The Amphetamine Margin in Sports

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Abstract

The amphetamines can enhance athletic performance. That much seems clear from the literature, some of which is reviewed here. Increases in endurance have been demonstrated in both man and rat. Smith and Beecher, 20 years ago, showed improvement of running, swimming and weight throwing in highly trained athletes. Laboratory analogues of such performances have also been used and similar enhancement demonstrated. The amount of change induced by the amphetamines is usually small, of the order of a few percent. Nevertheless, since a fraction of a percent improvement can make the difference between fame and oblivion, the margin conferred by these drugs can be quite important.

An analytical chemistry laboratory is now as much a part of Olympic competition as the Olympic flame. It owes its status mainly to widespread covert amphetamine ingestion by athletes and their belief that amphetamines enhance performance. The efficacy of amphetamines in competition, although still questioned occasionally by critics (e.g., 9), appears to be securely established. This review reexamines the evidence for this assertion. Since we have treated the details in earlier publications, we will be selective rather than exhaustive in our present coverage (6,15,16). To spare the reader suspense, we will here conclude that there is indeed an amphetamine margin in sports. It is small but important.

Endurance. By the time the last beer commercial has faded from the television screen on Sunday afternoon, the gladiators of professional football must feel as drained as discarded beer bottles. The hours of supreme effort and physical punishment press endurance to its utmost limit. A medication that retards the inevitable depletion of physical capacity would represent a potent competitive advantage. The history of research on performance enhancement owes much to the realization of both sides in World War II that a drug able to keep soldiers performing at a high level of efficiency would be equivalent to a powerful weapon. The potential offered by amphetamines was discovered quite early. Figure 1 shows the results of a German study of running to exhaustion on a treadmill (4). The length of bar is proportional to the number of minutes that a single female subject could run at high speed before collapsing. The chart demonstrates that these intramuscular injections of methamphetamine ("Pervitin") did indeed promote endurance in this physically demanding effort.

Most of the other laboratory studies of endurance confirm such an effect, although usually in a much diminished amount. A study by two British scientists employed both cycle and hand ergometers (3). Figure 2 shows results with the cycle ergometer. The subject, a young man, was instructed to pedal at a speed of 52 revolutions per minute against a constant load of 2 kilograms, matching his pedalling against a metronome. The Y-axis gives revolutions per 15 minutes; the performance can be seen (left graph) to decay over the five hours of constant pedalling. At the indicated times placebo tablets were given with no effect. In the graph to the right, a 15 mg amphetamine dose produced a marked rise in pedalling rate for several hours. Amphetamine altered performance on the hand ergometer in a similar fashion.

Another aspect of prolonged performance is possibly relevant to athletic performance: at least two groups (2,14) noticed that soldiers forced to march long distances and given amphetamines tended to ignore severe foot blisters and were willing to continue marching despite them. Mandell (7) has reported that football players on amphetamines behave like this, playing on while ignoring pain from injuries.

Amphetamine-induced increases in endurance can also be seen in laboratory animals, a fact that gives the findings we have just reported for man some biological generality. Gerald (3) studied treadmill running by rats. Injections of between 0.6 and 5.0 mg/kg _d_-amphetamine increased the length of time that his rats ran before failing to keep up with the rate of the treadmill. A dose of 10 mg/kg decreased endurance. Swimming endurance is also prolonged. Figure 3 shows data from a study by Bhagat and Wheeler (1), who injected _d_-amphetamine before allowing rats to swim until exhausted, at which point they were removed from the water. They tried to reduce the variability of performance by giving the rats extensive practice before testing. Comparison of the two studies shows that much lower doses of drug were effective with running than with swimming. The key to the difference may be that the treadmill task used by Gerald involved shocking the rats whenever they failed to run fast enough to keep up with the speed of the moving belt, and electric shock magnifies many actions of the actions of amphetamines (17).

