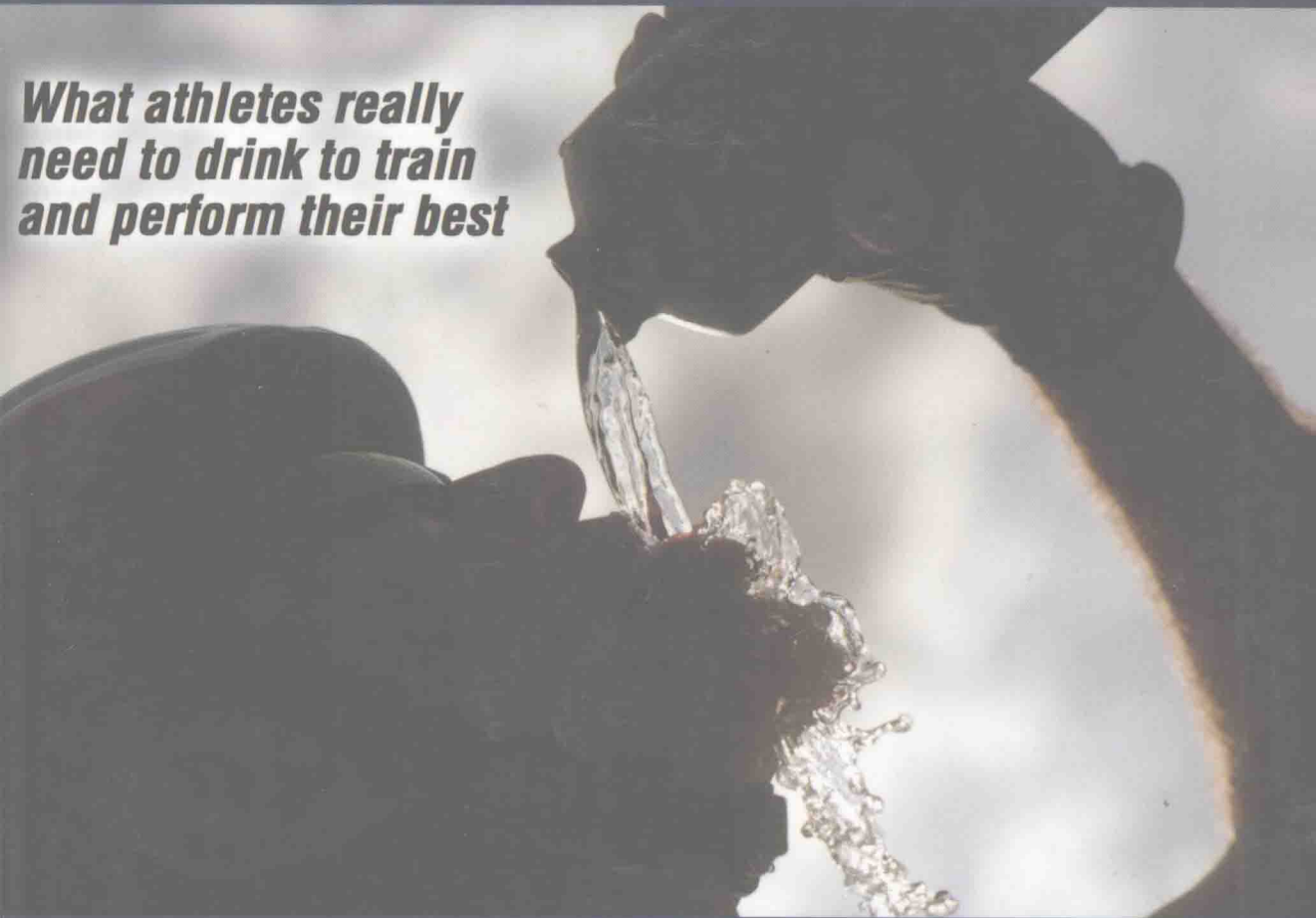


WATERLOGGED

The Serious Problem of Overhydration in Endurance Sports

*What athletes really
need to drink to train
and perform their best*



Tim Noakes, MD, DSc

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THE SERIOUS PROBLEM OF
OVERHYDRATION IN ENDURANCE SPORTS

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This book is dedicated to the memory of Cynthia Lucero, PhD,
and all those who have died from the encephalopathy
caused by exercise-associated hyponatremia.

I wrote it also for those who yet grieve,
that others may be spared your unimaginable sorrow.

This book is the culmination of an investigation that took 30 years,
each moment of which was shared with my most special friend
and inspiration, Marilyn Anne, to whom it is also dedicated.

