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Hill Training as a Safe, Successful Component of Distance Running Programs

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> "*East Africans have been traipsing up and down the steep slopes of the Great Rift Valley for millennia, and in the last half-century have rewritten the distance-running record books. Today, they run the hills harder than ever.*"
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> -Amby Burfoot, Editor of Runner's World

Many have questioned the validity of hill training as a component of a distance running program. In fact, hill training has inherited a bad rap over the last decade or two due to certain "experts" claiming that the benefits are unproven and that the risk of injury is too great. That said, recent findings are asserting hill training as being more important than ever. There is plenty of research to suggest that hill training is not only a component of a successful training program, but is a vital and essential part of nearly all elite distance runners' training programs. Training with hills has both mental and physical benefits that cannot be obtained with any other type of training.

Pre-note

Let it be known that I am a very strong supporter of running on soft or uneven surfaces whenever possible. I believe this to be possible for a majority of most runners' mileage, if they make the effort. Natural surfaces have been proven to reduce injury risk, enhance strength gains, and improve performance. When discussing hill training, it is recommended that this type of training be done on natural surfaces when it is an option. Doing so will effectively enhance the hill training experience and reduce the chance of impact and overuse injuries. For a more detailed account of research regarding natural surfaces, please see my article on natural surface running, online at http://www.runners-corner.com/runoffroadarticle.php .

Risks of Hills and Injury Prevention

Hill training has been much maligned as being a risk to runners due to its intense nature. Detractors will claim that the increased stress on the body increases injury and is too dangerous to undertake as a training method. They claim that runners will do just as well with speed sessions on flat ground, such as a track. A main argument is that uphill running tends to stress the lower leg too much and will lead to Achilles problems. They also argue that running downhill increases the impact on the body at footsrike, thus making the body more susceptible to impact injuries.

While I agree that uphill running can cause lower leg maladies, and that downhill running can cause knee and impact injuries, I will respectfully disagree that the hills are the actual source of the problem. The majority of these types of injuries likely come as a result of the runner undertaking their training program with too much zeal or not knowing how to properly train. Highly respected exercise physiologist Pete Pfitzinger (1999) notes: "Most running injuries occur because of the repetitive nature of the stride...You can prevent many running injuries by...correcting muscle imbalances and...by adjusting your running surface [and] terrain." Hill training would be an adjustment to terrain and running surface, making hills a likely benefit. It seems that injuries "from" hill training are likely no different than other overuse running injuries, in that they come as a result of the athlete jumping into the activity too hard and too quick without giving the body time to build up and adjust.

It would be rare (but possible, I concede) that a runner who regularly does uphill training would suddenly contract an injury such as Achilles tendonitis without any major changes to their regular regimen. Most likely this type of injury would occur with a sudden increase in either the volume or intensity of training, or with an unnatural increase in the amount of uphill training

they are doing. I will not delve into what is a natural amount of increase in a training program as this information can be found just about anywhere. But I will reaffirm that I believe that the injuries that hill training gets blamed for are more likely caused by the runner creating too great of a change in their training program and/or doing something they are not normally accustomed to doing.

At the risk of being cliché, moderation and variety should be the rule of thumb with any training program---this includes implementing hills into a training program. Perhaps the most respected running form and technique coach in the U.S., Dr. Tom Miller (2002), had this to say regarding hill training: "Developing a variety of training alternatives is important to prevent overuse injuries and maintain motivation."

British distance coach Brian Mackenzie (2007): "There are many advantages of combining hills and hard going (i.e. Soft surfaces such as sand or grass)... there is a reduced risk of damaging their legs through impact injuries...Running up a hill on a soft surface is much less damaging than doing, say, 1000m on a synthetic track, yet it gives all the pain and all the pleasure of a really hard work-out and that, after all, is what we are trying to achieve." Coach Mackenzie further emphasizes that the amount of distance run can be reduced due to the hard going of the terrain. Translation: More bang for your buck. A runner can still gain the benefits and burn just as many calories without having to run as far. Less steps = less overall stress on the joints = less chance for injury.

