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PREVENTION & REHABILITATION: EDITORIAL

Toe-tal recall — What on Earth are our toes actually for?

When viewed through an evolutionary or naturalistic lens, to walk, run and move barefoot is, of course, the default human condition. Any alteration of this is an alteration of not just millions of years of bipedal hominid function, but hundreds of millions of years of natural selection's honing and refining of foot structure.

The 2 papers featured in this section are, first, *The effects of dorso-lumbar motion restriction on the ground reaction force components during running*, by Moreley & Traum, and, second, *Effect of spinal stabilization exercise on dynamic postural control and visual dependency in subjects with chronic non-specific low back pain* by Salvati et al. The relevance of foot and, in particular, toe function, to these two papers will become clear as the editorial unfolds.

After researching evolutionary and comparative anatomy, and applying concepts from it clinically, such as barefoot conditioning, for around a decade, when this author first saw the commercial footwear product "Vibram Fivefingers" shortly after its 2006 market release in the US, he was inspired to both purchase a pair and, after a few days of use, to write to Vibram to ask if they would like their product featured as a viable rehabilitation tool in a Rehabilitation chapter that was being written in Leon Chaitow's Naturopathic Physical Medicine (Elsevier Churchill-Livingstone, 2008). Vibram, who had developed the shoe for sailing and perhaps walking had no idea their product could provide any potential benefit from a medical, rehabilitation or conditioning perspective; so they agreed to have them featured, but asked for some references for these benefits. The end result was an opportunity for this author to serve as distributor of Vibram Fivefingers to the UK market. As a consequence — for obvious reasons — a question that has been repeatedly been encountered is what are the toes actually for? Are they a necessary part of our foot function or some kind of evolutionary remnant we no longer need? It is clear that they are not utilised much in most footwear or sportswear.

Most anthropologists or holistically-orientate biomechanists would tell you that the toes are, indeed, important in optimal foot function. However, some people disagree. The biologist Heinrich (2007) wrote "for all practical purposes, all of our toes could as well be fused or our large toes could be enlarged and the others deleted, if we were uncompromisingly designed to be pure sprinters". On the other hand (or foot), humans are actually particularly poor sprinters whereas they feature among the elite when it comes to endurance running; a fit human outpacing even endurance specialists such as wolves, horses and deer in the long run (Bramble and Lieberman, 2004) — and especially in the heat. And when it comes to economy, the toes may well have an important role in foot function and should not be so easily disregarded.

For the majority of time since Western medicine has developed, the appendix was viewed as a vestigial organ of a bygone digestive system; an irritating remnant particularly prone to inflammation that may become fatal. Even during training in internal medicine in the 1990's were the pathologists and medical doctors towing the party line that the appendix was anachronistic and useless. It is only in the last few years that the function of the appendix as a storage pocket for beneficial bacteria that gets closed off when the gut swells with infection, so that, after the convulsions of diarrhoea have finished and the inflammation subsides, the neck of the appendix will open and allow the original beneficial bacteria to flourish once more; re-colonising the colon (Parker, 2007). The true reason for its predisposition to life-threatening inflammatory bouts is actually much more a product of our sedentary, nutritionally "refined" lifestyle with diuretics as our primary social drinks (alcohols, coffees, teas and sodas), and the constipation that ensues. And so perhaps there is a parallel here with the toes? Perhaps they do serve an important biological function? Perhaps the problems we have with our toes are related to our sedentary and culturally defined lifestyles. After all, when something that is both sensitive and vulnerable is retained by evolution (for example, eyes, appendices, testicles, breasts and … toes) they usually have an important biological role; why risk so much for so little?

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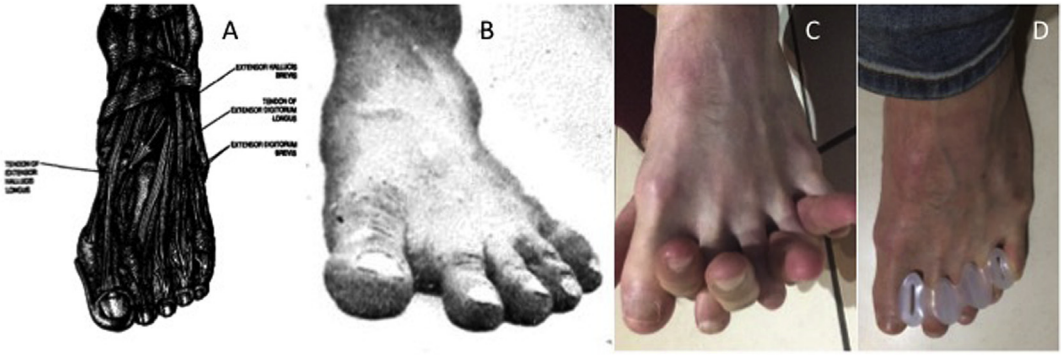

