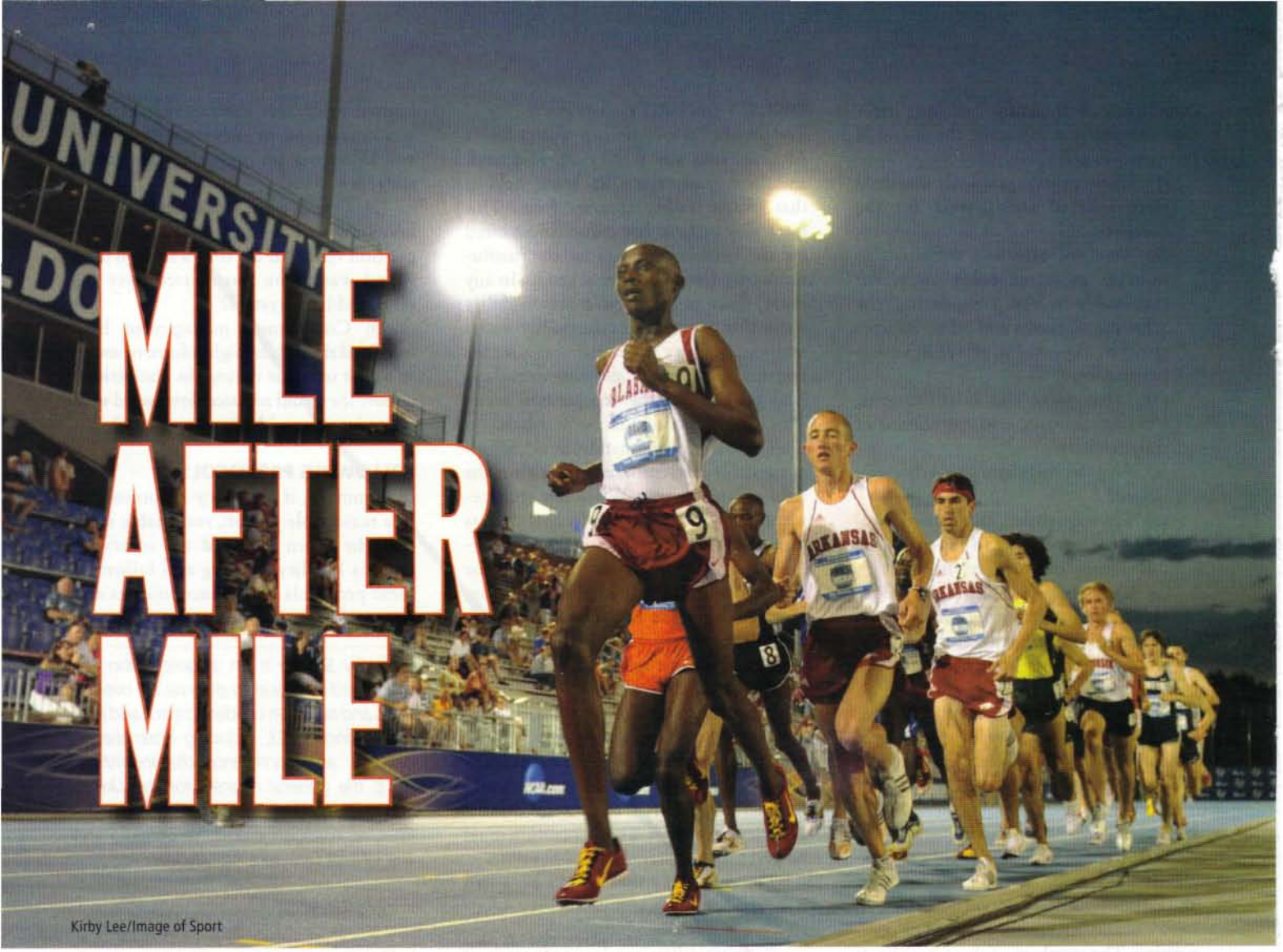
MILE AFTER MILE



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How much mileage is enough?