Athletic performance. The most extensive studies of the effects of the amphetamines on athletic performance were published more than twenty years ago by a psychologist, Gene M. Smith, and an anesthesiologist, Henry K. Beecher. Their studies were commissioned by the American Medical Association's Committee on Amphetamine Drugs and Athletes. Smith and Beecher (10) tested highly trained athletes, almost all of whom were members of either the varsity or freshman teams of large colleges and universities in the Boston area. This concentration of effort on well trained subjects was probably what made it possible for them to detect the small changes induced by the drugs. In a paper published a few years after their original work had been reported, they showed that the standard errors obtained with highly practiced swimmers were half as large as those for non-experts (12).

Smith and Beecher studied three classes of athletic performance: swimming, running and weight throwing. A dose of 14 mg/70 kg of d,l-amphetamine was given two to three hours before the event. Table 1 shows results on swimming performance, with each subject participating in his own specialty. For each event, the times represent the performance of three swimmers on four separate occasions. Although the differences were small, they were quite consistent; 14 of 15 swimmers improved with amphetamine.

Smith and Beecher encountered much more variability in studying running, probably because their runners ran in events extending from 600 yards to 12.7 miles, and because many events took place out of doors during inclement weather. Nevertheless, here too they found that the differences were predominantly in the direction of improved performance: 73%-(19 out of 26)- of the runners ran faster after amphetamine.

They also studied collegiate weight throwers and shot-putters. Six threw the 35-lb. weight and four the 16-lb. shot. The weight throwers improved 4.4% after amphetamine (44.68 ft. to 47.67 ft.); the shot putters improved, 4.6% (39.32 ft. to 41.11 ft.). In both cases we are citing the mean distance of the throws.

For the runners and swimmers, the drug effect could have acted on fatigue induced by the performance; such an effect would be easily understandable because amphetamine alerts people in many ways, from abolishing sleepiness to sharpening vigilance (6,13,16). But the results with the weight throwers and shot putters appear to reflect a different process; here, we are dealing with a brief, even explosive response in fully rested subjects. This phenomenon, too, has been demonstrated in the laboratory. Hurst and associates (5) studied grip strength. Their subjects squeezed a simple dynamometer, and exerted 4.2% more force after d-amphetamine than after placebo.

Smith and Beecher (11) also examined the subjective responses of their athletes. They found that the amphetamine increased feelings of being "revved up" before the athletic event; their subjects felt more vigorous, more energetic, more alert. These changes would certainly help prepare an athlete for a satisfactory performance. We should note, in passing, that humans have been reported as being more aggressive when given amphetamines (7). So have rats (8).

Conclusions. Amphetamines can confer a significant competitive edge in sports. That much is clear from the total literature. Their versatility, moreover, is so remarkable that they enhance acute bursts of strength as well as the ability to cope with prolonged challenges to endurance. When we started this review, we thought that we would be able this time to offer some good quantitative estimates of the amphetamine margin in sports. But we cannot; there simply is not enough published directly relevant to athletic performance. Unfortunately, something akin to industrial secrecy renders all the work done by athletes and coaches unavailable to the scientific community.

The continuing debate on efficacy of the amphetamines arises from a misreading of their quantitative contribution. Research strategies in the life sciences typically aim at large effects. These are usually large enough to be discriminated by statistical tests in a small or moderate sample of subjects. How many investigators would find it worthwhile to pursue a one percent difference? Yet, athletes endure years of torture to achieve just such a difference. The debate persists because of failure to appreciate this aspect of sports, and because of the intrinsic insensitivity of statistical tests to such minute differences.

There is an amphetamine margin. It is usually small, amounting to a few percent under most circumstances. But even when that tiny, it surely can spell the difference between a gold medal and sixth place. Figure 4 shows how the time to run one mile has decreased over the years. There has been only a 15% improvement over the 100 year period shown---omitting the first point. On the average, the time needed to cover a mile has decreased about 0.4 sec per year. The graph indicates that it takes about six or seven years to produce a 1% change. Interpretation of this estimate is complicated by the rapid increase in world population. And the number of men devoting their efforts to this rather esoteric pursuit is a function of many other variables. However, one can easily see that he who can run 1% faster today than yesterday will suddenly be years ahead of his time, so to speak. He will move from being a four minute miler to a hero who can finish the mile in 3:57.6. This is no mean feat for a pharmacologic agent. And even less of an effect can be important. For instance, when Roger Bannister broke the four minute barrier in 1954 he ran the mile in 3:59.4. Ten new records were recognized as runners successively shortened the time 10 seconds more to the 3:49.4 with which John Walker pranced into the record books in 1975. Six of those records depended on a difference of less than one second.