Figure 1 A) "The anatomy of the foot" from King (1998) … However, this is a foot that is deformed; probably by use of shoes and/or deconditioning of the anti-pronation mechanisms of the body. B) A naturally unshod foot where each of the rays run straight with no deviation of the toes. C) A foot handshake results in the toe returning to their natural alignment. This may be useful as an aspect of rehabilitation to stretch shortened tissues from habitual shoe use. D) An orthotic device that can be worn barefoot or within a shoe with a wide toe-box. This device, known as "CorrectToes™" holds the toes in a more neutral alignment whilst the user walks, runs, squats or moves in general.

Hi fives & low toes

Anthropometrically, it may come as little surprise that to give the foot a "high-five" and actually slot a finger between each toe results in a straightening of toes so that the digit aligns optimally with its preceding ray. To encourage patients to hold their feet in this way while relaxing in the evening may help them to reverse some the damage caused by years of wearing shoes that have turned their feet "shoe-shaped" from feet that were once "foot-shaped".

It was the picture below, from 1998 edition of the Journal of Bodywork & Movement Therapies that inspired this author to write to a large sports shoe manufacturer at the turn of the century to suggest they produce a highly tactile shoe with individual toe pockets, so that the toes didn't get bent inwards. What was striking about the image is that it was depicted as "the anatomy of the foot", and not "the anatomy of a deformed foot" See Fig. 1. It was clear that any medical student or trainee in human anatomy may look at an image like this and make the reasonable assumption that this is what a foot *should* look like; indeed, it is what most Western feet *do* look like. This would be akin to a zoo-goer looking at the floppy fin of the Orca and assuming that this is what all Orca's dorsal fins look like; which is a long way from the truth (Bowman, 2013). To understand human function it is important to understand how evolutionary processes have molded the human frame in its natural environment; and to, only then, apply it to the modern environment. It is quite feasible that 100 years from now, people will look back at 20th Century feet and wonder how such intelligent humans lacked the insight to see the mutilation that footwear was causing; in much the same way that the early 19th Century fashions for corsets that deformed the rib cage are looked at incredulously through 21st century eyes.

Mutilation aside, function is quite obviously related to structure; a wheel that is buckled does not travel as effectively as one that is not buckled; and similarly a line of bones that, in nature, are aligned straight (the rays of the feet), but by habitual use of shoes, other aberrant loading, or through disease processes, start to buckle, will alter the stresses going through the joint creating compression on one side and traction on the other and compromising overall performance. These aberrant stresses alter muscle firing around the joint, information feedback to the nervous system (Wyke, 1979) and the piezoelectric profile of the tissues under stress.

Simple Newtonian physics dictate that the broader any structures' base of support relative to its superincumbent profile, the more stable it will be. And the narrower the base of support (a biped versus a quadruped base of support, for example), the more exponential an effect that even small differences will make. Balance is not the only consideration, but also power generation and traction. So, from a human performance perspective, a broader base of support should, indeed, enhance performance. Research in this area is inconclusive (see below under Balance on your toes).

Of course, to view the foot as a simple platform however, is to miss the point. Beyond its platform function, it is highly adapted to both absorb and to store kinetic energy as potential (elastic) energy; to adapt to contours in the substrate; to provide feedback to the CNS about the characteristics of substrate; and the interaction of the foot with that substrate.

One often overlooked aspect of limb design is that the muscle mass is always situated primarily at the proximal end (Radinski, 1989) as any mass at the distal end will increase energetic costs of the inertial loads of swinging a limb back and forth. Since all animals occupy an energetic niche, the less energy they expend, in return for whatever energy they accumulate, the better. It may be of little surprise then that most elite runners have calf muscles where the mass is "high" in the lower leg, that running shoes are generally made of very light materials, and that barefoot running is generally found to be more efficient than shod running, in spite of poor habituation to this state by most tested (Divert et al., 2008; Squadrone and Gallozzi, 2009; Perl et al., 2012). Hence, the foot itself, and the toes as the terminal portion of the foot, are not highly muscled, nor especially strong, but the arrangement of the