BY JASON R. KARP, PHD

I recently finished reading Scott Thorpe's *How to Think Like Einstein*. The book's theme is that you have to break rules in order to solve difficult questions. According to Thorpe, Einstein discovered the theory of relativity by seeing past rules other scientists thought were unbreakable.

One of the "rules" of distance running is that athletes must run a lot of miles. Indeed, most runners link their fitness level to the number of miles they run, assuming that more is better. A friend of mine who almost made the U.S. Olympic Team in the 1,500 meters ran 100 miles each week. Frankly, I thought he was nuts. And I began to wonder: Is it really necessary to run 100 miles per week to train for a four-minute race?

As legendary coach Arthur Lydiard so ardently claimed, lots of aerobic running forms the basis of any distance training program. Whether athletes are training for the mile or the marathon, it all starts with mileage. That's because endurance training stimulates many physiological, biochemical, and molecular adaptations. All these adaptations can be thought of as the body's attempt to cope with the demands placed on it by running every day.

For example, endurance training stimulates more fuel (glycogen) to be stored in an athlete's muscles, increases the use of intramuscular fat at the same speed to spare glycogen, and improves blood vessels' oxygen-carrying capability by increasing the number of red blood cells and hemoglobin. It creates a greater capillary network for a more rapid diffusion of oxygen into the muscles, and through the complex activation of gene expression, increases mitochondrial density and the number of aerobic enzymes, which in turn increases an athlete's aerobic metabolic capacity. The link between an increase in mitochondrial enzyme activity and an increase in the mitochondria's capacity to consume oxygen has provided much insight into the adaptability of skeletal muscle.

Generally speaking, the greater the

demand, the greater the adaptations. Although many scientists have acknowledged that there is an upper limit to the volume of training that will cause further adaptations, research has not yet documented at what point these adaptations stop occurring in response to demand. In other words, how much mileage is enough?

The answer depends on a number of factors, including athletes' genetically-determined propensity to continually adapt to greater amounts of running and the amount of running they can physically and psychologically handle. "It's very hard to say how much mileage is ideal to maximize the various cellular adaptations that take place as a function of time spent running," says Jack Daniels, PhD, Head Distance Coach at the Center for High Altitude Training at Northern Arizona University and author of *Daniels' Running Formula*. "The best answer might be to do as much as you can without losing interest or getting sick or injured."

While most runners and coaches believe that more running equals greater success, Daniels cautions about its potential to dissuade potential distance runners. "We may be going overboard with the mileage thing in running, especially for youngsters," he says. "We may lose too many potential runners if we start stressing mileage when they are in middle school or even high school."

EFFECT OF TRAINING VOLUME ON PHYSIOLOGY AND PERFORMANCE

As coaches, we all know that the better our athletes get, the harder it is for them to improve. Unfortunately, none of the adaptations associated with training continue indefinitely.

Much of the research on biochemical adaptations to endurance training has been done on animals. For example, the mitochondrial enzyme content of rats has been shown to reach its maximum adaptation by running 60 minutes per day five days per week.

A 1998 study published in the *European Journal of Physiology* on horses training for 34 weeks found that increases in muscle fiber area and the number of capillaries per fiber plateaued after 16 weeks of training. After the first 16 weeks, the horses were divided into two groups: a control group and an overload training group that trained with higher mileage.

Both groups increased mitochondrial volume and VO_2 max with the increased mileage over the next 18 weeks, but there was no difference in those variables or in muscle fiber area and capillarization after 34 weeks, despite the two-fold difference in training volume between groups over the final 18 weeks. Clearly, there is a limit to muscles' adaptive response to training.

Obviously, the more untrained your athletes, the more they can expect to improve by increasing their mileage. For example, a 1992 study published in the *Journal of Applied Physiology* found that weekly mileage ranging from five to 75 miles per week explained 86.5 percent of the difference in VO_2 max between runners.