The experimental literature probably underestimates the competitive edge conferred by the amphetamines. Almost all experimenters have studied a fixed single dose given to all their subjects at a fixed time before an event. A pharmacologically aware coach or athlete would titrate both dose and latency to performance on repeated trials until sure of the best combination. In this way, he could stretch the margin still further. Amphetamine is called "speed" for good reason.

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Table 1

Amphetamine-induced changes in swimming (10).

	Placebo	Amphetamine	% Improvement
100 yd Free style	57.47 sec	56.87 sec	1.04
100 yd Butterfly	70.96	69.36	2.25
200 yd Free style	136.88	135.94	0.69
200 yd Back stroke	159.80	158.32	0.93
200 yd Breast stroke	171.87	170.22	0.96
			1.17

Figure Legends

Fig. 1. Running time until exhaustion as a function of methamphetamine treatment. This is portion of Figure 1 from reference 4.

Fig. 2. Performance on cycle ergometer after the indicated treatments. Adapted from Figures 5 and 6 in reference 2.

Fig. 3 Swimming of rats after doses of d-amphetamine sulfate. Data are derived from Table 1, reference 1.

Fig. 4. Records for the one-mile run over a 100 year period.

FOOTNOTES

1. From the Symposium on Drug Use in Athletics presented at the 64th Annual Meeting of the Federation of American Societies for Experimental Biology, Anaheim, California, April 15, 1980.

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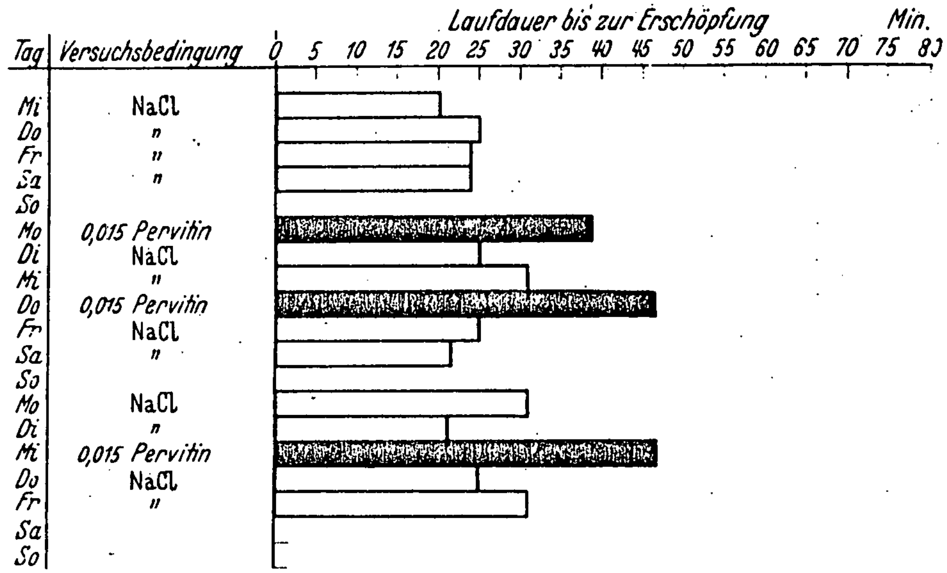
Laufdauer bis zur Erschöpfung Min.
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Versuchsbedingung
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Mi NaCl
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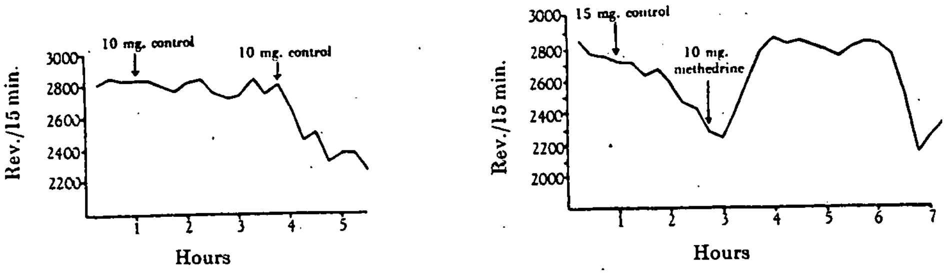
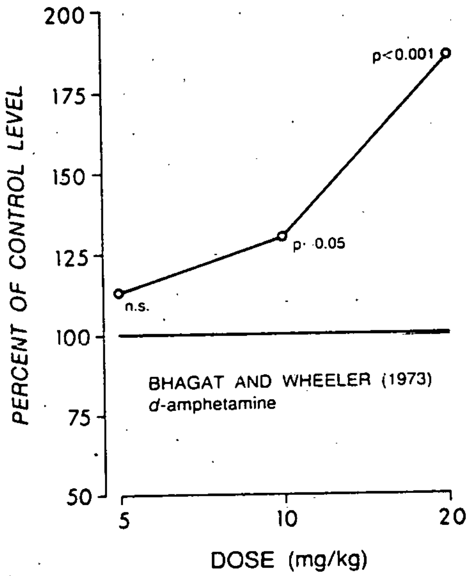
Figure 1



