


The 400 metres

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Introduction

Although once classified among middle distance events, the 400 metres is now regarded as a “prolonged sprint”. This term appears to be appropriate, especially when one considers that Michael Johnson’s 1999 world record of 43.18 is the equivalent of four consecutive 100m in 10.795 seconds. Sometimes the 400m is also referred to as the “killer event” (QUERCETANI, 2005) because, being just beyond the limit through which a well-trained runner can maintain his or her maximum speed, a huge stress is placed on the organism with the body invariably fatiguing, “rigging” or “tying up”, especially in the closing stage (NEUHOFF, 1978). As early as in 1888, this led Montague Shearman, the most famous observer of athletics in the 19th century, to refer to 440 yard runners as “runners who run themselves blind before reaching the tape” (QUERCETANI, 2005).

The purpose of this overview is to give a brief history of the event and summarise the current consensus thinking on the following points:

- Types and characteristics of 400m runners
- Energy and speed distribution in the 400m
- Mental makeup of successful 400m runners
- Characteristics of the 400m and commonalities with sprinting

- Biomechanical aspects
- Training principles
- Training methodology.

History and progression

In the middle of the 19th century, there were very few specialist 440 yard runners and no one could sprint all-out for the whole distance. Nevertheless, in 1868, the English championships was won in an English record time of 50 $\frac{2}{5}$ seconds by E. J. Colbeck, who before the race had first taken a second place in the 100 yards and then a first in the 880 yards in 2:02 minutes (DOHERTY, 2007). In 1881, Lawrence “Lon” Myers, one of the all-time greats, of track and field, won the English 440 yard championships in a best time of 48 $\frac{3}{4}$ seconds. In 1886, Wendell Baker, of Harvard University in the USA, set a 440 yard straightaway record of 47 $\frac{3}{4}$ seconds on a track whose “loose upper surface was scraped” specially for the one-man race against time (DOHERTY, 2007).

The first 400m world record acknowledged by the IAAF was 47 $\frac{4}{5}$ seconds, set by Maxwell (Maxey) Long (USA) who was the gold medallist in the event at the 1900 Olympic Games in Paris. The first official world record for 440 yards was 47 $\frac{2}{5}$ seconds, set by Ted Meredith (USA) in 1916. Meredith, who had won the 1912 Olympic 800m gold medal, strongly influenced 400m training methods and competition for several decades. All coaching books printed during this time include the 400m race under middle distance events and training.

It was not before the great victory of Eric Liddell of Scotland in the 1924 Olympics that the 400m changed into a sprint. Liddell, who

was best known for his accomplishments in the 100m and 200m, sprinted all-out to a clear lead at the 200m post in 22.2 and ripped through the tape in a new Olympic record of 47.6.

In the 1930s, most American coaches believed that the 400m specialist should set a pace fast enough to kill off the sprinter. Both this judgement and the close relationship between the 400m and the 800m races was strongly supported when the German Rudolf Harbig set new world records for 400m (46.0) and 800m (1:46.6) within a period of three weeks. Almost forty years later, the Cuban runner Alberto Juantorena also proved the close connection between the one- and two-lap races: at the 1976 Olympics in Montreal he won the gold medals for both the 400m and 800m – a feat that has remained unmatched.

However, history's greatest 400m specialist was once again, the sprinter type. Michael Johnson (USA), the current world record holder over both 200m (19.32 in 1996) and 400m (43.18 in 1999), achieved 200/400m doubles both in the 1995 World Championships in Athletics and the 1996 Olympic Games.

Browsing through the history of the 400m it becomes obvious that the race may well be described as one of the most "American" of all events, because American athletes have won 41 of the 77 medals so far awarded in the modern Olympic Games. Their harvest in the World Championships in Athletics is equally impressive: 14 of 27 the medals that have been at stake. And their share of gold medals is even higher: 19 out of 26 in the Olympics and six out of nine in the World Championships. Great Britain was for a long time the most serious challenger (with, most recently, Iwan Thomas, Roger Black, and Mark Richardson), and Jamaican runners were also strong (Herb Mckenley, George Rhoden, Roxbert Martin and Bert Cameron). In recent years the coming of age of Africa in the running events touched the 400m too

Davis Kamoga (UGA), 1996 bronze medallist at the Olympics, or Ezra Sambu (KEN), albeit not to such a great extent as in the middle and long distances (QUERCETANI, 2005).

Although the history of the women's 400m is far shorter than that of the men's event – it was only added to the Olympic programme in 1964 – it is more variegated. The current world record, 47.60 by Marita Koch of the former GDR, dating from as far back as 1985, appears to be unreachable for today's elite runners. The possible reasons are of course strongly connected with the eighties as the "Golden Age" of doping (QUERCETANI, 2005).