Cynthia Lucero
August 28, 1973 to April 17, 2002
2002 Boston Marathon bib number 15611

The Spirited Runner

While the world mourns for your departure
Your spirit lives on
You showed us how to live
And how to give
Four miles more you were only a Boston finisher
Four miles short you became a heroine
A legend
May you guide us
Through the clouds to heaven

Alan Lam
Reprinted courtesy of Alan Lam.

All royalties from the sale of this book will be donated to the
Tim and Marilyn Noakes Trust for Sports Science Research
and the Dr. Cynthia Lucero Center for Health Psychology.

FOREWORD

Tim Noakes doesn't do anything halfheartedly. In his youth, he ran marathons and ultramarathons and had many finishes in South Africa's two most famous races: the 36-mile Two Oceans and the 54-mile Comrades ultramarathons. Years later, when he turned to book writing, Noakes, a physician thoroughly versed in all aspects of running and exercise physiology, produced the astonishing *Lore of Running*, which is certain to remain the definitive evidence-based running book for decades to come. Running—it's a simple subject, but one worthy of deep exploration in the hands of a curious and inexhaustible mind.

Now Tim has turned his attention to water, another simple subject. And once again he has dug deep to produce a remarkable account. In *Waterlogged*, he explains how the commercial world came to exaggerate our need for daily fluid consumption.

I found myself immersed in this world nearly 15 years before I first met Tim. In 1968 I was invited to be a subject in an experiment comparing the effects of no fluids, water, and Gatorade on endurance performance. This study was designed by exercise physiologist David Costill, PhD, one of the first serious investigators in the physiology of endurance athletes. Gatorade was a new product then, concocted by Dr. Robert Cade to help the massive, out-of-shape, University of Florida Gators football team at their steamy first practices in August.

Costill, from Ball State University in Muncie, Indiana, had received a grant from the then-corporate owner of Gatorade, Stokely Van Camp. He wanted to see if the beverage would benefit highly fit, heavy-sweating, marathon runners. I readily accepted his invitation to participate in the study. Like most distance runners, I was eager to learn more about the physiology behind my performance.

Costill picked me up in Detroit at the NCAA Indoor Meet, where I had just been nearly lapped by Jim Ryun and Gerry Lindgren. I fell asleep in his car as he drove the 240 miles to Muncie through the middle of the night. On three of the following four days (I got one rest day), Costill asked me to run 20 miles on his laboratory treadmill at a pace of 6 minutes per mile. One day he gave me water to drink, one day Gatorade, and one day nothing.

After I finished the two runs with fluids, he snaked a long plastic tube through a nostril all the way down to my stomach. This enabled him to siphon off any unabsorbed fluids. I gagged on the tubing. "It's simple," he insisted. "Just pretend you're swallowing a strand of spaghetti." That helped a little, but not much.

I distinctly remember that I felt best the day I drank nothing. I had grown up in distance running without ever drinking water or anything else. I had run dozens of midsummer New England road races that began at high noon in July and August, and at none of those races had the runners been offered water. What's more, the old veterans of New England racing warned that cold drinks would

cause stomach cramps. “Don’t drink while you’re running,” they counseled. I did as I was told, and everything worked out fine.

When I tell this story to today’s runners, they look at me as if I’m a visitor from a distant, unenlightened land. They can’t imagine a time when races started at noon (in summer!) or how anyone could finish a 5K, 10K, or longer race without drinking copiously at almost every opportunity.

Back to the Costill experiment. On the two days when I received fluids (according to scheduled protocol), my stomach sloshed like the Pacific Ocean in a tsunami, and I felt nauseated. When I drank nothing, I felt fine. Two months later, Costill showed up at the 1968 Boston Marathon to weigh us before and after the 26 miles. At the start of the race I weighed 138 pounds. There were no water stops on the course then, just young children handing out orange slices. After a warm, sunny race to downtown Boston, I weighed 129 pounds.

According to physiology textbooks, I should have been near death after a weight loss that dramatic. I wasn’t. Quite the opposite: I was celebrating my victory in the race.

That day marked the beginning of my interest in—and skepticism about—fluid consumption, health, and endurance performance. Two decades later, I was stunned to see how many of my co-workers clutched at their 2-liter water bottles from dawn to dusk as if they were oxygen tanks on the moon. In 5K road races, some runners spent as much time at the water stops as they did moving forward. Marathoners dragged canteen belts to the start line, looking like Lawrence of Arabia on a desert campaign.

The magazine I edited, *Runner’s World*, carried advertisements warning that an athlete could lose up to 6 pounds of water per hour of exercise. That was technically true. I had actually attended a scientific presentation about a tennis player who sweated this prodigiously. But the researchers admitted the poor fellow was a genetic freak, like the 8-foot tallest man on Earth. The rest of us had nothing to learn from the “6 pounds of water” story. But of course it frightened many into thinking they’d better have another big gulp of fluid.