The increase in strength gained from hill running can also serve as an injury buffer. "Another aspect of cross-country and road running where greater strength makes a difference is hills, both up and down. Obviously, stronger muscles provide more power for running up inclines. Just as important, they also offer better shock absorption, and therefore more injury

protection, when running down declines." (Westcott, 1998) Highly respected coach and Runner's World Editor Hal Higdon (1999) adds "Hills strengthen your legs, especially the quads, lessening the possibility of a knee injury."

While downhill running often takes heat for being too pounding, the very nature of the activity has injury prevention benefits that are unique to its eccentric motion. The nature of downhill running can provide what some call soreness protection. By doing downhill running, the body is protected against muscle soreness in the future, and therefore protected from injuries that might usually occur while trying to train hard on muscles that are already sore. "Many runners develop muscle soreness after strenuous workouts or races. Research (Muscle function after exercise induced muscle damage and rapid adaptation, Medicine and Science in Sports and Exercise, vol. 24 (5), pp 512-520 1992) has shown that the muscle pain and loss of strength can be minimized if runners undertake regular sessions of eccentric training. For runners this would involve downhill running, since downhills put the muscles in the front of the leg under intense eccentric duress. A single downhill session (6 to 10 downhill runs over 300 metres) on a 300 to 400 metre hill with an inclination of 10 to 15 degrees should provide protection against muscle pain and loss of strength for at least six weeks."

Improvement of Vo2 Max, Running Economy

"*Hill work should be a regular part of all training*."

-Brian Mitchell in "Running to Win" (pg. 68)

Aside from providing possible injury protection to the runner, hill training is used by nearly all world-class athletes in their training. "Whether to build strength or to condition themselves for hilly races, most top runners use hills in their training." -Hal Higdon (1992, 151)

This may be due to the specific physiological benefits hill training provides. Mackenzie has this to say when speaking about increasing Vo2 max with hill running: “Mixed hill running can also be used to improve running economy and boost an athlete's VO2 max. To do this identify a six or seven mile undulating hilly course, commence the session jogging at a modest pace and gradually pick up the intensity as they move through the hills. The key is not just to run up and down a few hills in their workout but to find a place where they can run up and down hills nearly constantly... The key is not to let the flat ground running total more than 25% of the workout.

During most of the run, the athlete's heart rate should be close to 85% of maximum (85% of maximum heart rate matches up with 76% VO2 max). Do not let them blast up hills in the early part of the workout, this can stop them working though subsequent miles. The idea is to run constantly at a hard but not super fast speed. They should not feel like they are racing but as though they are running just slightly slower than lactate threshold, even if the actual pace is even slower than that. Alternatively, they can use heart rate, which should be at around 85% of maximum during at least the last two-thirds of their run. A run of six to seven miles in this manner is enough for a great workout, but you can expand the session as much as you want with some additional hilly, but easier miles. If you plan in a mixed hill session once a week over 10 to 12 mile course, you will be amazed at how their running takes off.”

Regarding running economy, Burfoot (2005), adds: “A chapter in the International Olympic Committee's 1992 book Endurance and Sport reported a study of runners who did 12 weeks of regular training, plus "hill training with 'bounce running.'" After the 12 weeks, the subjects' running economy (or how efficiently they ran) increased by an average of three percent. That's a nice increase in a running variable that's not easy to improve.”

Americans Deena Kastor and Meb Keflezighi (who both medaled at the 2004 Olympic

Marathon in Athens), were “both honed to an Olympic peak by the hill-training methods of Coach Joe Vigil: 'Deena and Meb are always on the hills when they're training in Mammoth Lakes [California].' Vigil has a Ph.D. in exercise physiology, so he views hill training through a technical lens. 'We use oscillatory terrain to increase the athlete's adaptation to stress, and to teach a more efficient use of glycogen,' he says. 'It also gives them a nice reactive power that improves their running economy.' " (Burfoot, 2005)

Improvement of Anaerobic Threshold

A 1977 article in the European Journal of Applied Physiology concluded that runners who followed an intense six-week program of hard uphill running enjoyed "significant improvements in training distances, anaerobic capacity, and strength." (Burfoot, 2005) Storied distance coach Jack Daniels (1998, pg. 179) adds this about anaerobic threshold: “Hill running is 'speedwork in disguise'. It can be used in place of grueling track workouts to improve your anaerobic efficiency.”