Types and characteristics of 400m runners

Writers have suggested that 400m runners, who are generally medium to tall in height and physically strong in build, fall into two distinct categories. One group includes the athletes who have a speed base and the other, athletes who have an endurance base. It has also been suggested that the two groups should have distinct tactical approaches to running 400m. It was thought that the speed-based athlete ran a fast first half of the race and then "held on" for as long as possible, hoping that fatigue would not slow him/her too much before the completion of the race. The endurance-based athlete would run differently, with a more even paced race, the time of the first half of the race being roughly similar to the time of the second half. However, from statistics collected since the 1968 Olympic Games in Mexico City, no race has been run where the second half has been faster than the first (ARNOLD, 1989).

Obviously the sprinter type has the advantage through the early stages; however, if he or she is not trained properly, this advantage can melt away in a hurry toward the end of the race. The endurance type will definitely have an advantage from the 300m mark to the finish (HART, 2000). The success of the

sprinter-type 400m runner is usually explained by the fact that it is easier to develop speed endurance in sprinter types than speed capacities in endurance-type athletes. In a simplified approach it can be assumed that 400m runners should aim to maintain an average speed that corresponds to 94% of the athlete's best 200m performance. At the same time the athlete should be capable of maintaining a stride length that corresponds to 1.3 of his height (the ratio for women is 1.2) (JARVER, 2005).

Energy and speed distribution

As no one is capable of running the 400m all out from start to finish, the ability to distribute speed and energies in the most efficient manner over the total distance is the primary means of achieving success in the 400m. Good pace judgement and effort distribution are therefore a must (GAMBETTA, 1978).

Generally, the outstanding 400m runner will have approximately a one-second differential between his/her best open 200m and the time it takes them to run the first 200m of the 400m race. The first sub-44-second runner, Lee Evans (USA), ran the first 200m in 21.2 seconds, only 0.5 seconds off his best 200m in his 1968 world record of 43.86 (GAMBETTA, 1978). However, Evans' 200m best was only average for a world class 400m runner and the faster one's personal best over 200m the greater will be the differential between the two halves of the race. For example, when Tommie Smith ran a world record 44.5 in 1967, his 200m split was 21.6, considerably off his lifetime best of 19.83. In general, one can say that the less-experienced 400m runner will have approximately a two-second differential. A good formula for predicting the potential 400m time for 200m runners, provided they are willing to train and to give all they can to reaching the top at the long distance, is to double the time of their best open 200m, then add 3.5 seconds.

To find out about the pace distribution of elite 400m runners, COPPENOLLE (1980) analysed 70 intermediate times for races varying between 43.8 and 45.9. Two categories were formed: absolute "top times" varying between 43.8 seconds and 44.9 seconds and "sub-top times" varying between 45.0 and 45.9. Twenty athletes were classified in the first group and 50 others in the second group. Both were compared on the basis of: 1) the average times over the first 200m; 2) the average times over the second 200m; 3) the average difference between the two 200m; 4) the correlation between the time over the first 200m, the time over the second 200m and the final time; 5) the correlation between the time over the first 200m and over the second 200m. Summarising the author states:

- 1) For both categories the time for the first 200m is more or less the same at 21.5.
- 2) There is a clear distinction between the top and the sub-top for the second 200m (23.0 compared to 23.8) Thus, for top athletes the time differential between the two halves of the race is smaller.
- 3) There is no distinct correlation in top athletes between the second 200m and the final time. A favourable final result can be run with a relatively fast or slow second 200m. This is not the case for the sub-top runners, where there is a distinct correlation between a better final time and a better second 200m time.
- 4) In both groups, there is a clear relationship between the first and second 200m. The athlete who runs a fast first 200m will generally run a slow second 200m and vice-versa.

According to HART (1981), coach to Michael Johnson and Jeremy Wariner (43.45 seconds in 2007), the ideal race pattern should be one of smooth deceleration with as little tightening up at the finish as possible. The 400m runner should:

- 1) Try to cover the first 50m at near top speed.
- 2) Relax the actions of the upper body at 50m while still trying to maintain leg speed.

- 3) Focus their thoughts on trying to settle into the rhythm of the race and to get a feel for the competition.
- 4) Begin thinking about the next big effort they will make (at the 200m mark).
- 5) Be trained and conditioned to know that at this point in the race they will make a determined effort to increase the actions of the arms and to begin driving and lifting the knees, trying to resume more of a sprinting action.

NORTON (1986) emphasises that the 400m race should be a relaxed effort. By running relaxed, the runner will be able to run close to full speed for the entire distance. There should be relaxation throughout the body starting with the muscles in the face and neck. Tension in the face, neck, shoulders, or arms will accelerate the fatigue process.

