How to Get the Most Out of the Latest Generation of Running Super Shoes

By Tom Michaud, DC

In 2018, runners wearing the Nike Vaporfly 4% shattered world records in nearly every long-distance event, including the 100 km, marathon, half marathon, and 15 km running distances. On October 12, 2019, wearing the next generation Nike Air Zoom Alphafly NEXT%, Eliud Kipchoge became the first person in history to run a marathon in less than 2 hours. One day later, Brigid Kosgei shattered the women's world record for the marathon wearing the same shoe. These shoes are not just for elite athletes as Nike boasts that regardless of skill level, the Alphaflys and their predecessors can improve economy by as much as 4%, which translates into a 3.4% increase in speed for the world's fastest marathon runners, and a 4% improvement in speed for three-hour marathon runners (1).

In response to the astronomical success of the Vapor and Alphafly series, pretty much every running shoe manufacturer dissected the Alpha and Vaporflys to isolate and perhaps improve upon the specific shoe components responsible for the faster running times. The end result is that almost all of the latest running super shoes are now made with 4 specific components that can potentially improve running performance (Fig. 1): (1) midsole stiffness moderators, typically graphite plates, which are designed to function like diving boards that bend and snap back to return energy during propulsion; (2) exaggerated toe springs to improve comfort and offload the Achilles tendon and plantar fascia; (3) highly resilient midsole materials to maximize the storage and return of energy and; (4) extra thick midsoles to increase comfort and extend limb length. The final modification is based on the clinical observation that animals with long limbs tend to be metabolically more efficient while walking and running, so running shoe manufacturers decided to make your limbs longer by increasing the vertical height of the midsole.

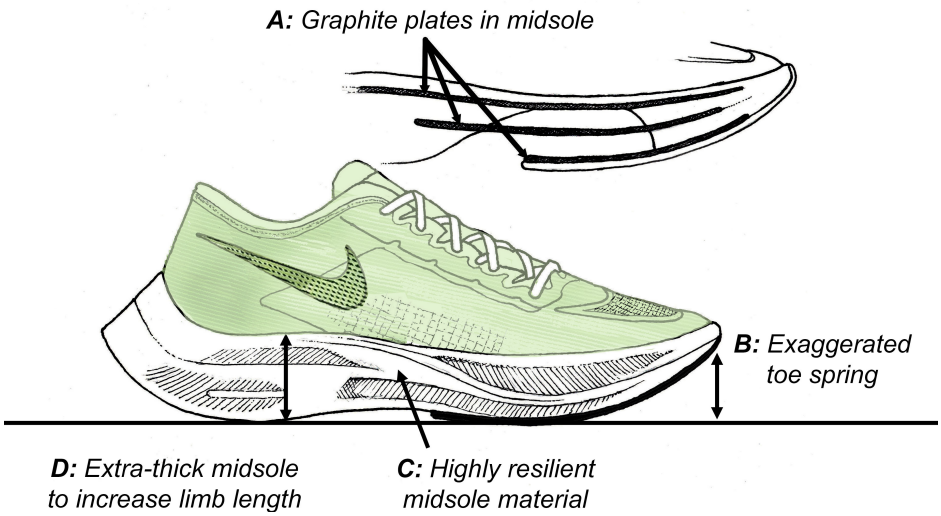

Fig. 1. Components of modern super shoes. A: Midsole stiffness moderators. The Nike Vaporfly has a single graphite plate embedded in the forefoot while The Nike Air Zoom Alphafly NEXT% (top) has three carbon graphite plates. **B**: An exaggerated toe spring allows you to roll through your propulsive period with limited upward movement of the toes. **C**: Highly resilient midsole materials to maximize the storage and return of energy. **D**: Extra-thick midsoles that effectively increase limb length, which in theory improves metabolic efficiency.

