



# Gasping for victory

This year's Olympics will take place in Athens, a city renowned for its hot, humid summers and stifling air pollution. Martin Leeb discovers how the athletes plan to overcome the hurdle of these tough conditions.

In 776 BC, when the first Olympic Games took place, Athens was a small town with a few thousand inhabitants. Things have changed. Nearly three thousand years later, the Greek capital is an industrialized, congested and chaotic sprawl of more than 3 million people, and one of Europe's most polluted cities.



The choice of Athens as the venue for this year's games must have come as a surprise to those concerned about environmental conditions at the site — including Olympic hopefuls. Dick Pound, former vice-president of the International Olympic Committee, revealed in his book *Inside the Olympics*, published this May, that concerns about the Athenian air quality led him to vote for Rome as the 2004 venue. “The evaluation commission failed to report on the air-pollution problems of the Greek capital,” he wrote. “To this day when I hear the world ‘Athens’ my visceral memory dating back to my first visit is the stench of diesel fumes. The conditions in Athens made the much-vaunted smog of Los Angeles appear to be a breath of fresh air.”

Concerns about athletes' health in such conditions are justified. During the 1984 Olympics in Los Angeles, British runner Steve Ovett collapsed after the 800-metres final with severe respiratory problems and had to spend two nights in hospital. “Pollution was one of

the major factors in my having exercise-induced asthma in Los Angeles,” he told *Nature*. “There was a significant number of sufferers there but not much was reported.”

In Athens, things have been improving. Ozone concentrations have decreased by about 13.5% in the past ten years, thanks to government initiatives, according to the local organizing committee for the games. Further measures are in place to reduce air pollution, including schemes to encourage spectators to use public transport rather than private cars.

## Winds of change

“I don't think air pollution will be a problem,” says Christos Zerefos, a climatologist at the University of Athens. But this is a bit of a gamble, as his prediction relies on seasonal winds that normally sweep the eastern Mediterranean clean from the end of May to the beginning of October. In August, this ‘Etesian wind’ is usually active for 6–20 days — but if it blows lightly this year, some say that the city could be in trouble.

Two pollutants of particular concern to athletes are ozone and particulates — tiny bits of soot and other matter — both of which can irritate the lungs and cause asthmatic symptoms<sup>1,2</sup>. In Athens, many August days are char-

acterized by a brownish–yellow smog of photochemical pollutants, which the locals call ‘nefos’. When the *nefos* hangs, ozone levels can rise to more than  $160 \mu\text{g m}^{-3}$ , some  $40 \mu\text{g m}^{-3}$  higher than the World Health Organization's recommended limit. Randy Wilber, the US Olympic Committee's senior sports physiologist, measured ozone highs of  $240 \mu\text{g m}^{-3}$  around the Acropolis last summer. At the same time, particulate concentrations can hit  $50\text{--}60 \mu\text{g m}^{-3}$  — just above the  $40\text{--}50 \mu\text{g m}^{-3}$  limit set by the European Commission.

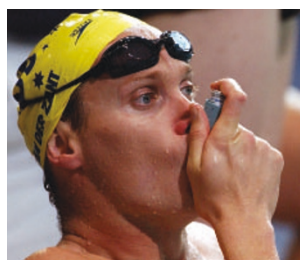
Exactly how particulates irritate the lungs is unclear, but it seems that coatings of tiny amounts of metals such as iron or copper on flecks of dust and soot can trigger reactions in the lungs that generate highly reactive free radicals<sup>3</sup>. That can lead to inflammation of lung tissue, tightening of the chest and shortage of breath. In severe cases, fluid may enter the lung, requiring emergency treatment.

Athens isn't the only place with a pollution problem. Cities such as Los Angeles and Beijing have similar or worse conditions, causing a small background increase in breathing problems in the average population. During the 1984 games, ozone levels hit highs of  $500 \mu\text{g m}^{-3}$  in the Los Angeles basin, contributing to Ovett's collapse.

Some 7% of the general population suffer from asthma. Heavy exercise can exacerbate the problem and about 13% of normal people and 20% of athletes report asthma-like symptoms as a result. This figure shoots up to 50% for road cyclists, who tend to breathe heavily during their endurance event. The

## Predictions for Athens in August

Ozone-level high:  $160 \mu\text{g m}^{-3}$   
 Particulate-level high:  $50\text{--}60 \mu\text{g m}^{-3}$   
 Average daily temperature high:  $33 \text{ }^\circ\text{C}$   
 Humidity: 49%



**Deep breaths:** clockwise from top left, Steve Ovett, whose performance in Los Angeles was hampered by pollution; and Paula Radcliffe, Jan Ullrich and Robert van Der Zant, all of whom suffer from asthma.

list of afflicted athletes includes Paula Radcliffe, who holds the world record for the women's marathon, and cyclist Jan Ullrich, who won the Tour de France in 1997 and a gold medal at the Sydney Olympics in 2000.