The mental makeup of successful 400m runners

The mental makeup of the 400m runner is of great importance to the degree of success he or she may obtain. As the race is a controlled sprint, it requires patience and determination. The strongest personality trait the 400m runner must possess is aggressiveness. The runner must learn to experience pain and fatigue and be willing to come back for more until he or she has learned to distribute the effort properly (HART, 1981).

Characteristics of the 400m – commonalities with sprinting

In the Western European and North American coaching literature of the last 60 years, it has usually been agreed that the 400m is an event apart from other sprinting events, with its own special demands (ARNOLD, 1989).

As mentioned above, success in the 400m depends not only on basic speed but also on a wise utilisation of the energy systems (aerobic energy system, lactic anaerobic

system, alactic anaerobic system) that are triggered at different speeds (PENDERGAST, 1990).

According to BLACK (1988), superior 400m runners exhibit the following characteristics:

- 1) A very high ability to produce energy via anaerobic glycolysis: When comparing heterogeneous groups of runners, the anaerobic capacity of the athlete, i.e. his or her ability to produce energy via anaerobic glycolysis, with the accompanying lactate acidosis, is the main determinant of superior ability to run the 400m.
- 2) Superior sprint speed: When comparing heterogeneous groups of runners characterised by a very high anaerobic capacity, those who are faster over shorter distances tend to also be faster in the 400 metres.
- 3) Superior alactate anaerobic capacity: It may be that those who are able to produce more energy in the early stages of the race, via the splitting of high energy phosphates, are the better runners.
- 4) High anaerobic power: Successful 400m runners are characterised by an anaerobic power similar to that of other athletes who participate in sports requiring a combination of speed and anaerobic endurance.
- 5) Average maximum oxygen uptake: A very high maximum oxygen uptake is not advantageous, and may even be detrimental, to high-level performance.

From these characteristics it can be derived that those training methods which most effectively increase the athlete's alactate anaerobic power and the capacity of the lactic anaerobic energy system will produce the fastest times.

Biomechanical aspects

Success in the 400m race requires the athlete to preserve the optimal technical characteristics of his/her stride despite intense fatigue. Using 50m intervals, GAJER et al. (2007) evaluated the time courses of velocity

and stride parameters (length and frequency) for races of three groups of athletes: world-class, national level and regional level. The better athletes were able to achieve higher absolute and relative velocities (% of their best performance over 200m). These were reached by way of both significantly greater stride length and stride frequency. In general, length rather than frequency is the stride parameter distinguishing the groups from each other. As the morphological characteristics of the subjects were similar, this could indicate greater maximal strength levels for the better athletes.

Training principles

As during 400m racing energy is mainly derived from the splitting of glycogen to lactic acid (which then becomes lactate), this mechanism must be addressed in training by doing up to 10-15 repeat maximal 30-60-second runs with rest intervals of 2-4 minutes duration. During these repeat runs, high acid concentration (low pH), similar to the internal state of the 400m runner during the race, is attained. The body must be exposed to such fatigue to learn how to deal with it. There should be a progressive overload on the body during the training sessions and the speed of the repeats should get progressively faster. It would be too physiologically and psychologically demanding to do maximal repeats early in the season. It is also important to run 400m repeats in practice. The speed of these runs will also vary with the time of the season and the condition of the athlete. Training must be specific because the body must get accustomed to the special demands of the 400m racing distance (NEUHOFF, 1978).

Although the training of the 400m athlete should replicate as much as possible the demands of the event, the inclusion of alternate, or varied, methods could be worthwhile. Not only will this add further physiological stimulus to the athlete's training, but the variety should also enhance the psycho-

logical aspects (QUINN, 1991). That high-altitude training can be a useful element of 400m training was demonstrated by NUMMELA & RUSKO (2000). In their study, eight 400m runners improve their performance after ten days of living in normobaric hypoxia and training at sea level. The factors responsible for this improvement might be changes in the acid-base balance and lactate metabolism.

Training methodology

As the 400m is performed mainly anaerobically, training for an optimal performance must be based on the development of the anaerobic energy system, which consists of two subsystems:

- 1) In the anaerobic alactic system, creatine phosphate (CP), an energy rich compound, provides an immediate source of energy for the re-synthesis of adenosine-triphosphate (ATP). In training terms this refers to high-speed repetitions of approximately seven seconds in duration.
- 2) After the depletion of the alactic system the anaerobic lactic system takes over as the source of energy production. In training terms this refers to three recognised categories:
 - a. Runs about 7-20 seconds duration (60-150m);
 - b. Runs about 20-40 seconds duration (150-300m);
 - c. Runs about 40-120 seconds duration (300-600 m).

