of muscle imbalance in around the pelvic region and many other areas, there appears little robust evidence to support their efficacy in restoration of muscle imbalances associated with chronic overpronation. If the deleterious effects of excessive pronation were a simple quick muscle restoration issue, there would be far fewer overuse injuries amongst athletes, and less emphasis in the commercial development and marketing of foot orthoses and antipronating running shoes. Nevertheless, as Graduate Sports Therapists, trained first and foremost in musculoskeletal rehabilitation techniques, we would always recommend musculoskeletal rehabilitation (corrective exercises) form part of a comprehensive multifactorial management approach. In the case of true forefoot varus which is a congenital osseous (bony deformity), corrective musculoskeletal rehabilitation techniques are pointless. However, a corrective exercise prescription is likely to be beneficial for forefoot supinatus which is considered to be an acquired soft tissue contracture. The level of benefit, and the duration, required to achieve any benefit are questionable, and can prove expensive. Therefore, we would recommend fitting wedges, then pursuing a suitable musculoskeletal rehabilitation plan simultaneously. If and when the pronatory forces have been controlled with no loss in performance, wedges can be removed.

Consider the Role of the Foot Beyond Cycling Activities

There is growing evidence to suggest that forefoot supinatus (acquired soft tissue contracture) develops over years and is a result of excessive subtalar joint pronation. Although never reported in cycling literature, we strongly believe that when excessive pronation exists, the role of the foot should be examined from both a cycling and gait perspective. The literature at good posture during gait is dependent on foot stability during midstance. Studies by Cobb and colleagues demonstrated that foot pronation displaces the body's line of gravity forward through forward pelvic rotation and levels of forefoot varus >7° cause core and pelvic instability. Thus, failure to address excessive foot pronation in both gait and cycling may lead to core and pelvic instability, leading to postural asymmetry being taken onto the bike.

CONCLUSION

Excessive pronation is prevalent amongst cyclists and is here to stay. Studies demonstrate that as pedal forces increase, pronation increases. Although we have no evidence, we strongly believe that modern carbonfibre equipment further exacerbate pronatory forces. Research indicates appropriate varus wedging can improve cycling performance (power output) by eliminating wasteful energy expenditure. Varus wedges also mitigate abnormal knee movement; which mitigates abnormal stresses up the kinetic chain. Wedging is instanteous, and inexpensive. Ideally, a suitable musculoskeletal rehabilitation strategy can run simultaneously while using wedges. Then, if proved successful, wedges can be removed. This assumes there will be zero quantifiable loss in power output. The level of benefit, and the duration, to achieve any potential benefit are questionable. Some longterm rehabilitation strategies can be expensive. Finally, in some cases, we believe abnormal foot dysfunction should be addressed on and off the bike.O

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