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Before discussing ideal footwear for children, consider normal foot development. The alignment of a child's foot and lower extremity changes in the early years. Sitting and crawling improves core strength, then they start to stand, cruise, walk, and finally run. Bones get longer and change shape. Due to the intrauterine position, newborns have a high arches, bowlegged limbs, and often in-toeing of the feet. Gravitational pull is strong enough to almost reverse this, and by age 4 children typically have a pronated foot and knock-kneed limbs. As activity increases, individual muscles get stronger. Due to continued gravitational pulls and the powerful developing muscles of children, this seemingly "malalignment" adjusts back to what would seem normal for an adult by the time they are 7–8 years old.

Here's an important point to keep in mind—a child's foot is not a miniature version of an adult's foot. In early development, a child's foot is widest across the toes. If our population wore shoes that were designed with this functional shape from birth, then most adults would also have feet with the widest part across the toes, and the toes would be perfectly aligned with the metatarsals (long bones in mid-foot). Most of a child's developing foot is composed of cartilage, which is gradually replaced by bone. If the cartilage is deformed by badly shaped or rigid shoes, the bones will take on the deformed shape. It's vital that kids' shoes allow enough room for natural growth, until the foot bones mature. This doesn't happen until ages 18–19 for girls and 20–21 for boys. Simply put, inflexible, poorly shaped shoes are potentially harmful—they restrict the natural movement and development of the foot.

Bony alignment changes are a healthy, normal, part of human development. Care must be taken when prescribing braces or devices, which may have the affect to create misalignment later in childhood. Pediatricians and podiatrists now realize that there is no single best leg alignment and to allow natural development.

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The widest part of newborn's foot is not the ball of the foot, but their toes. Adult feet in modern societies don't look the same. The narrow toe boxes in footwear have changed the alignment of our feet, just like braces were once widespread to change the alignment of the legs. Culturally a pointy shoe looks normal as does the foot shape accommodating this look. Children's shoes are often shaped to this last and thus change shape. This was demonstrated over 100 years ago in a seminal paper by Hoffman.

Children's shoes are often too stiff to allow natural movement. Materials used in the construction of adult shoes are reproduced for kids weighing a fraction as much. Children do not have the physical weight to flex these shoes. A child's foot is designed to move, and the specific strengthening of muscles aligns the bones and joints. Adults who have grown up barefoot or in minimal sandals developed very robust healthy feet with strong muscular attachments to stabilize the foot. The modern shoe-wearing adult's foot does not typically have the same strength and stability.

We are all born barefoot and if allowed to run, jump, and bound in our barefeet as children, we develop the "magic human spring," which starts at the foot [Lieberman]. When we begin to walk and run in stiff and cushioned shoes the spring gets smaller, and then with injury we are often told to run in a supportive shoes (spring getting smaller), and then with further injury we are advised to run in the supportive shoes and orthoses (spring getting smaller still).

The body will seek to find motion and impact reduction at other joints when not available at the necessary joint (the foot). In western societies we have a greatly

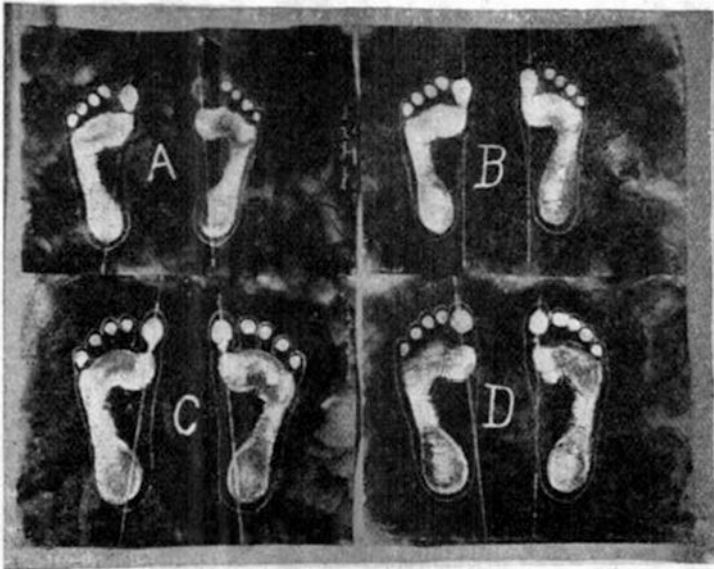


FIG. 10.—FOOT IMPRESSIONS AND TRACINGS OF BAGOBO CHILDREN, SHOWING THE EFFECT OF A FEW WEEKS OF SHOE-WEARING. A AND C BEFORE, AND B AND D AFTER SHOE-WEARING. NOTE NARROWING OF FRONT OF FOOT AND CHANGE IN DIRECTION OF LONG AXIS OF GREAT TOE.

