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PEAK PERFORMANCE

Special Issue
THE MARATHON

MARATHON RISKS

Lies, damned lies and statistics: what we know about the incidence of injury, illness and death in the London Marathon

The London Marathon has been a major participant event since it was first run by 6,500 people, mainly novices, in 1981. It now has 32,000 finishers and is the biggest marathon in the world. This article looks at the extent of illness, injury and death associated with the Marathon and the various factors involved.

Entry to the Marathon is open to anyone over 18. Since 1981, the charity element has expanded significantly, with many participants taking part not because they are traditional runners, but because they have been sponsored by friends and colleagues to raise money for a charity. A survey of runners and charities revealed that more than 75% of participants in the 2002 Marathon were raising money for charity and between them succeeded in raising £32m.

Entrants are sent a medical advice sheet, which gives them responsibility for being fit and well on the day of the race. It suggests they discuss any medical problems with their GP and don't participate without their agreement. It also suggests they surrender their entry if they cannot run 15 miles comfortably one month before the event. Runners who take advantage of this 'sick, lame and lazy' option are guaranteed entry the following year. This medical advice has been widely copied by other races.

First aid services on the day are provided by St John Ambulance, who set out more than 40 first aid posts along the route and at the finish, and two field hospitals at the finish. One of these hospitals has an 'intensive care unit' for more serious collapses, but intravenous fluids may be given at other sites, if necessary.

There is a much larger first aid post in the Isle of Dogs, two thirds of the way round the course. There are also cardiac units at the finish and resuscitation facilities along the course and at the finish.

In all, more than 1,000 St John staff volunteer to work on the day, together with other doctors, physiotherapists and podiatrists with an interest in sports medicine, who are recruited to work closely with St John, mainly at the finish. Local 'receiving hospitals' are pre-warned about the race and receive written advice from the race Medical Director during the preceding week, with St John liaison officers posted to their accident and emergency departments on the day.

A runner who makes contact with first aiders

In this issue

FROM THE EDITOR

The Marathon boom may be over, but the distance has an enduring appeal: around the time you read this, some 60,000 would-be runners will be told that their number did not come up in the Flora London Marathon ballot. So we thought the time was ripe to devote a special issue of *PP* to the legendary 26 miles.

Dan Tunstall Pedoe, the Marathon's medical director, is uniquely placed to sort fact from fiction whenever the doom-sayers start their 'running is bad for you' mantra. One telling statistic: five successful cardiac resuscitations have taken place in the 23 years of the London and all five were on people who had existing coronary heart disease. But what of marathon deaths? Before you read the piece, guess how many deaths you think there have been in the 23 London Marathons... and then see if the true figure surprises you.

Try telling Keith Anderson that running is bad for you: in his thirties he went from stressed couch potato to international marathoner. If his story about the marriage of science to determination inspires you, you may want to sample the real thing with the help of a schedule which has been validated both in the lab by Tim Noakes – who synthesised virtually every word ever written about running for his massive tome *The Lore of Running* – and on the unforgiving roads of South Africa where he ran a highly respectable 2:50 marathon.

A rower in his youth, Noakes took up running to take part in the 56-mile Comrades Marathon, so the Marathon for him was merely a staging post. Anyone for an ultra-distance *PP* Special?

Andrew Etchells, Co-editor

during the race is logged as a 'casualty contact', with diagnosis made by first aid staff, unless the condition requires physiotherapy, medical or podiatric treatment. Each first aid station reports the number of casualties and the primary diagnosis for each.

To minimise lurid newspaper headlines about Marathon casualties, these contacts are divided into categories which clarify the seriousness of the various conditions involved. These include:

- *Social contacts* – who stop and ask for such help as a drink, a shoelace or a dressing to treat themselves;
- *Musculoskeletal contacts* – with cramps or painful joints, bones or muscles;
- *Topical contacts* – with blisters, abrasions, runner's nipple, skin chafing or subungual haematomas (blood clots under the toenails);
- *Constitutional contacts* – who collapse, have chest or abdominal pain, diarrhoea, fits, vomiting etc.

The St John Ambulance reports are supplemented by enquiries to the designated receiving hospitals, which are asked to flag up all Marathon accident and emergency cases.

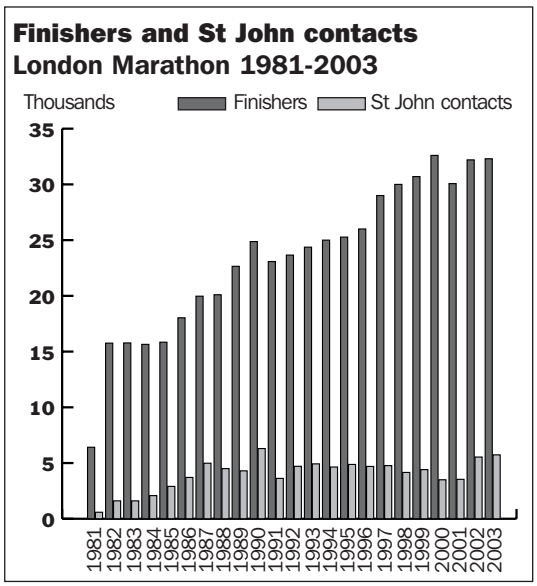
In 2000, when 32,600 runners completed the race, 4,633 St John Ambulance and 38 hospital contacts were recorded. By comparison, in 1987, when 19,970 runners completed the race, there were 4,984 St John Ambulance contacts and 10 hospital contacts. Totals for the 20 years show a hospital contact rate of 0.13% (one in 787). Hospital admissions are roughly 10% of the hospital contacts, but are increasingly difficult to define, as runners may spend many hours in accident and emergency.