Another study published in the *European Journal of Applied Physiology and Occupational Physiology* found that runners training more than 62 miles per week ran significantly faster in races ranging from 10K to 90K, compared to those who ran less than 62 miles per week. While it is likely, and even probable, that running more mileage leads to a higher VO_2 max and faster race times, we cannot conclude cause and effect from cross-sectional studies comparing separate groups of runners. It's likely that genetically-gifted runners

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While most runners and coaches agree that training volume is important, training intensity is even more important in improving fitness and performance, especially in highly trained runners.

SHOULD THEY RUN MORE?

Current Mileage	Advice
< 30 miles	Chances are your athletes will get faster by running more, possibly up to 60 to 70 miles per week, assuming they can physically handle it. Have them run the same mileage for two to three weeks, back off for one week to recover and adapt, then increase their mileage slightly (three to five more miles per week) to begin a new cycle.
30-60 miles	At the low end of this range, chances are your athletes will get faster by running more. At the high end of this range, they may get faster by running more, assuming they can physically handle it and have the genetic ability to continue adapting. Have them run the same mileage for two to three weeks, back off for one week to recover and adapt, then increase their mileage slightly (five more miles per week) to begin a new cycle. If they have more experience at this mileage range, you can increase their mileage for two to three weeks (five more miles per week) before backing off for a recovery week.
60-70 miles	Only increase your athletes' mileage past this point if their prior training and racing experience gives you reason to believe that they will continue to improve with more mileage. If their performances haven't plateaued at 70 miles per week, there's no reason to increase their mileage to 80.
> 70 miles	Running more than 70 miles per week may improve economy, but also comes with an increased injury risk. "For the average recreational athlete, 75 miles per week is the maximum he or she should attempt to achieve," says Timothy Noakes, MD, Discovery Health Professor of Exercise and Sports Science at the University of Cape Town in South Africa and author of *Lore of Running*. "Going farther is only of value if you are racing for longer than three to four hours. If your athletes are among the lucky ones who are blessed with great genes, they may improve by running more."

who have a high VO_2 max are capable of running more miles and faster races.

According to David Costill, PhD, Professor Emeritus of Exercise Science at Ball State University and former Director of its Human Performance Laboratory, physiological changes plateau at a modest amount of mileage. "When you go from an untrained state to a trained state, running 30 to 40 miles per week, VO_2 max and the measurements commonly taken from muscle biopsies increase. But as you move up to about 60 miles per week, things start to plateau," he says. "The exact mileage at which this plateau occurs depends on the individual, but beyond about 60 to 70 miles per week, there's not much change taking place."

If VO_2 max and muscle cellular adaptations plateau at about 70 miles per week, why do people run much more than that? "I really have no idea," says Costill. "People who run 5Ks and 10Ks still need a lot of speed, and when you run 120 or 130 miles per week, you can't do much quality."

HOW MUCH DO ELITE ATHLETES RUN?

In 2004, I conducted a study on the training characteristics of U.S. Olympic Marathon Trials qualifiers. My findings, which were published in the *International Journal of Sports Physiology and Performance*, revealed that the men averaged 90 miles per week with a peak mileage of 120, while the women averaged 72 miles per week with a peak mileage of 95 during the year of training leading up to the trials.

The elite male marathoners (sub 2:15) didn't run significantly more than the national-class marathoners (2:15-2:22). The elite men averaged 97 miles per week with a peak mileage of 126, while their national-class counterparts averaged 90 miles per week with a peak mileage of 119.

There was, however, a significant difference in mileage between the womens' performance levels, likely due to their greater range in performance. The elite women (sub 2:40) averaged 84 miles per week with a peak mileage of 112, while their national-class counterparts (2:40-2:48) averaged 69 miles per week with a peak mileage of 91.