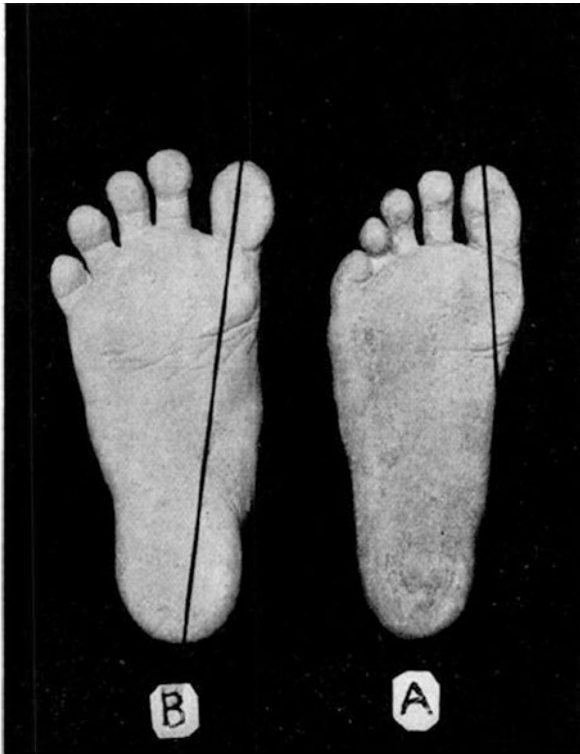


FIG. 11.—A, PHOTOGRAPH OF PLASTER CAST OF FOOT OF BAGOBO BOY THAT HAD WORN SHOES A FEW MONTHS, CONTRASTED WITH B, PHOTOGRAPH OF AN ADULT BAGOBO THAT HAD NEVER WORN SHOES.

disproportionate burden of lower back pain and injury, knee and hip replacements, and impaired general mobility with aging. We detrain our spring and these joints take the load. These conditions are nonexistent in barefoot societies who walk more than we do. Can we retrain all the adults? Maybe, with patience and a progressive re-adaptation, but it may take years. Once you are walking with a cane or walker, the chances are slim.

As a family and sports physician, I firmly believe that children should play in their bare feet or in activity shoes that complement natural foot development and proper biomechanics of movement. Runners, walkers, coaches, and the medical community are all awakening to the benefits of allowing proper natural foot motion to occur in all of our daily activities. Proponents of natural running consider that the smartest design developed for human movement and injury-free activity is the human foot itself and the critical need to enhance balance.

Pediatric footwear until recently have been marketed by the shoe companies to parents, educators, and health care professionals to prepare our kids for shoes they are marketing for adults to wear. The modern shoe industry and its marketing effectively convince parents that when running, a child should wear miniature versions of traditional adult running shoes; almost all of which have elevated heels, extreme

cushioning, and some form of motion control technology. Many dress and casual shoes for children are also stiff and overly supportive.

The APMA (American Podiatric Medical Association) [1] *parent flyer* states that parents should “*Select a shoe that’s rigid in the middle. Does your shoe twist? Your shoe should never twist in the middle.*” It also however states that, “*Step three does not apply to toddlers shoes. For toddlers, shoes should be as flexible as possible.*”

Lieberman has discussed the affects of footwear on gait, and some recommend that children should run barefoot as much as possible, and when they need a shoe, they should wear one that allows the young foot to develop its natural strength, support, and function. Parents should reconsider that their children need “sturdy” or “supportive” shoes. As Dr. Lieberman demonstrated well in his landmark paper in Nature (Jan 26, 2010 [2]), footwear can have a large influence on natural gait.



A foot builds its own intrinsic support via communication with the ground, building strength and stability through proprioception, and allowing normal force loads to be applied to the areas that nature intended. Any changes from what is natural in a developing child create an adaptation and has potential for further compensation.

An elevated heel sets up upstream mechanical compensations at many upstream joints. A child’s shoe that elevates the heel even as little as 4 mm puts the small foot at an angle of over 10°.



**Figure 4: Perfect feet of shoeless young boys. Note straight toes and spaces between.**

The limited literature on children’s footwear supports the “less is more” approach.

A recent review in *The Journal of Family Practice* [3] concluded that flexible flatfoot does not affect function and that there was no evidence to treat it. Twenty years ago, a review of children’s shoes and gait in the journal *Pediatrics* [4] outlined key factors that affect children’s feet:

- Optimum foot development occurs in the barefoot environment.
- Stiff and compressive footwear may cause deformity, weakness, and loss of mobility.
- The term “corrective shoes” is a misnomer.
- Shoe selection for children should be based on the barefoot model.

On the issue of a shoes' affect on gait Wegener in 2011 [5] concluded: "Shoes affect the gait of children. With shoes, children walk faster by taking longer steps with greater ankle and knee motion and increased tibialis anterior activity. Shoes reduce foot motion and increase the support phases of the gait cycle. During running, shoes reduce swing phase leg speed, attenuate some shock and encourage a rearfoot strike pattern. The long-term effect of these changes on growth and development are currently unknown. The impact of footwear on gait should be considered when assessing the pediatric patient and evaluating the effect of shoe or in-shoe interventions."