Pfitzinger and Douglas (1999, pg. 42) add: “A great way to increase your Lactate Threshold is by running long hills.” This increases number and size of mitochondria (increase o2 consumption); increase aerobic enzyme activity (speed energy production); increase capillarization (improve efficiency of delivery and removal which allows aerobic energy production to be maintained at a higher rate); increased myoglobin (more o2 can get to the mitochondria).” How's that for a super concoction of performance boosting benefits?

Hills as a Resistance Training Tool

> “*Many coaches and strength experts believe hills provide better strength for running than weights or machines. Weight lifting strengthens those same muscles, but it won't train them for the demands of running...Hill running*

builds strength and coordination at the same time."

-Jeff Galloway (From Run Fast p. 154)

Despite the lack of gyms in East African powerhouse running countries such as Kenya, these athletes continue to dominate the world competitive running scene. How is this possible? There is speculation that weight training can actually detract from running performance. However, it is more likely that these athletes benefit from "running specific resistance training" (i.e. Hills). Using the hill to make provide their body with resistance, these runners gain strength and power while still using a running specific motion.

Amby Burfoot (2005) says this about a visit to Kenya: "East Africans have been traipsing up and down the steep slopes of the Great Rift Valley for millennia, and in the last half-century have rewritten the distance-running record books. Today, they run the hills harder than ever. I experienced this first-hand on a 1998 trip to Kenya. One morning, I joined a handful of marathoners who were being coached by Dr. Gabriele Rosa as they tackled the infamous Fluorspar Hill (40 miles east of Eldoret) that rises nearly 4,000 feet in 13 miles."

"Marathon running uses a lot of quadriceps muscle fibers, and this is the best way to build the quadriceps," Rosa told me recently. "In Italy, we use the gym also. But the Kenyans do not have any gyms, so we run hills."

Coach Mackenzie (2007) adds: "In hill running, the athlete is using their body weight as a resistance to push against, so the driving muscles from which their leg power is derived have to work harder. Hill work results in the calf muscles learning to contract more quickly and thereby generating work at a higher rate---they become more powerful. The calf muscle achieves this by recruiting more muscle fibres, around two or three times as many when compared to running on

the flat. The "bouncy" action also improves the power of the quads in the front of the thigh as they provide the high knee lift that is required. For the athlete, when competing in their sport/event, it can mean higher running speeds and shorter foot strike times." Not only do hills provide athletes with stronger, faster muscles, but they spend less time on the ground (shorter foot strike) which means those muscles don't have to be in use as much.

Training with hills increases both the number of muscles fibers being used and in the use of different muscles that would otherwise not be used. Using a greater number of muscles and a greater amount of muscle fibers within those muscles must surely increase performance. "Hill training is almost as effective in building aerobic power as track interval training," says (2:27 marathoner and USA T&F Distance Coach) Chris Phelan. "And it's far more effective in building strength." Indeed, running uphill strengthens your hamstrings, calves, glutes, hip flexors, and Achilles tendons more than flat running, and it uses more upper-body muscles. "Hill running is resistance training for runners," says Phelan, "because you're fighting the resistance of the slope. It is extremely demanding at first because you work muscles that you don't use often."

Research backs Phelan up. A study co-authored by Mark Sloniger, Ph.D., an exercise scientist at Indiana University of Pennsylvania, found that more and different muscles are used in uphill running than flat running. "More force is required for uphill running, especially from the quadriceps," says Sloniger, "so more muscle fibers are recruited. A primary goal of any training is to utilize as many muscle fibers as possible so that adaptations can occur to make them more efficient." (Cooper, 2004)

Improvement of Running Form (Technique)

Another benefit of hill training is something that most runners really struggle with, and that is their running technique. Running hills can teach form in a way that just can't be taught on flat ground. The body is in some ways forced into being more efficient, thus improving form.