While no one would argue that the latest generation of running super shoes improve performance, researchers still haven't figured out exactly which components of modern super shoes are responsible for the improved running times. For example, while it seems logical that placing graphite plates along the longitudinal axis of the midsoles would naturally increase running times by providing free energy when the bending graphite plates snap back to their original position during propulsion, recent research has shown that the carbon plates do not act as springs (2) and play little to no role in improving running economy (3). The most frequently cited theory explaining the connection between stiff midsoles and improved running economy is that because the carbon plates prevent the toes from bending upward during propulsion, the metabolic cost of running is reduced as the muscles that control toe movement consume fewer calories when toe motion is limited (2). This theory was disproven in 2021 when Healey and Hoogkamper (3) evaluated running efficiency as athletes ran while wearing either the Nike Vaporfly 4%, or the same shoe modified with a series of midsole cuts that allowed the toes to bend. The end result was that despite the toes moving faster and farther in the modified Vaporflys, there was no difference in overall energy output or efficiency between the 2 shoes. A possible downside to the limited toe motion in the unmodified Vaporflys is that over time the less active toe muscles could weaken, which would increase the risk of a variety of injuries, including metatarsal stress fractures (4) and/or chronic heel pain (5).

Since limiting toe motion does not improve efficiency, an alternate theory explaining how a stiff midsole might improve running performance is that the graphite plate alters the length of the lever arm between the forefoot and ankle, which allows the gastrocnemius and soleus muscles to function in their optimally efficient positions (6). Even if this theory holds up, recent research shows the improved efficiency associated with graphite plates is minimal (3), and a potential downside of carbon plates is that they can produce up to 5 cm increases in stride length (7), which could possibly result in an increased risk of hamstring and/or Achilles injuries.

The second change in shoe production, the addition of exaggerated toe springs, are an extremely popular addition to not just the super shoes, but to almost all modern running shoes as they improve comfort by offloading the Achilles tendon and plantar fascia (Fig. 1B). While everyone agrees that toe springs improve comfort while walking and running, this comfort comes at a price. A recent three-dimensional biomechanical analysis proved that toe springs significantly reduce force output from the intrinsic muscles of the arch, which in the long run could produce injury and/or impairments in running performance. According to Sichting et al. (8) "toe springs may contribute to weakening of the foot muscles and possibly to increased susceptibility to common pathological conditions such as plantar fasciitis." This statement is supported by research from Sullivan et al. (5) who show the development of chronic heel pain is strongly correlated with toe weakness. Because of the possible long-term harm associated with toe springs, athletes should race in their super shoes but train in running shoes that allow their toes to bend. Either that or do aggressive arch and toe strengthening exercises on a regular basis.

The third manufacturing feature associated with modern super shoes is the state-of-the-art midsole materials that have been specifically designed to store and return energy. To actually improve performance, midsole materials must have a high compliance (the ability to deform) and a high resilience (the ability to return energy). The ideal material will function like a pogo stick, where the spring stores energy as your body weight stretches the spring downward and immediately returns free energy as you jump up, which would appreciably improve performance. Early on, Nike began using the lightweight midsole material Pebax, which is a polyether block amide that is exceptionally compliant and resilient. In a frequently referenced 2017 study published in *Sports Medicine*, Wouter Hoogkamer and his colleagues (1) compared running economy and high-level athletes wearing running shoes with different midsoles and determined that compared to conventional EVA and urethane midsoles, the Pebax midsole in the Nike Vaporfly lowered the metabolic cost of running by 4%. Subsequent research has confirmed the vast majority of energy returned while wearing Nike Vaporflys comes from the Pebax midsole, not the

graphite plates (3). The only possible downside to the Nike Vaporflys used in Hoogkamer's initial study is that the athletes wearing them had slight increases in their stride lengths and impact forces (1), which could translate into a greater prevalence of injuries.

