

The Artificial Advantage of Oscar Pistorius: The Evidence without the Emotion

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Is the ability of Oscar Pistorius to achieve world-class sprinting speeds attributable to his athleticism or his artificial running limbs? According to many reports, this core question in the Pistorius controversy remains a matter of reasonable scientific disagreement. While such reports may accurately reflect the confused state of the controversy, they do not represent the scientific reality. Here, in this second of two public statements, we provide a layperson's version of the science that explains how Mr. Pistorius' artificial limbs artificially enhance his running speeds.

The mechanics of human sprinting performance: Many mechanical aspects of running are not intuitive. One of the foremost is that faster top running speeds are not achieved via more rapid leg movements. Rather, for intact-limb athletes, whether male or female, fast or slow, essentially the same amount of time is required to reposition the limbs during top speed running. This is true regardless of how fast or slow the top speed of the individual is.

Thus, one of the most basic conclusions regarding human sprint running performance is that there is common lower limit on the time needed to reposition the limbs. For runners with biological limbs, this limit is fixed at just over one-third of a second. A primary consequence of the common minimum limb repositioning, or swing times, is that nearly all the differences in sprinting performance result from what occurs on the ground. Indeed, in the simplest terms, what makes elite sprinters elite is how quickly and forcefully they strike the ground. Truly world-class sprinters will typically apply peak ground forces that are five times their body weight and do so during foot-ground contact periods that last less than one-tenth of a second. Slow runners hit with peak forces of roughly 3 times body weight and foot-ground contact times considerably longer than one-tenth of a second. Slow runners are limited to these lesser forces and longer periods of foot-ground contact simply because they lack the athleticism to do otherwise.

The sprinting mechanics of Oscar Pistorius: Because the artificial lower limbs of Mr. Pistorius weigh only half as much as an intact lower-limb, he is not bounded by the swing time minimum that applies to athletes with biological limbs. Mr. Pistorius can reposition his lightweight, artificial limbs in 0.28 seconds, and therefore 20% more rapidly than most intact-limb athletes. To appreciate just how artificial Mr. Pistorius' swing time is, consider that the average limb repositioning time of five former 100-meter world record holders (Ben Johnson, Carl Lewis, Maurice Greene, Tim Montgomery, and Justin Gatlin) is 0.34 seconds. Mr. Pistorius' limb repositioning times are 15.7% more brief than five of the fastest male sprinters in recorded human history.

Reduced limb repositioning times allow Mr. Pistorius to spend less time in the air between steps. Shorter aerial periods, in turn, substantially reduce how hard Mr. Pistorius must hit the ground during each stance period to lift and move his body forward into the next step. Hence, the net effect of lightweight prosthetic limbs that artificially reduce the swing and aerial phases of the stride is to substantially reduce how hard Mr. Pistorius must hit the ground to run at the same speeds as his intact-limb competitors.

In this sense, the level of sprinting athleticism required for Mr. Pistorius to achieve world class speeds is dramatically reduced compared to his intact limb competitors. Mr. Pistorius attains

world-class sprinting speeds with the ground forces and foot-ground contact times of a slow and relatively uncompetitive runner. Mr. Pistorius' intact-limb competitors, with natural limb weights and swing times, lack this option, and therefore must achieve their speeds via exclusively biological means. Mr. Pistorius, in contrast, achieves these speeds through the use of technology.

Indeed, the gait anomalies of Mr. Pistorius are so large that they can be observed with a moderately experienced eye. Mr. Pistorius, like slow intact-limb runners, spends the majority of his race time on the ground while his competitors, in contrast, spend the majority of their race time in the air.

Many have offered the counter argument that Mr. Pistorius' speeds are achieved via innate athleticism by citing his unique ability among amputee runners using modern prostheses to achieve world-class sprint times. However, the vast majority of the athletes using similar prostheses are single-leg amputees who are unable to exploit the competitive benefits of lightweight prosthetic limbs. This follows from the inability of runners to reposition one limb more rapidly than the other when both limbs are attached to the same body. Because single-limb amputees are limited by the weight and repositioning time of their biological leg, exploiting the competitive advantages of artificially light lower limbs requires having two of them; and double-lower limb amputee runners are quite rare. Indeed, several single-limb amputee sprinters who competed against Mr. Pistorius in the 2004 Paralympics correctly noted that the bilateral condition of Mr. Pistorius left them at a competitive disadvantage.

Closing Remarks: If the scientific evidence is so clear, why is debate over the science of Mr. Pistorius' competitive advantage so confused?

A first factor is the presence, volume and frequency of misinformation. Many reports have cited invalid data, invalid comparisons and incorrect arguments as partially detailed above. Second, most journalists and the general public lack the expertise needed to differentiate between accurate and inaccurate scientific information. Third, many have conflated their interpretations of the evidence with emotional support for Mr. Pistorius. In this last case, the support and admiration fully warranted for Mr. Pistorius has led to biased interpretations of the science and emotionally-inspired, rather than data-based, claims of competitive equality.

We certainly value the experiences and emotions of all who have expressed their views and recognize that sentiment has an appropriate, and even necessary, place in the broader debate over policy considerations regarding Mr. Pistorius. However, a simple consideration of the statistical probabilities of the limb repositioning data immediately reveals how misguided and misinformed much of the public debate about competitive equality has been. The likelihood of observing the advantageous limb repositioning times of Mr. Pistorius by random chance alone is less than 1 in 6,000. Moreover, this is a conservative statistic that underrepresents the actual odds of observing this and the related advantages provided by Mr. Pistorius' artificial limbs.

Thus, while the evidence leaves open legitimate scientific debate about exactly how large the advantage of Mr. Pistorius is, there is no scientifically reasonable discussion about whether or not he has one.

We close by noting that, in keeping with our responsibility as researchers, what we offer is an objective evaluation of Mr. Pistorius's performances based on the comprehensive scientific and

factual history available. We wish him every success and the continued opportunity to push athletic and other boundaries in ways that inspire people throughout the world.

Matthew W. Bundle
Assistant Professor
Department of Health and Human Performance
University of Montana
Missoula, MT, USA

Peter G. Weyand
Associate Professor of Applied Physiology and Biomechanics
Department of Applied Physiology and Wellness
Simmons School of Education and Human Development
Southern Methodist University
Dallas, TX, USA