While the faster female marathoners ran more, only a quarter of the difference in marathon performance between the women could be explained by the amount of mileage they ran. Mileage accounted for even less of the difference among the men.

Running more doesn't necessarily make you faster. Regardless of how

HOW SHOULD THEY INCREASE THEIR MILEAGE?

Cycle #1	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1: 25 miles	3 miles	6	Rest	5	4	Rest	7
Week 2: 25 miles	3	6	Rest	5	4	Rest	7
Week 3: 30 miles	5	6	Rest	6	5	Rest	8
Week 4: 20 miles	3	5	Rest	4	3	Rest	5

Cycle #2	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1: 55 miles	4/5 (am/pm)	7	4/6 (am/pm)	9	8	Rest	12
Week 2: 60 miles	4/6 (am/pm)	8	4/7 (am/pm)	10	8	Rest	13
Week 3: 65 miles	4/7 (am/pm)	8	5/7 (am/pm)	11	9	Rest	14
Week 4: 43 miles	6	7	8	6	7	Rest	9

Once your athletes have reached a significant amount of mileage and/or you feel they are no longer gaining any further benefit from increasing their mileage, begin inserting more quality running (e.g., tempo runs, intervals).

much your athletes run, genetics plays a large role in their performance. A runner with a lot of talent will almost always outperform a runner with little talent and a lot of training.

"If you look at the training data of elite athletes, you find that the optimum training volume for the world's best athletes lies somewhere between 75 and 110 miles per week," says Timothy Noakes, MD, Discovery Health Professor of Exercise and Sports Science at the University of Cape Town in South Africa and author of *Lore of Running*. "However, the time spent running may be more important than the mileage, since a fast runner will run that distance much quicker than a slow runner. Humans may have a maximum training volume they can undertake, and I think it's close to 75 to 100 miles per week. Your body simply can't absorb any more training volume without breaking down."

BEYOND VO_2 MAX AND METABOLISM

If there is little or no improvement in VO_2 max and the metabolic profile of muscles as athletes run more than 70 miles per week, is there any benefit to running more? Maybe.

Research has shown that runners who run high mileage tend to be more economical, which has led to the suggestion among scientists that running more than 70 miles per week improves running economy (the amount of oxygen used to maintain a given pace). It is possible that, just as repetition of the walking movement decreases the jerkiness of a toddler's walk, repetition of the running movement has an under-recognized neural component.

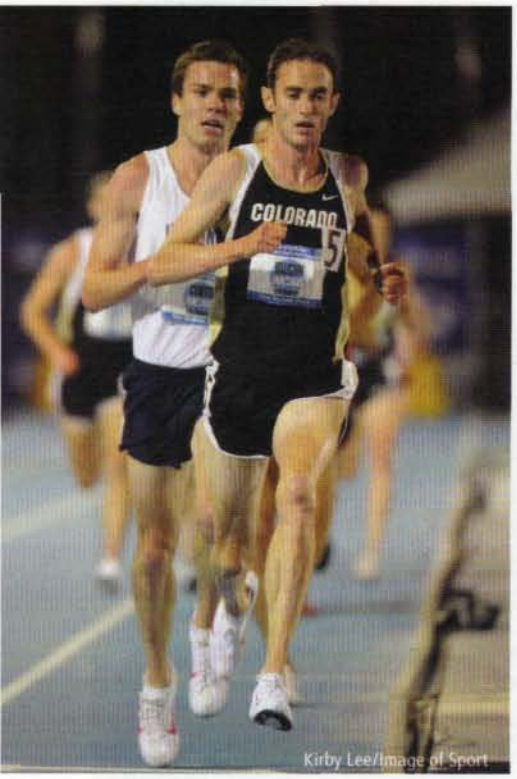
With countless repetitions, muscle fiber recruitment patterns and possibly even the relationship between breathing and stride rhythms are optimized to minimize the oxygen cost. In other words, practice makes perfect. Additionally, high mileage reduces body weight, which further reduces the oxygen cost. Because it is hard to prove cause and effect, it is not clear whether high mileage runners become more economical by running more miles or are innately more economical and can therefore handle higher mileage without getting injured.