Fascinated by the hoopla, but also confused by it, I spent several months in 2003 looking into the research on water consumption. I found no support for exaggerated claims about human needs. As far as anyone could tell, the human body had evolved an exquisite system to regulate water consumption. It’s called thirst. When you’re thirsty, you need to drink. When you’re not thirsty, you don’t.

Now I’d be the first to admit that we don’t always pay a lot of attention to our thirst. Not when we’re dashing through our busy lives, shuttling from work to family life to daily chores. Sometimes we get distracted, and sometimes we don’t find ourselves near a water faucet. No problem. As it turns out, the body is wonderfully equipped to deal with transient dehydration, which lasts from 4 to 8 hours. It’s only chronic dehydration, lasting for days on end, that leads to health problems. (The classic example of this is an elderly person trapped in an overheated apartment during a summer heat wave.)

Similarly, when we run marathons, we might not pay as much attention to our thirst as we should. But that’s okay, because a marathon is transient. It’s normal to get dehydrated during a marathon. When you reach the point of 2% dehydration, you probably will get thirsty and start looking for water. If you don’t find any water,

you might slow down a little. That's not the end of the world. You'll have plenty of time to rehydrate after you finish.

In the past decade, I'm happy to note, many runners, physiologists, and fitness experts have started to come to their senses. In early 2012, I interviewed a top American female runner, Mary Coordt, who has qualified for four U.S. Olympic Marathon Trials and also holds a master's degree in nutrition. I asked her about nutrition secrets of the top marathoners. She said, essentially, that there are none. A serious commitment to training is what makes Olympians, not quick diet fixes.

Naturally, I asked Mary about fluid replacement during a marathon. "That's one of the few areas where we have advanced beyond the old routines," she replied. "We used to be so afraid of dehydration that we told runners to drink before they got thirsty. Now we understand that when you run long distances, a certain amount of dehydration is part of the process. And you don't need to start sipping fluids until you feel thirsty. The days of chugging water are over."

This is what Tim Noakes has been telling us for decades. Without his persistent voice, we might never have changed course.

I doubt that Tim is fully satisfied yet. After all, old habits and unproven truisms often last far longer than they should. But Tim has almost single-handedly turned the tide, a Herculean task for which he deserves our credit and our acclaim.

Amby Burfoot

ACKNOWLEDGMENTS

Eleanor Sadler's letter describing her experiences in the 1981 Comrades Marathon projected me into an exciting academic odyssey that would not otherwise have happened. Atlanta physician Bob Lathan, who correctly concluded that he had developed exercise-associated hyponatremic encephalopathy (EAHE) because he drank too much (24 liters in just over 10 hours) during the 1983 Chicago 100-kilometer Ultramarathon, was the first to support our heretical opinions. Drs. Doug Hiller and Bob Laird, who both believed otherwise, were never other than respectful and gentlemanly in their opposition—the proper behavior in scientific discourse.

Dr. Tony Irving entrusted his academic future to my tutelage and applied his gentle mind and diligent manner to performing the first study proving that athletes with EAHE are indeed “waterlogged” because they consume fluids in excess during prolonged exercise. Tony showed that athletes with EAHE are not suffering from a sodium deficiency. By simple logic, his 1988 study also proved that the ingestion of extra sodium either before or during exercise cannot prevent EAHE in those who overdrink.

Dr. Dale Speedy performed a series of definitive studies in New Zealand triathletes, including the first intervention trial in the 1998 New Zealand Ironman Triathlon, thereby proving that the incidence of EAHE and exercise-associated hyponatremia (EAH) can be reduced simply by ensuring that athletes drink moderately and not to excess during prolonged exercise. Dale taught me that it is possible to study 700 athletes in a single endurance event.

This knowledge inspired our own studies expertly managed by Dr. Karen Heath (Sharwood), which challenged the industry-inspired dogma that any weight loss during exercise can have catastrophic consequences. Rather, those studies confirmed a historical observation: The best athletes in any endurance event finish the race with the highest levels of dehydration because they sweat the most and drink only sparingly when running the fastest. They also complete those races with the highest body temperatures.

Dr. Tamara Hew-Butler witnessed the inappropriate management of patients with EAHE and decided to study why the condition was so prevalent in the Houston Marathon. Her unwelcome discoveries forced her to seek solace in Cape Town, where I was privileged to add focus to her boundless energy, unbridled enthusiasm, and dogged determination to make a difference. She organized the First International Consensus Conference on EAH in Cape Town in March 2005. And there I met Drs. Arthur Siegel, Carlos Ayus, and Joe Verbalis, legendary North American colleagues, from whom I learned of the role that the inappropriate secretion of the hormone arginine vasopressin must play in the development of EAHE and the importance of using hypertonic sodium chloride infusions in the treatment of EAHE.