'Some races offer psycho-therapists at the start and massage therapists at the finish'

Only those deaths, or collapses leading to deaths, that occur during the Marathon or within the finish area of the race, are considered Marathon deaths. Seven cardiac deaths have been reported in the London Marathon: five from severe coronary heart disease – in 1991, 1994, 1995 1997 and 2003 – and two with hypertrophic cardiomyopathy (HCM, a chronic disorder affecting the heart muscle) – in 1990 and 2001. Five successful cardiac resuscitations have taken place (in 1983, 1988, 1990, 1997 and 1998); all patients had coronary heart disease and were subsequently discharged from hospital. In the millennium race, a young man collapsed at the finish complaining of neck pain and died the following day in hospital following a diagnosis of subarachnoid (brain) haemorrhage.

The overall mortality rate from the 20 years is one in 67,414, or roughly one death for every two million miles run.

The Medical Director of the race is updated on the casualty contact numbers and the numbers taken to hospital by St John Ambulance. The director can check the more serious medical problems at hospitals designated to receive casualties from the race. However, unless specifically notified, he will not be aware of casualties who bypass the race casualty control system and go to other hospitals, or of those who arrive at the designated hospitals later in the day without wearing running clothes and a race number, and thus are not recorded as race casualties.



The more attractive, obvious and frequent the aid points are in a marathon, the more likely a tired, cramping, blistered runner will make a 'pit stop' and become a marathon medical statistic. Some races offer psychotherapists at the start and massage therapists at the finish, which increases the potential for collecting casualty numbers. Definition of an injury and the numbers are, therefore, contentious.

Most runners suffer from minor injuries such as cramps, blisters, skin chafing and subungual haematomas. The medical staff may be unaware of many of these injuries, especially as the successful runners are euphoric, anxious to go home and usually convinced that they can handle the problems themselves. The staff lose contact with participants immediately after the race as the runners disperse across the UK and to several other countries, taking their non-immediate medical problems to a multiplicity of doctors and physiotherapists. This makes a survey of the impact of the Marathon on medical providers even more difficult than a questionnaire to runners.

The sports medicine definition of an injury as something that prevents training for a defined number of days is impossible to apply when severe muscle stiffness is almost universal and full training may not be part of the runner's post-race agenda. Aches and pains and severe delayed onset muscle stiffness are common after a marathon and may only be appreciated as

significant injuries if they fail to subside in the following two weeks. Some runners may experience severe pain for days after a marathon race when walking up or down stairs.

Deaths occurring during or shortly after a marathon are naturally blamed on the event, particularly by the media, but may, in fact, be random and possibly unrelated. For example, a known epileptic ran the Marathon, went home, suffered a fit in his bath while nobody was in the house, and drowned. If the fit was an unlikely event, precipitated by running the Marathon, it could legitimately be blamed on the race; however, without knowing the frequency of the fits, whether or not the man had taken his medication and other factors, the culpability of the Marathon is indirect.

Another runner died in his sleep 36 hours after completing the Marathon. He told his wife how well he had felt during and after it. He went swimming the next day, but his wife was awakened by him having a terminal anoxic fit (a fit caused by lack of circulating oxygen) that night. He was found to have HCM at the post mortem. A claim was made in the press that the Marathon caused his death, and it is conceivable that a lingering biochemical or endocrine effect of prolonged exertion precipitated a fatal cardiac arrhythmia.

This raises many questions, such as, for how long after a marathon can the run itself be blamed for death, when in the presence of a lethal condition that can kill at any time? Deaths caused by HCM can occur at any time and an infrequent or unusual event may be blamed as the cause. Epileptic fits may occur in close proximity to running a marathon, and a statistical analysis of fit frequency and the total number of epileptics running the marathon would be needed to draw sound conclusions. If HCM has an incidence of one in 500, and people with this condition are not inhibited from running, it can be calculated that about 1,000 runners with this condition have run the Marathon and only two have died during the race.

Finishers and hospital contacts

Year	Finishers	Seen in hospital
1981	6,418	11
1982	15,758	34
1983	15,776	19
1984	15,649	15
1985	15,841	6
1986	18,031	5
1987	19,970	10
1988	21,100	38
1989	22,651	19
1990	24,871	20
1991	23,080	24
1992	23,657	15
1993	24,369	20
1994	25,000	40
1995	25,272	40
1996	26,000	90
1997	29,000	27
1998	30,000	59
1999	30,700	35
2000	32,600	35
2001	30,071	25
2002	32,200	41
2003	32,300	58

Questionnaires have been used to assess marathon morbidity in locally based marathons, but cannot be applied to major international races. They have a notoriously poor return. For example, a small survey of British doctors running the London Marathon in 1996 showed that less than 20% returned a questionnaire after the race, making the finding of a low percentage reporting upper respiratory tract infections in the week after the marathon invalid. The anticlimax and fatigue following completion of a marathon appeared to militate against completing and returning a questionnaire.

The totals of St John Ambulance casualty contacts are the numbers declared the day after the Marathon, once St John Ambulance has had returns from all station crews who disperse to much of southern England after the race. This number is sometimes subsequently corrected and discrepancies may occur when spectators are included in some returns and not in others. The total number of runners who make contact with the medical first aid posts may, if they outnumber the first aid provision, be under-reported as treatment may take priority over reporting, if a first aid post becomes swamped.