Beyond the physiological adaptations to running lots of miles and their contribution to performance, the amount of mileage that athletes run may ultimately depend on their brains. "The more important explanation is that the brain is critically important in this process and is under-recognized," says Noakes. "The brain may optimally adapt to a certain volume of training, and a lot of our training focus and adaptation may actually be to teach us that we can run the distance. The mental preparation starts long before you go training."

While most runners and coaches agree that training volume is important, training intensity is even more important in improving fitness and performance, especially in highly trained runners. Research has shown that a high training intensity is vital for maximizing cardiovascular improvement and that VO_2 max and other physiological variables can continue to improve with the inclusion of high intensity training.

For example, interval training performed at 95 to 100 percent VO_2 max is the most potent stimulus for its improvement, and is necessary for further improvement in highly trained runners. Given that training volume will impact training intensity, the better question may not be how much mileage is necessary or enough, but how much mileage is too much to sacrifice intensity.

As your athletes prepare for their next race, how much mileage should they run? If you've read this far, you know the answer is not an easy one. (For guidance, see "Should They Run More?" on the preceding page and "How Should They Increase Their Mileage?" at the top of this page.)



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A runner with a lot of talent will almost always outperform a runner with little talent and a lot of training.

The best way to determine how much your athletes should run is to slowly and systematically increase their mileage from month to month and year to year, taking care to note how they respond to the training stimulus. And remember that more is not always better. Like Einstein, sometimes you have to break the rules. ☆

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LYDIARD REVISITED

New Zealand coach Arthur Lydiard, who passed away in 2005, was best known for his high-mileage approach. Even his middle-distance runners ran 100 miles per week, including Peter Snell, who won gold medals in the 800 and 1,500 meters at the 1960 Olympics. But is that amount of mileage necessary? Was Lydiard right, or did his talented athletes run well despite their training rather than because of it? Like my friend trying to qualify for the Olympic Trials, many of today's middle-distance runners run nearly as many miles as marathoners.

While 100 miles per week is probably not necessary for your athletes to maximize their potential in the mile, a moderate amount of mileage can help. Since any race lasting longer than about three minutes relies more on aerobic than on oxygen-independent (anaerobic) metabolism, having a well-trained aerobic system is still important for the shorter distances.

"Even the 800 meters demands some aerobic power, if for no other reason than to help recover faster during more intense speedier sessions," says Jack Daniels, PhD, Head Distance Coach at the Center for High Altitude Training at Northern Arizona University and author of *Daniels' Running Formula*. "Every race from the 800 meters on up is run at some fraction of your VO_2 max, so improving your VO_2 max increases the speed associated with any fraction of your VO_2 max. A miler needs that aerobic conditioning, and mileage helps a lot in that regard."

Although Lydiard argued that runners should build a solid aerobic base that includes high mileage before progressing to various forms of speed work, doing too much training too early may have detrimental effects when it's time to peak. A 2000 study published in the *Journal of Strength and Conditioning Research* found that the preseason training phase (May to August) of college cross country teams had the greatest impact on performance during the peak phase (November). Teams that qualified for the national championships took more rest days during the preseason phase and actually ran shorter weekly runs than teams that did not qualify (11.5 vs. 13.7 miles).

During the competition phase (August to October), there was no statistical difference in weekly mileage between qualifying and non-qualifying teams (72 vs. 63 miles per week, respectively). Among the qualifiers, the teams that ran more miles (above 70 miles per week) and ran twice per day during the summer months actually ran slower at the national championships in November than teams that ran less. It's possible that running too much in the summer makes your athletes too fatigued to race at their peak in the fall.