Since the anaerobic lactic system is the most important energy system in the 400m race, specific endurance, speed endurance and specific strength are the most vital areas to be developed in the quest for a maximal performance. However, the allied areas, such as speed, general endurance and general strength, although not having a direct effect, must not be overlooked. They belong to the holistic development of the 400m runner's yearly and long-term training programmes (GAFFNEY, 1991).

Based on the demands of the 400m event, HART (2000) recommends the following training workouts in varying degrees of emphasis during the training year:

- **Speed endurance:** In speed endurance running the runner incurs a high oxygen debt, and there is a definite acid build-up. This type of workout is vital to good 400m running. Examples: 10 x 100m (rest: 5-10 minutes); 6 x 150m (rest: 5-10 minutes); 5 x 200m (rest: 10 minutes); 4 x 300m (rest: 10 minutes); 3 x 350m (rest: 10 minutes); 2 x 450m (rest: 10 minutes).
- **Tempo endurance:** This is an aerobic workout that will help 400m runners to increase their oxygen uptake and thus shorten their recovery time. Runners using this type of workout will regularly be able to accomplish more and longer workouts. The emphasis in these workouts should be on quantity and not quality. Examples: 8 x 200m (rest: 2 minutes); 6 x 300m (rest: 2 minutes); 50-100-150-200-300-350m (rest: walk the same distance).
- **Strength endurance:** Strength endurance activities last longer than ten seconds and include resistance running, long-hill running, and stadium-step runs. Examples: 6 x 150m uphill; 6 x 60 stadium steps; 6 x 15 seconds rope-resistance runs.
- **Endurance running:** This is pure aerobic running and consists of continuous runs of 15-45 minutes at a steady-state speed. Examples: 15 minutes at steady-state speed; 30 minutes of fartlek running; 6 x 800m on cross country course with 3 minutes recovery.
- **Power speed:** Power-speed workouts emphasise speed of muscle contraction and are characterised by fewer than 10 repetitions of no more than 10 seconds per repetition. Examples: Short-hill runs of about 60m; 10 x 30m harness runs; 10 x 10 seconds fast rope jumps.
- **Event running (segment running):** Here the runner runs different distances at a predetermined race strategy in order to learn to work on different aspects of running the 400m. Examples: 3 x 300m: first

50m all out, next 150m with a relaxed, floating action, last 100m all out; 2 x 450m: the first 200, 300, 400, and final 50m are all timed and recorded; 1 x 350m: quality run, with each segment run as if in the 400m race.

- **Speed:** Speed workouts vary from 30-150m and are done at full speed with long rests. Examples: 6 x 40m starts; 6 x 60m flying starts; 6 x 60m sprint-relay hand-offs.
- **Strength:** While general strength development is done through the traditional weight-lifting programmes of both free weights and machines, specific weight work uses plyometric drills. Examples: 30 min traditional weight-lifting workout (1 set, 13 repetitions); Explosive jumps for the development of starting power and acceleration, 3 sets of 10 hops, each leg; Fast 50 metres bounding runs with barbell.

A sample microcycle for a 46-second 400m runner during the early season (January-February) could look as follows:

Monday:

(1) Warm-up: 1600m of in and outs (100m sprint / 100m walk, 3 laps, faster each lap, 4th lap run of 200m in 26 sec); (2) Flexibility exercises; (3) 2 x 500m, speed: 70 seconds (56 seconds / 400m pace), rest: 15 minutes; (4) 3 x 200m, speed: 30-29-28 seconds, rest: 3 minutes; (5) 8 x 10-second rope jumps, rest: 10 seconds, repeat.

Tuesday:

(1) Warm-up: 1600m of in and outs; (2) Flexibility exercises; (3) 8 x 200m, speed: 28 seconds, rest: 3 minutes; (4) 6 x 150m long-hill runs, speed: fast, rest: jog back; (5) Weights.

Wednesday:

(1) Warm-up: 1600m of in and outs; (2) Flexibility exercises; (3) 4 x 300m (event run), speed: 42 seconds, rest: 5 minutes; (4) 3 x 200m, speed: 30-29-28 seconds, rest: 3 minutes; (5) 6 x 10-second rope-resistance run, speed: fast, rest: 10 seconds.

Thursday:

(1) Warm-up: 1600m of in and outs; (2) Flexibility exercises; (3) 1 x 350m, speed: fast, rest: 15 minutes; (4) 4 x 200m, speed: 26 seconds, rest: 5 minutes; (5) Weights.

Friday:

(1) Warm-up: 1600m of in and outs; (2) Flexibility exercises; (3) 3 x 200m, speed: 30-29-

28 seconds, rest: 3 minutes; (4) 1600m relay handoff work.

Saturday:

Competition.

Sunday:

No organised workout; possibly about 20 minutes of light cross-country running.

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