Another conference attendee, Dr. Lulu Weschler, offered expert understanding of the mathematics of sodium balance in the body. This taught us why only a minority of those who overdrink during exercise develop either EAH or EAHE.

Few but the most fortunate scientists in developed countries can fulfill their creative urges and so maximize their productivity exclusively by undertaking publicly funded research that improves the human condition. Thus, virtually all creative scientists in the 21st century are faced with a classic conflict of interest. To fulfill their inventive drives, they must undertake commercially driven research, whether or not it also advances truth. As a scientist working in developing countries, I am especially vulnerable because the level of government funding of research is even more limited than in Europe or North America. Unless one researches the scourges of developing nations—HIV/AIDS, malaria, and tuberculosis—it is extremely difficult to build a world-standard research program without industry support. Our group has undertaken research sponsored by a number of commercial companies, including those that produce sports drinks and nutritional supplements.

My involvement began with the Leppin company, then a wholly owned South African business, who developed the Leppin FRN sports drink and sports supplement line. The acronym FRN refers to the surnames of Bruce Fordyce, Bernard Rose, and me, the three South Africans who helped in the initial development of these products. At the time of my initial involvement, the company was not publicly listed. I am indebted to Nils and Til Hanneman, who provided the initial funding (10 R100 notes in a brown envelope) to reimburse research subjects in one of our very first studies. Their financial support when we had little else helped Drs. Vicki Lambert, Andrew Bosch, John Hawley, Holden MacRae, and Sandy Weltan develop expertise in the study of carbohydrate metabolism during exercise. This research became the basis of all our subsequent research.

It was a special privilege to work with Bernard Rose and Bruce Fordyce during that period. We shared a great friendship and some wonderful memories, especially during Bruce's nine victories in the 90-kilometer Comrades Marathon as well as the 1984 and 1985 London-to-Paris Triathlons. Neither Nils nor Til ever asked me or any of my staff to say or write anything about their products that was scientifically indefensible. This attitude continues as a requirement in all our dealings with the commercial funders of our research.

When the Hannemans sold their company, we began to work with the Bromor Foods company. I thank that company for honoring our scientific independence and for using their marketing prowess to ensure that their sports drink, Energade, became the official drink of the 90-kilometer Comrades Marathon, South Africa's unique foot race. They also supported our campaign to ensure that South African athletes drink according to thirst (*ad libitum*) during exercise and not as much as tolerable. The incidence of EAH and EAHE has been negligible in the Comrades Marathon since 1990, which is a direct result of our ability to establish a credible contrary message, first in South Africa and New Zealand and then in the rest of the world.

More recently, another South African company has acquired Bromor Foods, and our collaboration with Bromor has ended. Collaborating with DSM (manufacturers of nutritional products), Drs. Andrew Bosch and Vicki Lambert have continued our research into athletes' use of supplements.

The major sponsor of my work and that of the Sports Science Institute of South Africa (SSISA) is the health insurance company Discovery Health, which has supported our primary function to undertake studies that improve the health and physical fitness of all South Africans.

Through their contributions, the Medical Research Council of South Africa, the University of Cape Town, and the National Research Foundation, especially through the THRIP program, have made it possible for me to undertake research of an international standard in a developing nation.

It is a pleasure to acknowledge the independent thinking of Professors Frank Marino and Paul Laursen from Australia, Sandra Fowkes-Godek and Jonathan Dugas from the United States, Drs. Chris Byrne and Yannis Pitsiladis from England, Dr. Jason Lee and Professor Fabian Lim from Singapore, and Andrew Edwards (together with Dale Speedy) from New Zealand, all of whom were unwavering in their support of our once heretical ideas.

Equally important was the support of two scientific journals, *Clinical Journal of Medicine* and *British Journal of Sports Medicine*, whose respective editors, Winne Meeuwisse and Karim Khan, were fiercely independent and never hesitant to take on these controversial issues. Without their principles of integrity and honesty, this story could not have been told. Professor Khan's friendship for the past two decades has been one of the joys of my scientific career.

I am especially indebted to my colleagues and students at the UCT/MRC Research Unit for Exercise Science and Sports Medicine and the Sports Science Institute of South Africa, who contributed the bulk of the work described in chapter 3, which forms the scientific basis for this book. All showed personal courage in undertaking work that would bring them into conflict with a majority of their international peers.