Since no writing on running technique would be complete without a to the point quote from running form expert Tom Miller, I offer these selections from his excellent book *Programmed to Run*: "Uphill intervals can be used to improve your form." "Downhill runs can teach relaxation and improve leg speed and stride." (2002, p. 151) "Steep uphill repeats (emphasize) explosive push-off...proper arm swing...form and quickness." "Gentle downhill repeats (teach) a faster than normal turnover rate" (pg. 73)

Jeff Galloway adds: "Pushing up the incline builds the lower leg muscles. With power there, you can develop a more efficient push-off, better running posture, and more strength in your legs." (Higdon, 1999, p. 154)

Greene and Pate mention technique improvement as one of three main benefits of hill training for youth in their book on training young distance runners. "One of the most complete crossover methods (of training) is hill running, which develops strength endurance, cardiovascular fitness, and technique." (2004, pg. 124)

Other Benefits

"*Running up and down hills gives the body strength, so when you get to the flats, you can run quite nicely without much problem.*"

–Paul Koech, 26:36 10k and 10 Mile World Best Holder. (Pfitzinger, pg. 173)

Hill training has many benefits besides the ones mentioned above. It is a boon to the cross-country runner, altitude dweller, and provides mental benefits as well.

In *Daniels Running Formula,* Dr. Jack Daniels writes: "It becomes mentally demanding to hold a constant intensity of effort for a two-hour long run when hills of varying grade and size are constantly confronting you....and at race time the hilly terrain runners can look around and imagine that they are just a little tougher than the rest of the crowd they see lining up around them. (1998, Pg. 179) This is also a strategy of Hawk Harper, Coach of the Sojourners Running Club in Utah. Hawk says he believes in giving his athletes (especially the younger ones) such challenges in practice that race day seems easy. He believes that if his athletes can conquer a mountain or gargantuan hill that tests them to the core in practice, that race day will be made easier. I have seen his athletes respond to this, and the results are phenomenal.

Another benefit of using the hills is to enable a runner who lives at altitude to be able to get the same amount of leg turnover they would get at sea level. Hal Higdon (pg. 152) writes: "At altitude, one of the negative factors is that you can't get the quality of speed training you can at sea level. (Herb) Lindsay (a former #1 ranked road runner) explains. 'You're limited by the thin air, but you can compensate by running on a gentle downhill incline. With gravity pushing you along, you can run as fast (that is, with the same leg speed) as you can at sea level.' "

Hill training also aids in faster race finishes, upper body strength, and of course, whenever a hill is encountered on the race course. In *Running to Win*, Brian Mitchell adds: "Lifting and pushing the body uphill will create considerable strength...a vigorous arm motion... produces strength in the upper body...This aids (the runner) in fast finishes, and, of course, on the hills." (pg. 41)

Hill training is also a natural benefit to the cross country runner. The extra muscles used

and the added strength gains help out a lot when the lower leg muscles begin to fatigue due to the different terrain. Pfitzinger (pg. 170) writes: "By training on hills, soft surfaces, and uneven terrain, you'll prepare your muscles…to deal with cross-country conditions. Each year, several relatively unknown men and women use this strategy to beat better known track and road racers."

Conclusion

"South African coach Abrie de Swardt is a big fan of hill training for endurance athletes, believing that this training method can literally make the difference between winning and losing. Working with his athletic charges, de Swardt has found that hill training:

- Helps develop power and muscle elasticity;
- Improves stride frequency and length;
- Develops co-ordination, encouraging the proper use of arms during the driving phase and feet in the support phase;
- Develops control and stabilization as well as improved speed (downhill running);
- Promotes strength endurance;
- Develops maximum speed and strength (short uphill runs).
- Improves lactate tolerance (mixed hills)" (Training for Maximum Endurance, 2007)

Distance runners should use hills in their training programs to gain the many benefits available to them. Hill training, when done correctly, is a safe and effective way to improve performance, gain an edge on the competition, and even prevent injury. Training in the hills can improve Vo2 max, boost Running Economy, and buffer Anaerobic (Lactate) Threshold. In addition, hill training can be used as a form of resistance training to supplement or even (as in the case of many elite African runners) replace weight lifting. Running technique can be improved, and there are specific benefits to be had for cross-country runners and those who live at altitude. The mental benefits of training with hills, and especially in the mountains can yield fantastic results. Distance runners should incorporate hills into their training as a safe, effective way to successfully improve their running performance and enjoyment.

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