Warm up

The time lords – measurement and performance in sprinting

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The modern Olympic Games were founded by Baron Pierre de Coubertin in 1896, with the intention of improving health and education, promoting world peace, and encouraging fair and equal competition. Such Victorian values, although inherently ennobling have little resonance in modern sport.

The motto of the modern Olympic games—*Citius, Altius, Fortius* (swifter, higher, stronger)—illustrates how winning, not just participation, is just as important now as it was 2500 years ago in ancient Greece. Then, as now, winning athletes were treated like heroes. It is no wonder, then, that athletes have used any means at their disposal to improve their performance.

In some cases, it is the evolution of technology that alters the sport rather than the athlete adopting ergogenic aids. In sport, there exists a balance between technology and tradition. The ruling bodies either allow technology to advance a sport (such as in the pole vault with the advent of flexible poles or full body swimming suits to reduce friction) or use it to under-engineer a sport (such as modifying the javelin to reduce throwing distances). As long as the same technology is available to all competitors at the same time, then it comes down to the ability and the skill of the athlete. Problems arise when technology is available exclusively to only one group of athletes.

TIMING PERFORMANCE

One of the crucial aspects of sport is measurement. The precision by which performances are judged provide the basis of records and disqualifications.

STARTING THE RACE

In the ancient Olympics, the Greeks had a sprint of about 190 metres called the *stadion*, which involved a sprint down a straight track and back again. The technology of the day consisted of nothing more than a wooden post at one end to help the runner on his return. Races began with the athletes standing upright, with their toes resting in grooves in a starting stone. Later a starting gate (called the *husplex*) was used, much like that in horse racing today.

In the modern Olympics, sprinters start from a crouching position, pushing against starting blocks to help them accelerate. Blocks were introduced in the late 1920s and were first used at the 1948 London Olympics. Instrumented starting blocks appeared in the early 1980s. A device within each starting block records the interval between the gun firing and the first athlete leaving the blocks. A false start is declared if this interval is less than 0.110 of a second, since this figure has been determined as the limit of human reaction time.

JUDGING THE FINISH

Timing the finish of events has similarly evolved over time. Originally the race winner was determined by a judge or judges who determined the result visually. This has evolved into the extremely complex systems in use in today's modern Olympics.

Judging very close running races visually was a problem until photo finish cameras were used. Originally, film-based cameras were used, but this meant that athletes and spectators had to wait until the film was developed before they knew the result. The introduction of the vertical line-scanning video system in 1991 removed human error from the judging of running events. The video image of each athlete as they actually cross the line is shown superimposed with a grid that records the time for each competitor. This system allows judges to declare the result more quickly and more accurately.

The timing of performance initially used hand-held stopwatches, which in turn depend on human judgment and reactions for their accuracy. The stopwatches themselves also have an inherent inaccuracy of the order of 0.2 of a second, which would correlate to an error of 2 metres in a 100 metre sprint.

Such inaccuracy presents real difficulties. In the 1960 Rome Olympics, Australia's John Devitt and America's Lance Larson finished virtually simultaneously in the 100 metres freestyle final. Two of the three first-place judges had Devitt as the winner whereas two of the three second place judges had him in second place. All three timekeepers using stopwatches gave Devitt 55.2 seconds, while the timekeepers on Larson's lane gave him 55.0, 55.1, and 55.1 seconds. Because all six measurements were within 0.2 of a second of each they did little to help decide the winner. On the basis of the decisions by the first place judges, the gold medal was awarded to Devitt and the official time for both was recorded as 55.2 seconds.

In 1964 an electronic quartz timing system was used for the first time in international events, thereby improving timing accuracy to 0.01 of a second. The computerised timing used in events today has increased the accuracy to 0.001 of a second, which is 10 times the accuracy required under current rules.