My personal assistant, Megan Lofthouse, manages my daily work plan, ensuring that at least most of the time I know where I am meant to be and what I should be doing. To the book she contributed thousands of hours typing, managing the reference material on which the book is based, inserting the references into the text, and tracking down crucial but elusive material. Her calm demeanor never faltered; she is another of the group of women who have made my life journey a pleasure and whose contribution made the production of this book a continual source of joy. I thank Amanda Sables for contributing hours of typing my handwritten corrections to many of the 26 drafts from which the final manuscript eventually materialized for submission to the publisher, Human Kinetics.

I was privileged to discover the artistic ability of Sigal Chives more than a decade ago. Since then she has produced every academic slide or figure that I have ever used. Her special ability is to precisely visualize my always cryptic and inadequate explanations. Sigal produced all the original figures, which were then skillfully finalized for inclusion in this book.

This book would not have happened without the support of an extraordinarily committed group of people working for Human Kinetics (HK). When I completed what I considered to be the final (27th) draft of this book, I was still without a publisher but was hopeful that Human Kinetics, the publisher of my book *Lore of Running*, might be interested. With some apprehension, I e-mailed a 1,300-page manuscript that contained everything I know about fluids and exercise.

A few weeks later Ted Miller, vice president of acquisitions for Human Kinetics, phoned to confirm that, yes, his company was interested but the information could not be published as I had presented it. It would require a major overhaul for HK to produce a book that would do proper justice to the topic. Were I willing, he would be happy to appoint Chris Drews as editor to bring focus to my wordy and sometimes derisive detail.

For the next 7 months Chris worked tirelessly to turn my manuscript into a work of focused beauty. The scale of her contribution cannot be overstated. Without Chris' involvement, there would have been no final book; the product of 30 years of work would have languished as a brooding academic tome, unknown to the wider public. Although the words in this book remain mine, they have been carefully selected and reorganized in a way that I, because of my subjective involvement with the material, could not ever have achieved.

Thanks, Chris. It was a great privilege and joy to have worked with you on this book. Your extraordinary commitment to producing the best possible work based on your mystical ability to choose only what is necessary was at all times humbling. I know that the magnitude of your effort went way beyond considerations of financial reward. I trust that presenting the truth will always be the more satisfying reward.

Laura Podeschi was responsible for putting the final product together by selecting and sourcing the photographs, finalizing the permissions, and ensuring that the painstaking job of copyediting was skillfully done within the required time frame by Jan Feeney. To her and all at Human Kinetics who worked so diligently to produce this book, a huge thank-you. Your contributions have all been flawless. Could an author ever wish for more?

Ultimately it is one's family who provides the time and the support required to produce a work of importance. Marilyn has been my sole and constant companion since we first met on 9 December, 1966. Now in our 41st year of marriage, she has provided the foundation for all that I have achieved during that time. She remains as fresh, as beautiful, as vibrant, and as unique as she was when, at 15 years old, she first captivated me. Our children, Travis Miles and Candice Amelia, now our friends, are a constant source of pride, joy, knowledge, and fascination.

To all of these people I am sincerely indebted. My hope is that this book honors all of you, your contributions, and your sacrifices.

INTRODUCTION

When I began running in 1969, completing my first 42 km (26 mile) marathon in September 1972, we were advised to drink sparingly, if at all, during exercise. As I recall, that race provided only one “refreshment” station at 32 km (20 miles); there, our running times were also recorded, perhaps as proof that we had indeed been present at least at one point on the race course.

This approach had been followed ever since marathon running became an official event in the first modern Olympic Games in Athens in 1896. Until the 1970s, marathon runners were discouraged from drinking fluids during exercise for fear that it would cause them to slow down. For some, drinking during marathon running was considered a mark of weakness. My childhood running hero and subsequent friend, Jackie Mekler, five-time winner of the 90 km (56 mile) South African Comrades Marathon, described the drinking philosophy of runners with whom he had competed before his retirement in 1969: “To run a complete marathon without any fluid replacement was regarded as the ultimate aim of most runners, and a test of their fitness” (Noakes, 2003, p. 252).

Marathon runners were not alone in this belief. Cyclists in the race that was considered the ultimate physical challenge—the Tour de France—were advised similarly: “Avoid drinking when racing, especially in hot weather. Drink as little as possible, and with the liquid not too cold. It is only a question of will power. When you drink too much you will perspire, and you will lose your strength.” As a result only “four small bottles for a long stage (of the Tour), it was frowned upon to drink more” (Fotheringham, 2002, p. 180).

There is no evidence that this advice was especially dangerous, produced ill health or death, or seriously impaired athletic performance. Indeed, the most rapid improvements in marathon running performances occurred from 1920 to 1970 (figure 1, page xiv) in the period when athletes were not drinking much during races and were generally ignorant of the science of distance running, including the value of specific diets (Noakes, 2003).