Accurate reporting of race casualties also becomes a problem where the fallen runner may have more than one diagnosis, eg exercise-associated collapse, plus blisters, plus subungual haematoma, plus groin chafing, but is only reported under the presenting complaint of

'Deaths occurring during or after a marathon are blamed on the event by the media, but may in fact be random and possibly unrelated'

Breakdown of diagnoses		**%**
Social ('vaseline')	97	2
Constitutional	197	4
Topical ('blisters')	731	15
Muskoskeletal	3,963	79
Total	**4,988**	**100**
Breakdown of 'constitutional' casualties		
Chest pain/breathing	3	2
Headache	7	4
Dehydration	14	7
Collapse	17	9
Feeling cold	25	13
Nausea/vomiting	45	23
Tired	86	44
Total	**197**	**100**

Figures from the 1987 London Marathon

collapse. A further complication is that the same runner may make contact with more than one aid station, making pit stops for 'repairs' at several and being counted as a fresh casualty or contact at each point. However, the multiple reporting error was assessed in one marathon and found to be a minor source or error in the grand total.

Casualties are assessed rapidly by first aiders and only very few are seen by trained diagnosticians. The diagnoses are, therefore, anatomical rather than accurate, where pain is the prime complaint. A painful shin may be a fatigue fracture, but there is usually no easy follow-up. Exercise-associated collapse may be registered under a variety of names, eg hypothermia, collapse and severe fatigue, even in hospital cases.

In summary...

Based on 23 years' experience, the approximate overall risks of running the Marathon are:

- contact with St John: 1 in 6;
- contact with a hospital accident and emergency department: 1 in 800;
- hospital admission: 1 in 10,000;
- death: 1 in 67,414 – a risk which is comparable to many daily activities.

Dan Tunstall Pedoe

Adapted and updated from 'Morbidity and Mortality in the London Marathon', a paper in Marathon Medicine, RSM Press Ltd, £19.95, 2001, www.rsmpress.co.uk/bktunstall.htm.

PERSONAL EXPERIENCE

How one former couch potato found a talent and then called on the appliance of science to become an élite performer

This is a personal account of my life as a runner. At the age of 30 I was just an average bloke. I was stuck in a rut with a stressful job that had long, unsociable hours. I was overweight, taking no exercise and enjoying a smoke and a drink. Then something happened: whatever it was – an early mid-life crisis or a sudden awakening of an inner competitive spirit – it eventually changed me into an international athlete. It is an unlikely tale but this is exactly what happened.

'It was simple: I just put my shoes on and ran...I had no plan and no patience'

Not all of this story may seem relevant, but I believe it highlights a number of factors which athletes of all standards should consider in their pursuit of peak, or at least improved, performance. It shows why there is a need for careful planning, patience and progression in your lifestyle, training and racing. How vital the relationship is with your coach. How both athlete and coach have to have total belief in what they are doing and total respect for each other. Each has to have a full understanding of, and commitment to, the plan. Your coach has to understand you as a person. Yes, there are coaches who can motivate and inspire groups of athletes but to really coach an athlete takes time, energy, commitment and knowledge. I hope this article also demonstrates the need for the athlete to have personal responsibility for, and understanding of, their own training. After all it is the runner who does the running so, to my way of thinking, there had better be some good reasons why I am doing it! An athlete and a good coach should also be open-minded enough to evaluate and experiment with new and different training methods.

This journey would never have happened were it not for the support of my wife or the guidance, generosity and knowledge from physiologist and coach Dr Tony Trowbridge. I must also thank Bruce Tulloh and his wife, and the willingness of a group of world class Kenyan athletes, who allowed an unknown old guy to be part of their group and share in their training methods for two months.

It was a journey that would last just over 10 years. Along the way there were many unforgettable and exciting moments. There was also a great deal of hard work and disappointment. It was, without question, a journey that changed me as a person.

The first few steps of any running career need encouragement and motivation. I was lucky enough to start my journey on the trails and fells of Ambleside in the Lake District. Not only was the scenery inspirational, but there was also a very friendly, small, running club, Ambleside AC, who helped me get out and run. My running at that time was based on enthusiasm. It was simple: I just put my shoes on and ran. I had no knowledge about what I was trying to do. I had no idea of the changes my body would have to go through to become a runner. I had no concept of pace or recovery. I had no plan and no patience. Eventually this would lead to frustration and disappointment and in that unpleasant combination lay real potential for failure and it is a combination that has claimed many athletes – even good ones – in the past.

I was trying to run with people who were much better runners than me. I was running at their pace, often over difficult terrain. Yes, I was losing weight: I had weighed in at 190lbs and 22% body fat, and I was getting fitter but I was breaking down on a regular basis. Why? At that time I had

no idea why. When I was on an 'up' part of the cycle, races and results were pretty good, I was finishing in the top 10 of medium-length fell races and I had run 31:05 for my first 10km on the road. For most people in their first year of running that would have been enough. But I was hungry for more. The problem was the downside: this left me feeling totally fatigued and despondent and wanting to give up running before I had even started. I went through a number of cycles like this before deciding that there had to be a better way.

I had started to read running magazines and became interested in articles on physiology and heart rate. I decided the control that these concepts offered must be of some help in my situation. I bought a heart rate monitor and was ridiculed by many fell runners for doing so, but decided I needed someone qualified to show me how to use it. I made several enquiries with various institutions and eventually had a meeting with Dr Tony Trowbridge who was in charge of the Medical Science department at the University of Sheffield. This was to be a major step in my athletic career.

I was fully assessed by Tony and his team. There were machines, leads and tubes everywhere. I ran to exhaustion and they tested everything: VO_2max, running style and gait analysis, running economy, heart rate, blood lactate, flexibility, strength, body composition, diet, work and even sleep patterns. My life was about to change. The bar was about to be raised and I was about to train, and be looked after, like a professional athlete.

We discussed and planned our short-, medium- and long-term objectives. We discussed and planned my training routine. The discussion, questioning and understanding of the science underpinning each training session gave clarity to what we were trying to achieve.

