How do they do that?

Disability allowance? Keeping tabs on technology

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The resilience shown by disabled athletes is a source of admiration to all those who follow their progress. So it is surprising that, far from expecting allowances to be made for their physical qualities across the board, Paralympic competitors may sometimes expect to face competition bans – because certain factors associated with their disability could so enhance their performance that they get the edge over their able-bodied colleagues. However, the data is far from conclusive.

OSCAR PISTORIUS: PROFILE

Oscar Pistorius is a bilateral transtibial amputee, meaning he has had both of his lower legs removed and replaced with prostheses. Irrespective of this, he is an incredible athlete and an inspiration to all. Anyone who has been following Oscar over recent years will know of his ambition to run in this year's London Olympics Games alongside able-bodied athletes. Oscar is currently the world's fastest Paralympic 100m, 200m and 400m sprinter (sport class T44) and, if he is to achieve his dream, he needs to run a qualifying time of 45.25 seconds within the 3 months leading up to the start of the games.

The debate on whether Oscar should run in the Olympics has been heating up as we approach 2012 and, although the ethical implications of this argument surpass that of Athletic Board rules and science, for now I want to discuss the science behind Oscar's prostheses.

There are four key points in the research that highlight how the prostheses affect Oscar's biomechanics and physiology while running and whether he has an advantage when competing alongside able-bodied athletes. This analysis of the research is not exhaustive but gives a snapshot of the key points.

1 Oxygen consumption

Research showing an advantage

One of the key arguments that Pistorius has an advantage over able-bodied athletes is the fact that he has a better running economy: he is able to run with about 25% less energy expenditure than able-bodied sprinters, running at the same speed during a 400m maximal- intensity sprint [1]. However, the same study also noted that Oscar's oxygen uptake was higher for the first 15s compared to the able-bodied sprinters – suggesting that, although he has an advantage at top speeds, he is hindered during the acceleration phase of the race.

› Counterpoint

The running economy of six amputee sprinters using prostheses similar to Oscar's was compared to six age-related and fitness-matched able-bodied runners. Amputees performed worse on their running economy across all speeds than the able-bodied sprinters [2]. However, results did not reach a statistical significance. Another point to note is that five of the subjects in the study were unilateral amputees and thus not comparable to bilateral amputees like Oscar. Of relevance here, and an argument that features across the board, is that it is wrong to ban someone from competing in the Olympics without statistical evidence based on data from a study with more than one participant.

2 Reduced mass of carbon-fibre limbs

Research showing an advantage

Another key factor in the debate is the fact that the prostheses that Oscar uses do not replicate the lower limb mass of an able-bodied athlete. However, as Oscar does not have the benefit of the lower limb muscles to propel him forward, might this balance out any advantage?

The total mass of the human leg below the knee with a spike shoe on the foot can be calculated as little more than 5.8kg. The blades that Oscar uses including the stump of the leg have a total mass of about 3kg. This indicates a lesser mass for each artificial limb of 48%, in relation to a healthy below-knee human leg with a running shoe [3]. Therefore, while running, Oscar is not bound by the swing time minimum that applies to able-bodied sprinters, meaning he can reposition his limbs 20% more rapidly than intact limb athletes. To highlight how quick this is, these times make Oscar 15.7% faster at repositioning his limbs than six of the greatest sprinters of all time (Ben Johnson, Carl Lewis, Donovan Bailey, Maurice Greene, Tim Montgomery and Justin Gatlin) [4].

› Counterpoint

Leg swing time data at sprint speeds exist for only one amputee, Oscar Pistorius [4] and leading sports scientists in support of Oscar have stated that, "Until recently it would have been preposterous to consider prosthetic limbs to be advantageous, thus the burden of proof is on those who claim that the prostheses are advantageous" [5]. It is further hypothesised that the higher rate of the leg swing is a compensation for the fact that Oscar has ground reaction force

limitations [4] (see next section). It is also important to note that Oscar has to work to balance more while turning corners and running against headwinds, as he is running on a smaller contact point with the ground.

3 Force differences

Research showing an advantage

The vertical ground reaction force (GRF) that Oscar produces during running is remarkably different from that of able-bodied sprinters. In fact, Oscar had 22% lower stance average vertical GRF than performance-matched intact sprinters, and his horizontal GRF was also less – which may translate into lesser braking forces slowing him down as he runs [3]. It has been claimed that the lesser vertical forces and impulse allow Pistorius to perform less mechanical work than his peers while sprinting [3].

› Counterpoint

Those who have supported Oscar's right to compete against able-bodied sprinters focus on the key point that vertical ground reaction force is the primary determinant of maximal running speed [6, 7]. Therefore, because Oscar's GRF is less while running, he is at a disadvantage to able-bodied sprinters. Again as mentioned before, Oscar's supporters say it is unscientific to make a significant conclusion based on a subject number of one. However, it is important to note that, although research outcomes are predominantly based on large subject groups and statistical analysis of significant amounts of data, the value of a case study cannot be dismissed completely as in this situation it is impossible to conduct statistical analysis due to the lack of subjects and relevant data.

4 Superior energy returns from carbon-fibre limbs

Research showing an advantage

In the initial research analysing Oscar's running biomechanics (back in 2007), it was reported that the artificial ankle joints of the prostheses have a significant advantage in energy storage and return in relation to the healthy human ankle joint, allowing an energy return of 92% – while the human ankle joint energy return comes in at 41.4% [1]

The mechanical behaviour of the blade indicates very small loss of energy while running, or in other words, it ensures a high percentage of energy return. That means the energy return of the artificial ankle joint is more than 7 times higher than the energy return of the healthy ankle joint of the able-bodied athletes [1].

› Counterpoint

The main counterpoint to this is that, if you look only at the ankle, it does appear that Oscar is getting a lot more bang for his buck – although it is important to remember that in able-bodied athletes there is the possibility of energy transfer to other joints. Due to the fact that muscles span multiple joints, energy can be transferred through those joints, so that the energy is not lost [4]. This may suggest that the energy is transferred to the knee joints of able-bodied athletes through the calf muscles – an advantage that Pistorius obviously does not enjoy.

Reflection

It goes without saying that I admire Oscar as an incredible athlete and an inspiration in sport. However, the argument here is not about Oscar but about the use of technology in sport. As we continue to develop technology that surpasses natural human capability, how do we regulate the inclusion of this technology? Oscar was banned once from competing, but the ban was reversed due to lack of data supporting an advantage – not because there were data to disprove one. So this begs the question: when new technology is introduced into sport, will its use continue until there is enough data to establish an advantage, or otherwise?

As yet, the debate continues over Oscar's clearance to run against able-bodied athletes in 2012 and it is a debate that will go on until more specific guidelines are put in place. The moral implications of prohibiting a disabled athlete from running against able-bodied athletes because they have an advantage seems absurd given the context, but the science suggests otherwise – and until it is proven conclusively that no advantage exists, this debate will continue.

The use of prostheses in sport is not something new by any means but the science behind them has improved drastically since the Olympics began. One of the earliest records of an amputee competing in the able-bodied Olympics is George Eyser, an American who won a gold medal in gymnastics competing with a wooden leg at the 1904 Games in St Louis. If Oscar qualifies to compete in London 2012, he will be the first-ever amputee to compete in the track and field category of the able-bodied Olympics.

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