A plateau in running times occurred after 1970. This effect is most apparent in the 42 km marathon, suggesting that all human runners, marathoners especially, are rapidly approaching the physical limits of human running ability. Note that in the period of 1900 to 1970, marathon runners were actively discouraged from drinking during exercise. The introduction and encouragement of frequent drinking after 1976 were not associated with any sudden increase in world-record performances in the marathon. Rather, an opposite trend is apparent (figure 1). The same trend exists also at the shorter-distance races, during which athletes do not usually drink.

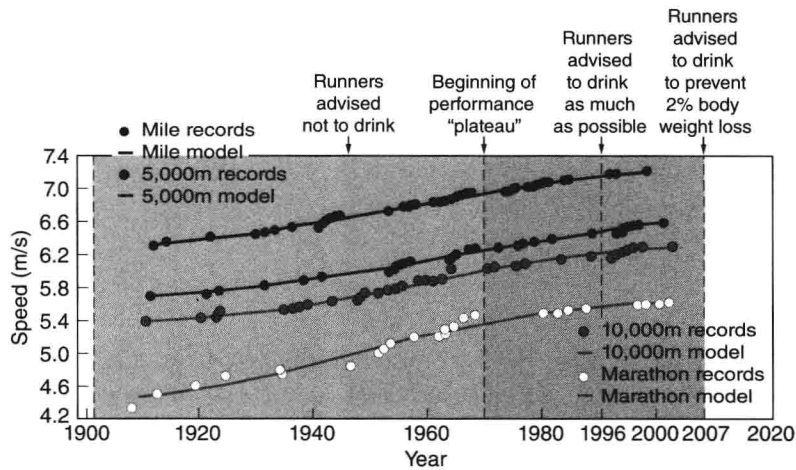


FIGURE 1 The progression of world running records at the mile (1.61 km), 5,000 m, 10,000 m, and 42 km marathon distances from 1900 to 2000 shows an acceleration in record-breaking performances at all distances from 1900 to 1970 and a definite slowing (plateau) thereafter.

Adapted, by permission, from A.M. Nevill and G. Whyte, 2005, "Are there limits to running world records?" *Medicine & Science in Sports & Exercise* 37(10): 1785-1788.

The notion that athletes should drink during exercise took hold rather slowly. In November 1976 the prestigious New York Academy of Sciences (NYAS) held a conference titled "The Marathon: Physiological, Medical, Epidemiological and Psychological Studies" (Milvy P., 1977). The conference coincided with the first running of the New York City Marathon through the five boroughs of the Big Apple.

The race was a major success, launching the concept of the big-city marathons and stimulating an unprecedented growth in marathon running in particular and endurance sport in general. Thus, entrants in the New York City Marathon climbed from fewer than 2,000 in 1976 to more than 10,000 in 1980, reaching 30,000 by the late 1990s. Similar rates of growth were seen in the Boston and London Marathons, among many others (figure 2a).

No speaker at the NYAS conference on the marathon spoke exclusively on the role of fluid ingestion during exercise. Fluid balance during exercise was discussed only fleetingly because it was considered to be of little scientific relevance.

James F. Fixx, a writer from Riverside, Connecticut, who had begun running in the late 1960s—in the process losing 27 kg (60 lb) and completing six Boston Marathons—was an especially attentive attendee at the 1976 NYAS marathon conference. He came to acquire the medical and scientific information necessary for completing a book titled *The Complete Book of Running* (Fixx, 1977) that he had begun writing in April 1976. When published a year later, the book became an instant phenomenon, topping the *New York Times* best-seller list for 11 weeks and selling over a million copies. It was subsequently translated into all the major languages.

In *The Complete Book of Running*, Fixx wrote the following: "Drink lots of water while you're exercising. It used to be considered unwise to drink while working out.