It was important I understood why. Tony was not only at the top of his profession in human performance but he was a runner himself and devoted a great deal of time to thinking through and considering his coaching. Not only did he fully understand me as a person but he was also a coach who understood what it was like to do various sessions and could also explain to me why we were doing them.

My approach to running changed immediately and so did the size of my telephone bill. Training became a science. Other athletes thought I had lost the plot and enjoyed a joke at my expense. But I guess that's the price for being different. The important thing was I believed in the plan and I knew it would make me a better runner.

Whereas before I had just run how I felt, now I knew every step was meant and controlled. I ran everything to a prescribed percentage of maximum heart rate. Each time I ran I knew exactly why I was running, I knew what was the correct intensity, the duration and what that run was going to achieve. Because I was training to a plan, I was able to enjoy my easy runs and days off without feeling guilty. Because I was refreshed, I was able to work hard and successfully complete a threshold, hill or interval session. I started to understand what I was doing. During harder sessions we also took blood samples which were analysed for lactate levels. It wasn't always easy to get a few drops of blood out of a cold finger into a tiny phial on top of a Lakeland hill in the middle of November. However it was important as the blood lactate level, along with the heart rate readings, gave us accurate feedback about my performance and the intensity during the session. For the first time I understood why rest and recovery were to be counted as an important part of my training routine.

'Other athletes thought I had lost the plot and enjoyed a joke at my expense'

Why I became a treadmill trainer

Meanwhile, analysis of my body composition showed I was carrying too much body fat. For me my diet was always going to be the toughest part of my regime. I have a sweet tooth which has never helped my cause. Trying to loose body fat percentage as you trained through a northern British winter was as tough as it gets for me! I know deep down it was probably one of the areas where I could have been more dedicated. I managed to get to a race weight of 143lbs, which was good, but when I could lose those extra few pounds and race at 140lbs… then I was flying.

When I had my diet analysed, it was clear I was placing too much emphasis on carbohydrate. So what's wrong with that? I hear you say. A good runner's diet! The problem was that I had been eating very little quality protein for growth and repair. The analysis also showed that the overall quality of my diet was poor. The problems didn't stop there: I was also in a state of constant dehydration because I was not drinking enough fluid. These were some of the reasons I had been feeling so fatigued and breaking down. Not eating a nutritionally balanced diet with the necessary variety of minerals or ensuring one drinks the right amount of fluid on a regular basis sounds like an elementary mistake. I have found from other runners, however, that it is an area where a lot of up-and-coming athletes have problems. It is an area that has such a fundamental effect on performance that it requires as much focus and planning as the physical training.

Another element that changed in my routine was the use of a treadmill in my training. This again set me up for more ridicule. But it worked for me. I was living the heart of the Yorkshire Dales which was great for good trails and quiet roads. However the weather was often poor with strong winds. The nearest track was an hour away and very exposed. We decided that having a

controlled environment for my speed sessions was important. I had a treadmill installed in my garage. It was to prove a very useful tool and one that I would learn to use to good effect.

Fell running had been a good grounding: it had given me good leg strength, strong ankles and knees, good balance and really good leg speed from long, fast descents.

Treadmill running enhanced that leg speed. We found that I could run quality sessions in a controlled environment. We could make incremental changes in speed, gradient or recovery depending on my performance. We could also collect the heart rate and blood lactate information. Running on the treadmill gave me the opportunity to practice mental focus for races. It also allowed me to think about style and relaxation, concentrate on my running rhythm and pace judgement. I could do all this in the relative comfort in my garage. There were no climatic influences and I could wear racing kit instead of layers of protective clothes battling into a gale. Some may say that the latter is character building! They may have a point but I felt I got enough character building in my races.

'I was not training for myself, but as part of a group. I was doing big mileage and hard sessions but there was not enough rest or recovery!'

My training also included good sessions of threshold and hill work. All this was done to a planned heart rate and recovery. I learned that my training now required a different mental approach: I had to be patient and initially slower doing the sessions governed by heart rate and that meant accepting whatever time or distance I got on the day.

Working in this carefully planned, patient and progressive routine, my body and performances responded. My body was able to accept the small changes without rejection or illness. Times and race results both improved. I was now able to plan race tactics based on my strengths. I learned that no matter how competitive I wanted to be mentally in a race, sometimes I had to be patient physiologically. If the pace were too fast at the start of a race I would produce a better performance by backing off a little and working my way through the field.

A good example was my first English National Cross-Country Championships. The start of the 'National' is traditionally a fast charge. The year I ran in South Shields, most of the course was dry and the early pace was vicious. I dropped off the pace because I knew that if I had gone with the pack my blood lactate levels would have been through the roof and it would have taken most of the race to recover. I knew this from training and had a good feel as to how hard I could push my body and yet keep lactate levels manageable. After the first half lap I was about 35th but I was in control. I then kept mentally strong and maintained a good, even pace while others around me suffered from the over-exuberant start. I eventually worked through to fourth, missing a bronze medal by just two seconds.

My results became more consistent and I was always in the shakedown at the quality road and cross-country races. We tried to ensure that I did not over-race. Tony was always very wary of returning to what he called 'the valley of fatigue' and always tried to freshen me up after a period of hard work. It worked as I went from running 31 minutes for 10km, and 50 minutes for 10 miles, to 29.04 for 10km, and 48.15 for 10 miles. Tony was reluctant to let me run many longer distances, being wary from his personal bad experiences of just how much races like the marathon can take out of you. He was also concerned about picking up long-term injuries. For that reason I never pushed him to let me try a marathon even though deep down I considered it the ultimate running challenge.

