Why women wiggling in high heels could help improve prosthetic limbs and robots

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Oscar Pistorius

People walking normally, women tottering in high heels and ostriches strutting all exert the same forces on the ground despite very differently-shaped feet, according to research funded by the Wellcome Trust and the Biotechnology and Biological Sciences Research Council. The finding suggests that prosthetic lower limbs and robots' legs could be made more efficient by making them less human-like and more like the prosthetics used by 'Blade Runner' Oscar Pistorius.

Walking involves a repeated process referred to by scientists as 'crash, vault, push' – landing ('crashing') on the heel, vaulting over the stationary leg and then pushing off with the toes. This is the most economical way of walking and, as research published today in the Journal of the Royal Society Interface shows, the force exerted on the ground is the same for people walking normally or in high heels and for ostriches.

Dr Tatjana Hubel from the Royal Veterinary College explains: "Despite vastly differing arrangements of joints and hip wiggles, humans walking normally, women in extremely high heels and ostriches all produce strikingly similar forces when walking. This is the most mechanically economical way of walking. We do everything we can to make the forces follow the same pattern, which is why for example women wiggle their bottoms when they're in high heels. The question for us is, why is the human foot shaped the way that it is and not, say, like an ostrich's?"

When scientists model how the leg moves, they tend to simplify the movement and view the leg as a stick with a block on top (the body) which moves in an inverted pendulum motion. In this simplified model, the shape of the human foot does not make sense. But in fact, the human leg is more complicated than this; it contains muscles that likely evolved out of a tension between being optimised for walking and being more efficient at running. As humans are intelligent and able to plan and use tools, being able to move quickly to catch a prey or to evade a predator is not essential.

The shape of the human foot means that when the foot is flat on the ground, all the force goes through the ankles, allowing the muscles to support the weight of the body whilst being largely unloaded during the 'vault' stage. When muscles bear a load, they get tired easily, even if they are doing no work. For example, if we hold our arms outstretched, after a few minutes they will grow tired; by comparison, a JCB digger can extend its arm indefinitely.

The researchers believe this finding may have implications for the design of better prosthetic limbs for above-knee amputees and for the legs of humanoid robots. These might be improved by bearing more resemblance to an ostrich leg than that of a human.

Dr Jim Usherwood, a Wellcome Trust Senior Research Fellow at the Royal Veterinary College, explains: "If you want to make a good prosthetic foot but don't care what it looks like, you should put the motor – in this case, the ankle – as far up the leg as possible, where it can provide the power without making the feet heavy and hard to swing backwards and forwards. There's no point in putting the motor at the end of the foot, where it makes the leg more difficult to swing forwards – important in both walking and running.

"Some clever prosthetics copy the ankle and are very human-like, which is fine for prosthetics to replace the foot, but for above-knee amputee, a typical prosthetic leg which is very human-like is heavy and hard to move around. It's much better to have an ostrich foot at the end of a very lightweight leg.

An example of this kind of prosthetic already in use are the blades used by Paralympic athlete Oscar Pistorius – the 'Blade Runner'. These blades are light, springy and without a heel, similar to an ostrich's legs, which are optimised for running from predators rather than for walking.

More information: Usherwood, J et al. The human foot and heel-sole-toe walking strategy: a mechanism enabling an inverted pendular gait with low isometric muscle force. *JR Soc Interface*; 9 May 2012.

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