The extent to which athletes are likely to be affected by pollution depends to some degree on their event. Endurance and outdoor athletes are more at risk than, say, table-tennis players. In Athens, road cyclists are likely to be most affected, says Wilber, because the races will take them close to the Parthenon and the Acropolis — one of the most polluted districts of the city.

### Hard to endure

Of the two airborne irritants, ozone is the most problematic, says Frank Kelly, a professor of environmental health at King's College in London. For endurance events such as road cycling or marathon running, the threshold of ozone levels that could cause lung tissue to inflame will easily be exceeded if the cleansing Etesian wind isn't blowing, says Kelly.

Athletes can cycle about 150 litres of air in and out of their lungs every minute during competition — ten times more than normal — which exposes them to more pollution. To make matters worse, they also inhale much more deeply, taking pollutants into the deepest regions of the lungs. "Even spectators who are exposed to these pollutants are easily taken up to the threshold level," says Kelly. "But it is the athletes who are at greatest health risk."

Even if few athletes are likely to need hospital treatment, the air pollution in Athens will probably affect their performance. Few studies have been done to assess the extent of pollution's effects — and most of the work has involved recreational athletes rather than the elite. But the data that do exist are worrying. Greg Whyte, sports-science coordinator at the English Institute of Sport in Manchester, UK, has exposed highly trained athletes to ozone concentrations of  $100 \mu\text{g m}^{-3}$  — over half the

level expected for a hot and calm August day in Athens. His unpublished results show that performance decreased by about 3–4% — a lot for athletes who can win or lose events by a fraction of a second.

### Tough climate

National Olympic teams have been trying to make the best of the situation. The US Olympic Committee took some of its athletes to Athens to see how they would perform. "We measured their respiratory functions before and after test competitions at some of the Olympic venues," says Wilber. About 20% of the team members are known asthmatics, or are known to suffer from exercise-induced asthma. But a further 30% of the non-asthmatic athletes were sensitive to Athens' air-pollution levels. The difference was subtle, but for these athletes, the pollution made breathing just a little harder.

Other national committees do not consider such tests particularly wise. "Training in an industrial area and deliberately exposing athletes to a risk is not a rational option," says Hans Holdhaus, director of the Institute for Sports Medicine and Science in Vienna, who will look after Austria's athletes in Athens. Instead, the Austrian trainers have

limited themselves to telling their athletes about the dangers of pollution, and have advised them to restrict their training when ozone levels are high.

But knowing which athletes are likely to have a problem with the conditions is crucially important, says Wilber, as they can then be treated with anti-asthmatic drugs. The most effective of these, including a class of drugs known as  $\beta$ -agonists that help to relax the airways, are on the Olympic banned list and are available only to proven asthmatics. But other sensitive athletes can take alternative anti-inflammatory medication, including leukotriene antagonists — a new class of anti-asthmatic drug that blocks receptors in the lungs that normally trigger inflammation — or antioxidizing agents such as vitamins C and E. They might not be as effective as  $\beta$ -agonists, but at least they are legal. And Whyte's studies show that they help to protect against the inflammatory effects of air pollution by mopping up noxious free radicals before they can do any harm. "Now we are able to adjust and optimize athletes' medication," says Wilber.

Heat will be another issue. Experts are predicting that Athens could win gold for the hottest games ever held — a dubious honour currently held by St Louis, the 1904 Olympic host, where the average daily maximum temperature in summer was  $31^\circ\text{C}$ . At those games, only 14 of the 34 starters finished the marathon. In Athens this August, the average daily maximum temperature is expected to be more than  $33^\circ\text{C}$ , with an average humidity of 49%. "We anticipate that there will be several collapses due to heat," says Wilfried Kindermann, head physician for the German Olympic team. In the worst cases, true heatstroke can be a life-threatening emergency, he says.

Hot on the heels of pollution tests, the United States has also sent its athletes to islands such as Mallorca and Crete to try to acclimatize them to the Mediterranean climate, says Wilber. Acclimatization to such conditions seems to prevent heat injury<sup>6</sup>. But even with the best preparation, athletes will lose fluid more quickly and will be more prone to collapse.

Coaches will be watching to see who will be affected most by the stresses of heat and pollution. And not just this year. The 2008 summer games in Beijing will likewise be a challenge for athletes. The annual average particulate concentration there is as high as  $162 \mu\text{g m}^{-3}$  — about three times that in Athens — and temperatures are similar to those in the Greek capital. Athletes: start acclimatizing now. ■

**Martin Leeb is an intern with Nature in Munich.**

1. Mudway, I. S. & Kelly, F. J. *Am. J. Respir. Crit. Care Med.* **169**, 1089–1095 (2004).
2. Brunekreef, B. & Holgate, S. T. *Lancet* **360**, 1233–1242 (2002).
3. Donaldson, K. *et al. Free Radic. Biol. Med.* **34**, 1369–1382 (2003).
4. Martin, D. E. *Sports Med. Train. Rehabil.* **6**, 249–267 (1996).

AP

V. R. VIEIRA/PA

N. SIMPSON/EMPICS (LEFT); L. REBOURS/AP