Coping with the loss of a coach

Dr Tony Trowbridge died aged 52. Ironically, he suffered a massive heart attack. I was in Portugal warm weather training. It was the saddest day of my life. He had been much more to me than a coach.

I have found that running has many more benefits than just physical fitness. My running helped me through this difficult time. I was fortunate in that Tony had fully involved me in the training process. If I hadn't been so involved, then the story may well have ended right there. But it didn't and it would have been wrong if it had.

However it was never going to be quite the same. Tony was the control factor; he always erred on the side of caution. I guess this was because he was a scientist and felt responsible for me as the runner. It was perhaps inevitable that I lost some of this control factor and definitely did get a few things not quite right from then on.

I decided to try altitude training and went with a Bruce Tulloh group including Richard Nerurkar (then the top British marathoner) to Font-Romeu in the French Pyrenees. I am not sure altitude training necessarily improved my performance, but what did work for me was the training camp life. It would drive some people nuts, but a simple life of training, eating and sleeping with no distractions was no problem for me. But there was a different problem: I was training too hard. Furthermore, I was not training for myself, but as part of a group. I was doing big mileage and hard sessions but there was not enough rest or recovery! I was basically in great shape and although I could get away with it in the short-term, it would eventually take its toll.

But I was still running well and about to turn 40, so I decided to try to earn some money on the American masters (veterans or over-forties) road race circuit. With a young family and a mortgage

it was always a juggling act to balance the books. Running for money is not what I would recommend as it did affect my performance, but that is how I made my living. My sponsorship with Adidas also helped to support me as a full-time athlete.

I went to the US just after my 40th birthday in August 1997 and based myself outside Boston. There was a series of five good money races in a six-week period. I would train during the week and then fly to a race over the weekend. But my first big race on US soil was not good. I had gone from training very well 10 days previously, to really struggling. Yes, there was jet lag and the heat and humidity, which you have to experience to really appreciate. But I was just exhausted. I had fallen into the valley of fatigue. I did win my age category and capture the all-important prize money – but only just. I was hanging on.

After that I rested more and results improved dramatically. Not only did I win my category but I was usually finishing as the first non-Kenyan in 9th or 10th place overall and running close to world masters (over-40) records. However the cumulative effect of training, travel, racing and still too little recovery was starting to catch up on me.

I had decided that I would race again in America in the spring, as there was another series of good money races culminating in the Boston Marathon. I had never done a marathon for the reasons I have explained, but decided that I would give it a go. I was making my marathon debut at the age of 40!

What I learned from the Kenyans

I set up a trip to Kenya and had a wonderful experience. All in all, I spent two months in Kenya, most of it in Nyaruru. It was a very simple and humble existence but I had everything I needed. Great running trails, wonderful home-grown food and lots of rest and relaxation. I wanted to learn how to become a marathon runner. I ran with a group of 40 Kenyans every morning at 6am. There were many world and Olympic champions among them. They made me welcome and I like to think I earned their respect for the effort I put into my training with them. The great steeplechaser Moses Kiptanui was the boss. Even as a 3,000 metre runner he ran 21km each morning in November! I learned the value of threshold running and the emphasis the Kenyans put on hill running.

We tend to assume that the Africans are haphazard in their training methods. From my experience I have to disagree. They work very hard, running hills from November until April. They run some great threshold sessions. They never ignore speed. But they have made rest and recovery into an art form. They listen to their bodies exceptionally well. They also get a one-hour massage, of the most comprehensive type I have ever had, every day!

I returned to the US for what was to be the last time as an athlete. I based myself in Boulder, Colorado, and stayed with top American marathon runner Mark Coogan and his family. I trained and raced as before to earn money and the result was I ran a tired marathon in Boston. Still, I recorded 2:17:08 for a marathon debut, which was not bad for a veteran virgin. I think I was capable of a lot better but after an excruciating wait and against all the odds, the selectors picked me to run the marathon for England in the Commonwealth games in Kuala Lumpur.

For that race in KL I sacrificed everything. I did everything I could to run my best: I didn't race too much; I trained at altitude and then acclimatised to hot and humid conditions; I planned my marathon race considering my fitness and the conditions. I felt under some pressure believing, rightly or wrongly, that I was running for all the 40-year-olds who may ever have a chance of running in a major Games. I desperately did not want to let anyone down. I feel my plan worked. The acclimatisation, my fitness, mental strength, pace judgement, patience and hydration plan all came together. In a field of much faster runners, I finished 10th at my first and only international Games.

For me that was it. It could not get any better than that. I had reached a level that 10 years earlier would have been unimaginable. I felt there was nothing left to give and I retired from serious running a couple of months later.

Looking back would I do it all again? Too right I would. But would I change anything?

With the aid of hindsight I think I would. Science would always provide the fundamental building blocks of the whole training regime. Without it there was no plan, no measured starting point and no measured improvement. However I think the training at times was perhaps a little too cautious because of our interpretation of the science. Perhaps I would run the same mileage but include more threshold work and definitely more Kenyan-style hill work during the winter months. If I had a choice I would have raced less for money but in the absence of handouts, I didn't have that luxury. Finally I would have put that little extra bit of effort in on my diet.

I am writing this article from our apartment balcony in the French Alps. It is a beautiful sunny day and the mountains are covered with an early fall of snow. We moved here as a family a couple of months ago. I haven't trained seriously for four years but I am now giving it another go at the age of 46! Why? Because I have the opportunity to see if I can apply my own revised training methods. It will be interesting to see if I can get it right this time with the aid of both science... and hindsight!