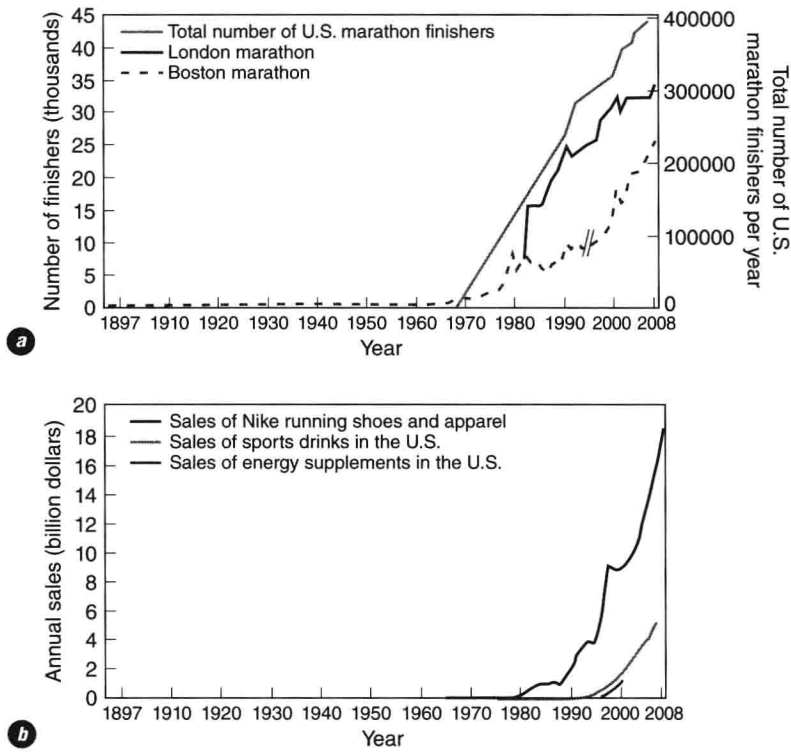


FIGURE 2 (a) Participation in individual marathons increased from only a few hundred entrants each year to over 30,000 in big-city marathons, with a total of 400,000 runners competing in marathons in the United States in 2008. (b) Three industries that benefited from the growth in interest in physical activity after 1976 were Nike and the sports drink and sports supplement industries, especially in the United States. All showed impressive growth at the same time that marathon running was becoming a global phenomenon.

Recent studies have shown, however, that athletes, including runners, function best when allowed to drink *whenever they want to* [my emphasis]. A 5 percent drop in body weight can reduce efficiency by 15 percent, and 6 percent is about the maximum you can comfortably tolerate” (p. 146).

Perhaps Fixx’s summary of the “state-of-the-art” guidelines gleaned from the 1976 NYAS marathon conference was that runners should drink according to the dictates of their thirst (“drink whenever you want to”) and should not lose too much weight during exercise since this causes an impaired “efficiency.” Interestingly, he made no reference to any dangers caused by dehydration in those who drank little and lost substantial amounts of weight during exercise. Rather, he reported that a loss of up to 6% of body weight could be “comfortably tolerated.” This confirms that Fixx did not hear anything at the NYAS conference or elsewhere proposing that runners should drink as much as tolerable in order to prevent any weight loss during exercise.

The sudden global growth in the number of marathon runners in Europe and North America soon generated a potential market for those selling products used by runners. James Fixx was himself perhaps the first to benefit through the sales

1 The Nike company born in 1972 soon became the maverick in the industry (Katz, 1994), selling not simply equipment but also an emotion. In 1978 the company published an ad claiming that excessive pronation (inward rotation) of the subtalar (ankle) joint was the cause of most running injuries to the lower limb. Naturally, Nike alone produced the solution to the problem—specially designed antipronation shoes. Sports doctors, including me, became disciples of this received wisdom (Noakes, 2003). In our naïvety we failed to question whether the advice was designed to sell more running shoes. Perhaps the fact that I received free running shoes from Nike South Africa for many years blunted my appetite for serious interrogation of their claims.

Only later (when my supply of free Nike running shoes ran out) would I begin to question whether excessive pronation is the cause of most running injuries. Indeed, it may play little role at all (see Noakes, 2003, pp. 767-770).

Writing this book has made me more aware of the effects of accepting even the most innocuous gifts from industry. How could a few dozen pairs of shoes over decades possibly influence my thinking? But it did. Because I was (and still am) a Nike guy. And Nike guys don't question the hand that is feeding them the myth.

of his book, unmatched by any subsequent book on running. Other beneficiaries would be Nike running shoes¹ followed closely by the sports drink and nutritional supplement industries (figure 2b).

I visited New York in 1976 to attend the NYAS marathon conference and to run the marathon. I wished also to take home some Nike running shoes, then unavailable in South Africa. To do this, I was forced to travel the length and breadth of New York City. Eventually I found the single shop in the entire city that specialized in running shoes. The subsequent growth of Nike would parallel the growth in the number of runners in the New York City Marathon (figure 2). It predated the growth in the sports drink and nutritional supplement industries by some years.

Until then, there had been little incentive to study endurance exercise because the only sports with money were the professional sports such as American football, basketball, and baseball and, to a lesser extent, golf. Sports medicine encompassed the orthopedic and medical care of professional athletes injured in those sports. The physiological needs of endurance athletes were not considered particularly important. Frank Shorter, the American winner of the 1972 Munich Olympic Marathon and the person held accountable for the subsequent

growth of marathon running especially in the United States, wrote at the time that people expressed their disbelief whenever he referred to himself as a "professional marathon runner." What sort of profession was that? they wondered.