The final feature added to the new generation of super shoes is the incorporation of extra-thick midsoles (Fig. 1C). I find this the most interesting addition because it's based on a study by the famous paleoanthropologist Herman Pontzer. In 2007, Pontzer published a fascinating paper showing that terrestrial animals with longer limbs are more efficient while walking and running (9). Pontzer states that at any given speed, "smaller animals use shorter steps and must therefore generate ground forces over shorter amounts of time, thus requiring higher rates of muscle force production, resulting in a greater cost of transportation." Apparently, someone in the running shoe industry read this paper and decided to make the lower limbs of runners longer by increasing the height of the midsole. Think of the circus performers walking around on stilts: they cover extremely long distances with little to no energy owing to the greatly exaggerated stride lengths associated with the use of the stilts. Interestingly, even though they had not been adequately studied, World Athletics recently banned running shoes with midsole thicknesses greater than 40 mm because of perceived advantage associated with the thicker midsoles.

In June of 2023, researchers from the Human Performance Lab in Calgary (10) proved the World Athletics ban on running shoes with thick midsoles was unjustified, as their 3-dimensional and metabolic study conclusively demonstrated that excessively thick midsoles have no effect on running economy or performance and may actually increase the risk of injury by exaggerating foot pronation. Note that this was an exceptionally well-done study, as the authors took 21 recreational runners and had them perform 5-minute treadmill running trials wearing running shoes that were identical in every way except for the midsole thickness, which ranged from 35 to 50 mm. Even though the authors theorized that the runners wearing the thicker midsoles would be more efficient, they were not. The authors conclusion that the excessive midsole thickness might increase a runner's risk for injury had been previously demonstrated. In 2020, researchers from San Jose State University performed a similar study of maximalist running shoes and noted that compared to conventional running shoes, runners using the thicker maximalist shoes pronated farther and faster than runners wearing the traditional and minimalist shoes (11). The excessive rolling-in was especially apparent as the runners were pushing off. The authors state that "the eversion mechanics in the maximal shoe may place runners at a greater risk of injury." Previous research has linked a wide range of lower limb and leg injuries to excessive pronation (12,13). If you have flatfeet and you're considering these shoes, you should preemptively strengthen the muscles that control excessive pronation, such as tibialis posterior, and/or place varus posts beneath your insoles (Fig. 2), which have been proven to reduce the range and speed of foot pronation (14).

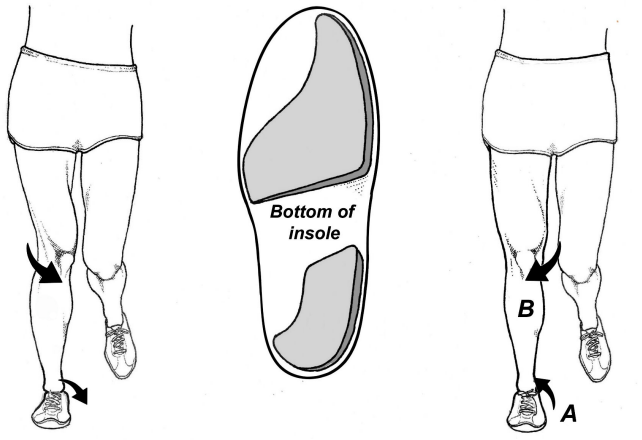

Fig. 2. Peel and Stick Varus wedges can be attached directly to the bottom of your insoles. These wedges limit the velocity and range of pronation (**A**), limit the inward twist of your lower leg (**B**), and can even reduce strain on your plantar fascia (17).

The bottom line with all of these studies is that even though the new generation of super shoes can produce slight increases in running performance, these improvements come at a cost: the graphite plates and more resilient midsole materials slightly increase stride lengths and impact forces, which may potentially injure the Achilles tendon and/or the hamstring muscles. The exaggerated toe springs can weaken the intrinsic muscles of the arch and may lead to chronic plantar fasciitis. The excessive thickness of super shoe midsoles increases the rate of pronation, which has been correlated with a wide range of running injuries.