Keith Anderson

'I recorded 2:17:08 in Boston, which was not bad for a veteran virgin'

MARATHON TRAINING

A schedule for the non-specialist, which has been tested in the lab and on the roads

'This programme is for runners wishing to complete a marathon comfortably with a low risk of injury'

If you are a novice and have completed all the training necessary to run a half-marathon, you should be ready to start training for a marathon, should you so wish. It is necessary to emphasise that if you started as a complete novice with no recent running experience, you should have undergone at least 25 weeks of training. If you start on the next phase of the programme, without an adequate base, you will be at greater risk of injury once you start running more intensively with less rest between long runs.

The table below details the programme that I suggest to ensure that the runner (who is training for 160 minutes per week and who has successfully completed at least a 10km race) will be able to complete a standard marathon in a further 26 weeks. The programme is a slight modification of the one we used successfully in 1983 to train 26 novices to complete a marathon within 36 weeks of their first 20-minute walk.

The key to the programme is the gentle extension in daily training volumes, with emphasis on the long runs, which increase by 10 minutes every second week.

This programme is clearly for those runners wishing to complete a marathon comfortably with a low risk of injury, and with the highest possible probability of success. It does not include speed or hill training which, if done properly, will undoubtedly improve your race time substantially.

Many programmes advise on the exact mileage that runners should cover when training for a marathon. This begs the question of what science tells us about the optimum training distances for marathon runners. In fact, there are few studies of the actual distances people run in training for a marathon. Thus, we do not really know what the optimum training distance is for the majority of novice marathon runners. The distances advocated in this programme have been arrived at empirically, but are compatible with the findings of a study by Grant and others.[1] When evaluating the training patterns of 88 runners in the 1982 Glasgow Marathon, Grant and colleagues found that that average distance run in training was 60km per week for the 12 weeks prior to the race, and this ranged from 24 to 103km. This study also debunked two important myths. Firstly, there is no relationship between weekly training distance

Tim Noakes' 26-week progression from a 10km race to a full marathon
All figures are minutes

Day	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	30	-	-	-	-	-	-	-	-
2	-	25	35	20	40	40	30	40	50
3	30	40	30	-	20	20	50	50	40
4	-	-	-	35	-	-	-	-	-
5	35	30	30	-	45	50	50	50	60
6	25	25	25	20	20	20	20	20	20
7	40	30	50	40	60	50	70	60	80
Day	**Week 10**	**Week 11**	**Week 12**	**Week 13**	**Week 14**	**Week 15**	**Week 16**	**Week 17**	**Week 18**
1	-	-	-	-	-	-	-	-	-
2	30	60	65	60	70	70	70	70	85
3	55	35	40	30	40	30	40	35	40
4	30	60	30	50	60	60	70	70	75
5	55	40	40	35	40	35	30	35	40
6	-	-	-	-	-	-	-	-	-
7	70	90	80	100	90	110	100	120	110
Day	**Week 19**	**Week 20**	**Week 21**	**Week 22**	**Week 23**	**Week 24**	**Week 25**	**Week 26**	
1	-	-	-	40	40	-	40	40	
2	80	80	85	80	90	90	-	20	
3	45	40	35	40	40	40	40	10	
4	70	75	75	40	90	90	30	-	
5	40	25	20	35	40	40	-	-	
6	-	20	20	-	-	-	60	-	
7	130	120	140	130	150	60	20	Race	

and marathon time (as shown by Franklin and others)[2]. Secondly, despite their apparent inadequate training, the runners did not slow down dramatically after hitting their predicted 'collapse point' at about 27km. Thus, they could find no evidence to support the collapse-point theory proposed by Ken Young[3]. This theory holds that runners who do not train more than 101km per week 'collapse', and are reduced to a 'shuffle' when they race more than three times their average daily training distance for the last eight weeks before the marathon. Finally, as in the Franklin[2], these novice marathoners were unable to predict their marathon times accurately. However, the accuracy of their predictions did improve the closer they were made to race day.

During my marathon running career, I achieved personal best times of 2:50:20 (42km/marathon), 3:59:49 (56km/35 miles) and 6:49:00 (90km/56 miles). I achieved these times on the training programmes described here. I present them as an option for those with a similar physiology and training capacity. A measure of my physiological capacity were my best times for certified courses of 60:59 for 16km/10 miles and 81:39 for 21km/half-marathon.

My personal training approach was similar to the legendary Arthur Newton's [4]. It included plenty of long, slow distance to the exclusion of speedwork. This was because I originally switched to running (from rowing) with the express intention of completing the 56mile Comrades Marathon, regardless of finishing time. For the first six to eight years of my running career, I trained exclusively by running long, slow distances. However, I now firmly believe that this training approach, which emphasises distance training to the virtual exclusion of speedwork, although very safe, is not the best way to train for any distance, including ultra-marathons. I endorse Roger Bannister's view that high mileage distance training increases the athlete's speed of recovery from effort, but does not increase racing speed. The athlete must achieve a balance by doing just the right amount of speed training.

Thus, the evidence is that the fastest middle-distance and cross-country runners are the best at all distances, even the very long ultra-marathons. However, there is one important proviso – they need to have superior fatigue resistance. But this alone will not make a world-class marathon or ultra-marathon runner. For that, both speed and fatigue resistance are required.

With this background, I include details of the training practices I followed when running marathon races on a regular basis between the ages of 22 and 36. After that, I found that I could no longer train as hard as the programme required.

The initial goal of my hard training programme (see table above) was to condition myself to be able to run 110km per week, a distance that I have also found to be optimal for the majority of recreational runners who have major time constraints. This break-in phase lasted for 10 to 12 weeks, during which time my long weekend runs would not be less than 24km and not longer than 32km. The major indication that this phase had had its desired effect was that I started to finish the long runs so fresh that I wanted to run farther on the following long run. At the same time, my average training speed increased and the hills that I ran became much easier. When this happened, I was ready to move on to the second phase of my programme, the so-called 'peaking phase'.