10 mg. control
10 mg. control
Rev./15 min.
3000
2800
2600
2400
2200
1
2
3
4
5
Hours
15 mg. control
10 mg. methedrine
Rev./15 min.
3000
2800
2600
2400
2200
2000
1
2
3
4
5
6
7
Hours

Figure 2



200
175
150
125
100
75
50
PERCENT OF CONTROL LEVEL
p<0.001
p· 0.05
n.s.
BHAGAT AND WHEELER (1973)
d-amphetamine
5
10
20
DOSE (mg/kg)

Figure 3

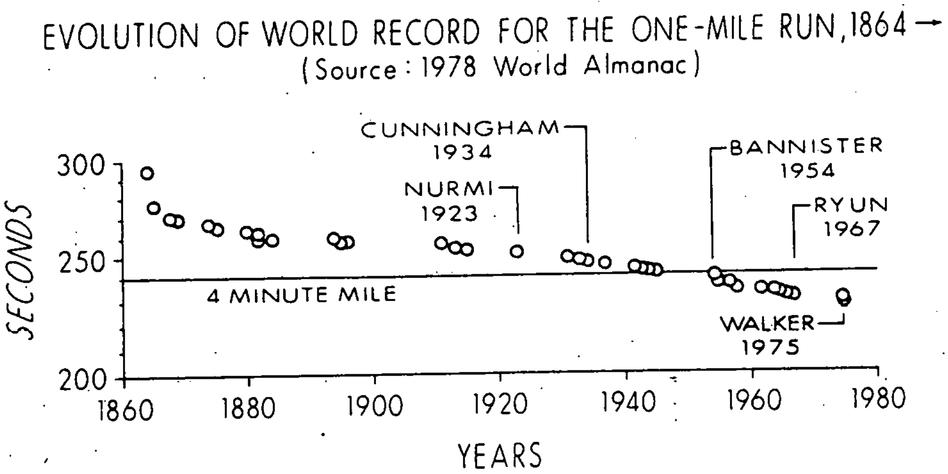

EVOLUTION OF WORLD RECORD FOR THE ONE-MILE RUN, 1864 →
(Source: 1978 World Almanac)
CUNNINGHAM 1934
NURMI 1923
BANNISTER 1954
RYUN 1967
WALKER 1975
4 MINUTE MILE
SECONDS
300
250
200
1860
1880
1900
1920
1940
1960
1980
YEARS

Figure 4