With such astounding accuracy, unsuspected problems may become apparent. For example, the timing device has to be stable to about 100 parts per million per degree Kelvin to stop it losing accuracy as the ambient temperature fluctuates. Fortunately such accuracies are becoming easier to solve due to improvements in microchip technology.

DOES TIMING TECHNOLOGY AFFECT SPRINT PERFORMANCE?

As far as the sprinters themselves are concerned, the technology available to them is fairly limited. Most developments have focused on improving the surface of the track and designing running shoes that are lighter and give a better fit. The winning times for the 100 metre sprint at the modern

Table 1 Olympic 100 metre times (seconds)

Year	Men	Women
1928	10.8	12.2
1932	10.4	11.9
1936	10.3	11.5
1948	10.3	11.9
1952	10.79	11.65
1956	10.62	11.82
1960	10.32	11.18
1964	10.06	11.49
1968	9.95	11.08
1972	10.14	11.07
1976	10.06	11.08
1980	10.25	11.06
1984	9.99	10.97
1988	9.92	10.54
1992	9.96	10.82
1996	9.84	10.94
2000	9.87	10.75
2004	9.85	10.93

Olympics show a downward trend that appears to be levelling out (see table 1). Given the data, it is difficult to see any particular moment when there has been a significant increase in performance. It is likely, therefore, that the 100 metre sprint is dominated by human ability and that improved performance is most likely caused by improvements in diet, coaching, fitness, and physiology, with technology playing a relatively minor role.

In the 100 metre sprint, it seems that the strength and power of the athlete dominates, and that no technological development has arrived that requires a change of rules. This in contrast to other sports such as pole vault, where performance improved dramatically with the introduction of flexible poles in the 1960s, and javelin where the authorities altered the rules of javelin by exploiting the laws of physics to reduce throw lengths and make the sport safer for both athletes and spectators. In both cases, it has been the ability of the athlete to adapt to the new equipment, rather than the physics of the equipment itself, that has produced the gains.

A century on from Baron de Coubertin's original vision of the Olympics, the motto swifter, higher, stronger reassuringly still depends on the skill of the athlete.

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Definitions for the purist

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WHAT IS A SECOND?

Since 1967, the international standard for a second has been defined as the time it takes for 9 192 631 770 oscillations of the microwave radiation corresponding to the transition between two hyperfine levels of the ground state of an atom of celsium-133. It sounds complex and an extremely accurate method for measuring time although a more recent proposal using a ytterbium standard is superior by a factor of more than a hundred times.

WHAT IS A METRE?

The origins of the metre go back to the late 18th century. At that time, there were two competing proposals for how to define a standard unit of measure, or metre. The astronomer Christian Huygens suggested that the metre be defined by the length of a pendulum having a period of one second; others favoured a metre defined as one ten-millionth the length of the earth's meridian along a quadrant (one fourth the circumference of the earth). In 1791, the French Academy of Sciences endorsed the meridian definition because the force of gravity varies slightly over the surface of the earth, affecting the period of a pendulum. On 22 June 1799, the French Academy Archives adopted its standard metre, recorded on a platinum bar. The French, however, miscalculated the flattening of the earth due to its rotation in their quadrant calculations. As a result, the metre in the Archives is 0.2 millimetres shorter than one ten-millionth of the quadrant of the earth.

The French government made the metre the compulsory standard of measure in 1840. The Treaty of the Metre was signed in 1875, and in 1889 a platinum-iridium bar was established as the International Prototype Metre. In 1960, the General Conference on Weights and Measures redefined the metre in terms of the number of waves of a very precise colour (wavelength) of light emitted by krypton 86 atoms. In 1983, the conference discarded the krypton standard and redefined the metre in terms of the speed of light. The metre is now officially 1/299 792 458 the distance travelled by light in a vacuum in one second.

WHAT IS REACTION TIME?

Reaction time is the time that elapses between the moment a stimulus is detected by the brain and the moment a response starts. Studies have shown that nobody can react in less than 0.110 of a second.

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