But the tipping point occurred after 1976 with the sudden explosion in the number of marathon runners entering races, especially in the United States. This would provide a massive new market not just for running shoes but for a novel product, a sports drink for use during exercise, which had been developed in the late 1960s by a renal physician, Dr. Robert Cade, working at the University of Florida.

Already by 1976 his product had become a runaway commercial sensation in the United States, soon establishing itself as an essential ingredient for success in American football. The product also claimed medicinal properties. While it could enhance athletic performance, it could also prevent and cure dehydration, heat-stroke,² and muscle cramps. Before long, its manufacturers would begin to eye the much greater numbers of the physically active, including this new population of joggers aspiring to become marathon runners.

But Dr. Cade's product faced some significant challenges. First, if drinking during exercise was so important, then why should a product that contains no

unique molecules (i.e., a product that was *not* discovered in an ultrasophisticated laboratory after decades of intensive research including thousands of heart-wrenching failures) ever be taken seriously, especially if its core ingredients are chemicals present in even the most rudimentary kitchen—glucose, salt, water, and a dash of lemon? Second, how does one advance substantive medical claims in the absence of proof of efficacy?

Thus, the challenge faced from the outset by those manufacturing Dr. Cade's product was to sell a drink consisting of common kitchen chemicals on the basis of scientific evidence that did not exist in the 1960s and that some would argue still does not exist even today. The commercial success of Gatorade confirms the effectiveness of modern marketing tactics and the strength of a unique, positive product image.

"Advertisers have dispensed with the idea of promoting a product's attributes in favour of marketing the product's image. This image is conceived by marketing psychologists quite independently of the product itself, and usually has more to do with a target market than the item being sold" (Rushkoff, 2000, p. 19).

Indeed, the marketing of drinks claiming medicinal properties, of which Coca-Cola was the first global success, led to the following conclusion: "Patent medicine makers were the first American businessmen to recognise the power of the catchphrase, the identifiable logo and trademark, the celebrity endorsement, the appeal to social status, the need to keep 'everlastingly at it.' Out of necessity, they were the first to sell image rather than product" (Pendergrast, 2000, p. 11). Thus, "Like all great love affairs ours depends to a large extent on creating a set of illusions, feelings that we are special. We are who we are because we are all things to all people all the time everywhere" because "we're selling smoke. They're drinking the image, not the product" (p. 443). So it was that a drink, with ingredients that are freely available and cheap, became iconic.

One might argue that this is simply the reality of the modern world and that we are naïve to expect otherwise. But it is disturbing that incorrect advice to the public and the public's own susceptibility to effective promotional efforts resulted in a novel medical condition that affected thousands of soldiers, hikers, runners, cyclists, and triathletes, causing some to die (appendix A). Sadly, this phenomenon and the deaths that apparently resulted from it were preventable.

This story also is a cautionary tale about how a movement can take hold and manifest itself into something unhealthy and potentially very harmful. As bad as water restrictions and required ingestion of salt tablets were during the 1960s, so too is the current nearly universal notion of drinking despite a lack of thirst. Today, athletes, parents, coaches, and even many professionals in medicine, fitness, and sport science push the intake of fluid far beyond the bounds of what solid research suggests. Indeed, tens of millions of athletes and fitness enthusiasts

2 If heatstroke is caused by not drinking, then many runners must have developed this condition in that period before 1976 when they were discouraged from drinking during exercise. In addition, those cases should have disappeared after marathon runners began to drink more copiously after the introduction of new drinking guidelines beginning in the late 1970s. As you will learn in chapters 3 and 5, heatstroke historically has been rare in endurance sport. Of nearly 2,000 cases of heatstroke reported in the medical literature, only 6 have occurred in marathon or longer running races, including 3 since 1976, whereas many occur each year in short-distance running races (5 to 15 km, or 3 to 9 miles), which are over well before the athletes can become dehydrated. Thus, something other than dehydration causes heat stroke.

are waterlogged in that the hydration practices to which they religiously adhere adversely affect their health and performance.

The driving force in writing this book is a desire to reposition the commonly held belief of proper hydration so that it is consistent with the research and more effective for today's and future athletes and fitness enthusiasts. I do so by presenting the facts. And I do, based on that evidence, present guidelines for intake of water and sports drinks that should replace the general "drink until you can't take another sip" hydration practices that prevail today.

My days as a marathoner might have ended years ago, but I continue to enjoy running, in part because I train and race smarter today than I did even a decade ago. *Waterlogged* affords you the same opportunity to make intelligent, informed decisions regarding hydration. Drink it up.