Noakes' typical base training week
All figures in km (to convert to miles divide by 8 and multiply by 5)

	am	pm
Monday	5	7
Tuesday	7	7
Wednesday	7	7
Thursday	7	7
Friday	5	5
Saturday	24-32	-
Sunday	-	8-14
Total	**96-110**	

If there is one contentious issue in training for distance running, it is the exact value of running many miles at low intensities. That the majority of runners spend most of their time training at quite low intensities has been shown by a number of studies. For example, a study of 13 élite New Zealand distance runners[5] found that their average training intensity was characterised by the following: their average heart rate was 145 beats-per-minute; their average percentage VO_2max was 64%; their average running speed 15.6km/9.75 miles per hour, which corresponds to 77% of the speed at which the lactate turnpoint occurred. Remarkably, only 4% of their training involved running at speeds greater than that at which the lactate turnpoint occurred.

Another study found that the average training pace of a group of top German female marathoners corresponded to only 60% VO_2max, or less than 77% of the running speed at which their blood lactate concentrations reached 4 mmol.l-1.

However, I am not yet ready to conclude that all low-intensity training is unnecessary. Certainly, provided the total training volume is less than 100km/62miles per week, this low-intensity training would not seem detrimental. But its value for running performances, certainly over the shorter distances, has not yet been proven. I have also collated evidence showing how well many elite runners have performed on relatively little training[6]. The major benefits of heavy training volumes in excess of 120km/75miles per week are

'The emphasis on distance training to the virtual exclusion of speedwork , although very safe, is not the best way to train for any distance'

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Noakes' six-week peaking schedule
All figures in km (to convert to miles divide by 8 and multiply by 5)

	am	pm	Effort
Monday	5	7	jog
Tuesday	7	16	moderate/hard
Wednesday	7	7	jog
Thursday	5	16-21	moderate/hard
Friday	5	5	jog
Saturday	10-16	-	race
Sunday	20-32	-	moderate
Total	**c 120**		

to increase the strength of the connective tissue in the muscles and the resistance to the eccentric muscle damage that produces fatigue after running 30 or more kilometres (19 miles), which then increases your ability to keep running beyond the marathon 'wall'.

The aim of peaking is to increase the training load further, by adding speed training sessions, either in the form of intervals, speed-play (Fartlek), time-trials or short-distance races (5 to 16km/3 to 10 miles) for a period of four to six weeks before competitions. This form of training produces dramatic changes in racing speed but if maintained for too long, it can induce early symptoms of overtraining. Thus, it is a high risk/high reward period of your training.

The next phase of my hard training cycle differed, depending on the length of the race for which I was preparing. For shorter distances, I emphasised mostly speed training and maintained the weekly training distance at about 120km/75 miles per week. For ultra-marathons, I emphasised distance training and long weekend runs, only adding speed training when I had completed the heavy distance training.

During the peaking phase of my standard marathon training, I would emphasise speed training sessions, either on a Tuesday or a Thursday, and would run two or three races of 10 to 16km (6 to 10 miles) – but no further. I found that these are the optimum racing distances for preparing for both the 10km race and the marathon. Longer races tend to cause more severe muscle damage from which recovery is slow. Also, from a psychological viewpoint, the marathon breaks up neatly into two 16km/10 miles races and one 10km/6 miles race. Thus, during the marathon race, I would concentrate on running as close to my best times for each of these distances as was possible. When properly prepared, it is remarkable how close you can come to this goal.

During the second-last week before the marathon, I would reduce my training to between 50 and 80km/30 to 50 miles of easy running and would rest and carbohydrate-load for the last three days before the race. During the intervening four days, I would incorporate three days of mild carbohydrate-restriction and runs of 12 to 18km/7.5 to 11 miles, depending on how I felt.

The ideal taper for marathon and ultra-marathon runners has not yet been established in a scientific trial. My bias is to believe that there should be more rest and less running during the tapering phase and certainly more days in which you do no training at all.

I have written elsewhere about the 'Zatopek phenomenon'[7] in which élite athletes achieved remarkable performances after a period of reduced training – in the case of Zatopek, even after being hospitalised for two days before his record-breaking performances. Some 30 years since this phenomenon was first recognised, I realise that I ran one of my best 56km/35 miles–ultra-marathon races after a period of enforced rest. I ran the race a mere three weeks after undergoing surgery to my foot, which prevented me from running for two weeks. In the last week before the race, I had only been able to fit in a few jogs.

Without trying, I ran a time that was less than 40 seconds slower than my best, over the distance achieved three years later after a much more intensive training programme, but for which I did not taper properly. The last word on the ideal taper has yet to be written.

Tim Noakes

Adapted from The Lore of Running (fourth edition) OUP 2001

WHAT THE PAPERS SAY

Reports on recent marathon-related studies by Isabel Walker

Metabolic markers of peak performance

Differences in the metabolic response to exercise between sedentary and trained subjects are well-rehearsed. And much is now known about the differences between moderately- and highly-trained athletes. But what separates the high-level performers from those at the very top of the game?

That is what a French research team set out to investigate with a small-scale study comparing blood chemical parameters in 14 top-class male marathon runners from French and Portugese Olympic teams a few weeks before they were due to compete in international marathon events.

The subjects were asked to give the velocity they thought they would reach during their next

event, and a 10km run at this velocity was used for testing purposes. The mean extrapolated performance time for the marathon was 133.7 (2:13:42) minutes, with a range from 126.9 to 142 minutes.