Tudor in 2009 [6] concluded: "...no disadvantages in sport performance originating from flat-footedness were confirmed. Children with flat and children with "normal" feet were equally successful at accomplishing all motor tests; thus, we suggest that there is no need for treatment of flexible flat feet with the sole purpose of improving athletic performance, as traditionally advised by many."

An article in *Gait and Posture* by Wolf in 2007 titled *Foot motion in children shoes—A comparison of barefoot walking* wanted to test the hypothesis that the increased prevalence for flatfoot and hallux valgus in modern societies may be the consequence of inadequate footwear in childhood. Their study contrasted barefoot motion, motion in a thin and flexible shoe, and a more standard shoe. The conventional shoe significantly affected the motion of the foot compared with the flexible shoes. In conclusion, the authors state, "the encouraging findings with this shoe (flexible prototype) together with previous recommendations by Staheli and Maier would support the principle: *The shoe should in no other way influence the normal foot than to protect it against lesion and coldness.*"

Finally, a seminal paper in 1905 by Hoffman [7] concluded: "...feet all develop the same up until the time of wearing shoes, after which progressive characteristic deformation and inhibition of function ensue. The children of shoe wearers inherit the same foot type as barefoot races, and this type is changed only so far as foot wear modifies it. He goes on to state that flatfoot and the height of the arch of the foot are not pathological."

One example of deformation we see now in many high school runners is hallux valgus. Ill-fitting shoes with a narrowed toe box may aggravate hallux valgus. Furthermore, most runners, both young and old, cannot stabilize and balance on one foot.

The next time in a park, observe a child run barefoot. Notice the relaxed movement and foot placement. They spring. They do not strike hard on their heels. Then watch the child with the highly cushioned or supportive shoe. The difference is easy to see.

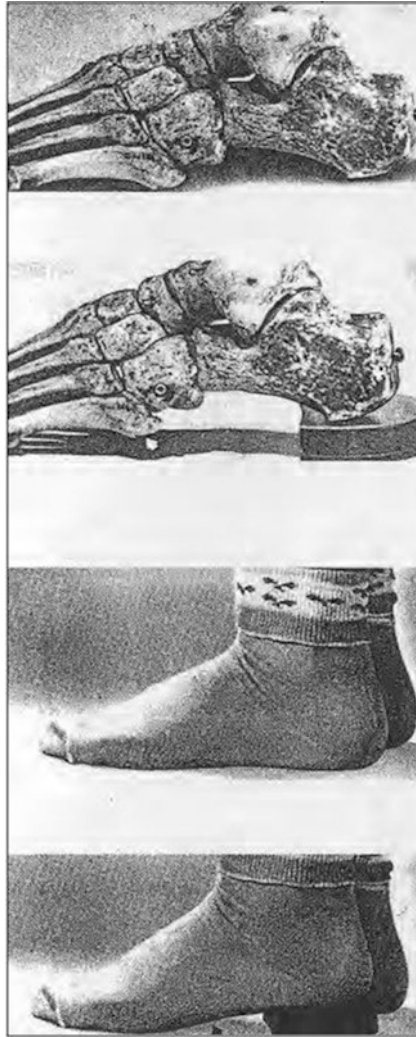


Fig. 33: Top, weightbearing function of base of fifth ray. Second, even low heel denies the ray its normal function. Third and fourth, same effect on flesh-covered foot.

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### So What Are the Important Features to Look for in a Child's Shoe?

- Ultrathin soles to allow proper proprioception, neuromuscular activation in the entire kinetic chain, and to complement the body's natural ability to absorb ground forces.



- Low, flat to the ground profile—shoes should allow all play activity that involves climbing, running, and jumping. Shoes should enhance lateral movement since the foot will not be up on a platform or have a slope from heel to forefoot.
- The materials should be soft and supple, thereby allowing natural foot function. The shoe should bend easily at the toe joints—this is where a foot is designed to bend to recreate the arch on takeoff.
- The toe box should be wide enough to allow natural toe spread. Foot support is created by the natural arch of the foot with the great toe stabilizing the arch. When the heel is elevated and great toe deviated toward the second toe (a common design flaw in many shoes which come to a point), this stability is compromised. The foot produces the most leverage when the toes are straight and aligned with the metatarsals. A child's foot is widest at the ends of the toes (as should an adult's be if they have been in proper shoes or barefoot).
- A single piece midsole/outsole allowing protection on unnatural surfaces (concrete, asphalt) and natural rough surfaces (rock, trail) while allowing proprioception and natural dissipation of ground reaction forces.
- Upper material should be soft, breathable, and washable.
- Get over the notion that shoes need “traction.” In a moving child the more stickiness and grip, the more heat produced in the foot and braking moments on running activity.
- Discourage the use of thick, heavy socks as these interfere with foot proprioception.
- All efforts should be made to use recycled materials in the construction of the shoe.
- Shoes should be a good value and of comparable price to other children's shoes.
- Design and colors should inspire fun and play.

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