To take advantage of the benefits associated with super shoes, it is essential that you strengthen key muscles of the toes and arch to offset the potential injuries associated with using super shoes. My favorite exercise routine to improve performance with or without super shoes is illustrated in figure 3. The high-intensity isometric contractions performed at the end of each set have been proven to significantly increase the ability of your tendons to store and return energy (15,16). One study showed that short bursts of high-intensity isometric contractions can increase tendon strength by 20% (16). In the original paper demonstrating the Nike Vaporflys produced a 4% improvement in metabolic efficiency while running, Dr. Hoogkamer and his colleagues state that "regardless of the shoes worn, in human running, the vast majority of the mechanical energy storage and return occurs within our natural biological structures." While no one would argue that the world's fastest runners would benefit from a 4% jump in running performance, it is possible for runners of all levels to significantly increase performance and reduce injury rates simply by improving the ability of their own tendons to store and return energy. Unlike the temporary gains associated with putting on a running shoe, making your tendons stronger and more resilient is a long-term investment in not just running performance, but overall health.

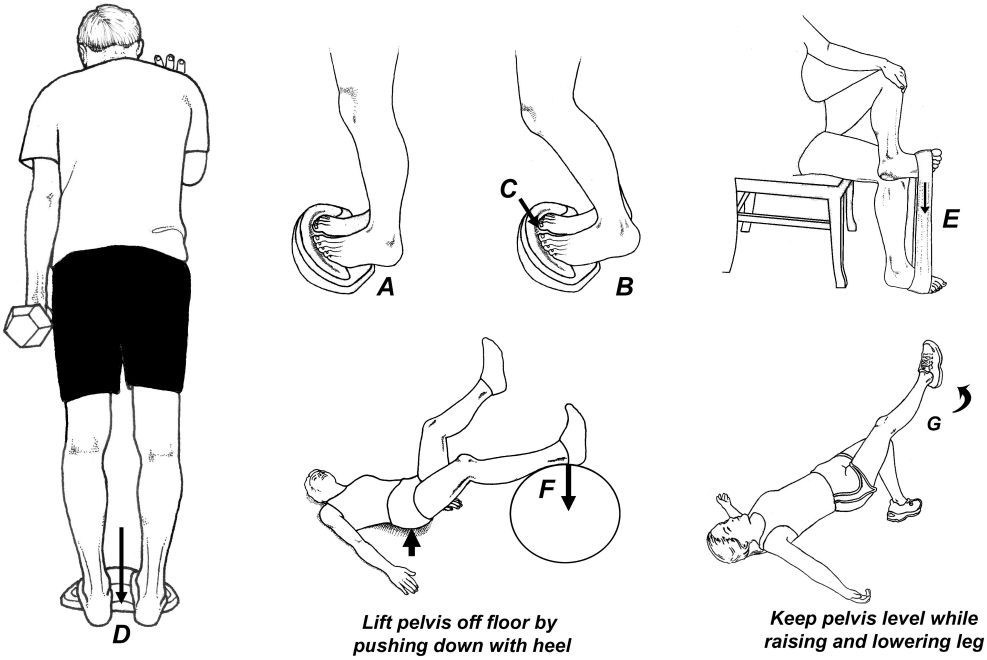

Fig. 3. Home exercises to help you get the most out of your super shoes. To strengthen your toe and arch muscles, which can be weakened by graphite plates and/or a toe spring, place a ToePro near a wall and do 2 sets of 15 repetitions with knees straight (**A**), and 2 sets of 15 repetition with knees bent (**B**). You should be driving your toes into the foam with each repetition (**C**). At the end of each set, hold a 30-second isometric contraction with your heels just slightly off the ground (**D**). You should be fatigued at the end of each isometric contraction, and if not, hold onto a weight to increase resistance. Because the extra-thick midsoles increase the rate of pronation, you should strengthen your tibialis posterior muscle with the exercise illustrated in figure **E**. Tibialis posterior is an important decelerator of pronation and this is an excellent exercise that effectively targets tibialis posterior (18). Lastly, because super shoes can increase stride lengths by as much as 5 cm, you should strengthen your hamstrings and hip flexors with exercises **F** and **G**. 3 sets of 15 repetitions performed 3 times per week is usually enough to strengthen these important muscles. To increase tendon resiliency, perform a 30-second isometric hold at the end of each set. A video of these exercises is available online at www.humanlocomotion.com

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