After a 15-minute warm-up, subjects were equipped with heart and gas exchange monitoring apparatus. Fingertip blood samples were taken at rest (before warm-up) and immediately after the 10km test. They were then analysed by a technique known as 'Fourier-transform infrared spectrometry', which is acknowledged to be the best method of analysing the global metabolic response to exercise.

In the event, several biochemical parameters of the metabolic response to a 10km run at individual marathon velocity were found to be strongly linked with the best performance. These were:

1. a slightly, but significantly, higher increase in blood glucose concentration;
2. improved fatty acid selectivity, with longer and/or less unsaturated fatty acids predominantly metabolised;
3. higher fatty acid uptake by skeletal muscle, as indicated by a more pronounced decrease in blood triglycerides and a proportional glycerol concentration increase;
4. higher amino acid production and blood release, correlated with an apparent breakdown of several proteins for amino acid supply to skeletal muscles.

'These metabolic adaptations to intense endurance training probably explained in part the difference between high and top-class marathon performances,' conclude the researchers. '… the best runners have enhanced both carbohydrate, lipid and amino acid metabolisms to improve energetic supply to skeletal muscle during exercise.'

Japanese Journal of Physiology, 52, 181-190, 2002

Injury risks for marathon 'virgins'

Men and women embarking on marathon training programmes are at significant risk of injury because of their lack of experience, according to a major study carried out in Texas – the first to describe the baseline characteristics of a large representative group of non-élite athletes and their relationship to injury risk factors.

A four-page questionnaire was completed by 1,548 of 2,314 people registering for the 1998-99 Houston Fit Marathon Training Programme, a 25-week running or walking programme designed to help individuals achieve their fitness goals while training for the Houston Marathon.

Key data revealed on analysis of the questionnaires was as follows:

- most (63%) of the sample were female and most runners of both sexes were concentrated in the 20-50 age range;
- 3.5% (mostly women) were underweight and 35.6% (mostly men) were over weight or obese;
- the mean number of years of running experience was 6.2 and only 10.2% had competitive running team experience, in most cases dating back to school days;
- the majority (52.3%) had not previously trained for a marathon and, of those who had, 28% had not completed a marathon;
- about a quarter of the sample had either done no prior running or had been running for one year or less;
- just over 16% (more women than men) had been physically inactive in the three months prior to starting the programme;
- 38.1% reported having had an injury during the previous three years and 35% of all injuries were still causing symptoms.

'The most significant finding in this study,' note the researchers, 'is that the majority of those in a training programme to complete a marathon are not élite, well-trained, experienced runners.

'Training techniques that may be associated with injury are more prevalent in those with relatively little running and marathon experience. … Thus we suggest that training programmes should take measures to establish baseline fitness, educate on injury prevention training techniques and set appropriate fitness goals to accommodate for the training needs of its participants and increase the chance for successful outcomes.'

Clin J Sports Med 2002;12:18-23

Carbohydrates and perceived exertion

Does carbohydrate supplementation exert an ergogenic effect during marathon running? That is the question US researchers set out to answer in a study of 98 male and female entrants to the 1999 Charlotte Marathon and the 2000 Grandfather Mountain Marathon in Boone, both in North Carolina.

The highly experienced (but non-élite) participants, ranging in age from 21 to 72, underwent a series of blood and anthropometric tests on the morning of the race and were then randomly assigned to one of two conditions:

- supplementation with a 6% carbohydrate drink, with each runner ingesting 650ml about 30 minutes before the start of the race and approximately 1,000ml at hourly intervals during the event;
- the same amounts of an inactive placebo

'The best runners have enhanced carbohydrate, lipid and amino acid metabolisms to improve energetic supply to skeletal muscle during exercise'

This month's contributors:

Keith Anderson started running at the age of 30. At 35 he was UK fell running champion and at 40 he placed 10th in the 1998 Commonwealth Games Marathon

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drink, identical in appearance and taste to the carbohydrate solution.

A chest heart rate monitor was attached to each runner, and research assistants, positioned every 3.2km along the racecourse to deliver the drinks, recorded heart rates and ratings of perceived exertion (RPE) at the same time. After runners crossed the finish line, blood samples were collected from each within five minutes.

Key findings for the two races combined were as follows:

- Race times for both the carbohydrate and the placebo group were slower than their personal bests of the previous year due to the hilly terrain of both these marathons. Although race times did not differ significantly between the groups, the placebo group was about 15 minutes slower by comparison with these earlier PBs than the carb group;
- RPEs during running did not differ significantly between the two conditions, although there was a non-significant trend towards a higher RPE during the later portion of the race with placebo;
- Runners in the carbohydrate group were able to run at a higher intensity – ie at a higher percentage of their maximum heart rate – particularly during the final 10km;
- Despite the similarity in RPE between the two conditions, there was a significant decrease in plasma glucose and insulin, concomitant with an increase in plasma cortisol and growth hormone, with placebo compared with the carbohydrate condition.

Based on the evidence of their previous laboratory-based studies, the researchers had hypothesised that RPE would be lower – ie running would feel easier – with carbohydrate supplementation. A possible explanation for their failure to replicate this finding 'in the field' is that experimental outcomes during an actual race can be easily affected by many extraneous variables, including weather, terrain and motivation as well as variations in the intensities at which the runners were performing from point to point.

'These findings suggest,' they conclude, 'that the attainment of a greater percentage of maximum heart rate at a given RPE can be attributable to a sustained supply of carbohydrate energy substrates to the exercising muscle.'

But they add: 'During prolonged strenuous exercise, where intensity varies from point-to-point as in marathon running, it appears that factors other than carbohydrate energy substrate availability play an important role in mediating the strength of perceived exertion.

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