Doing more with less: Sperm without a fully active tail move faster and more efficiently, new study finds

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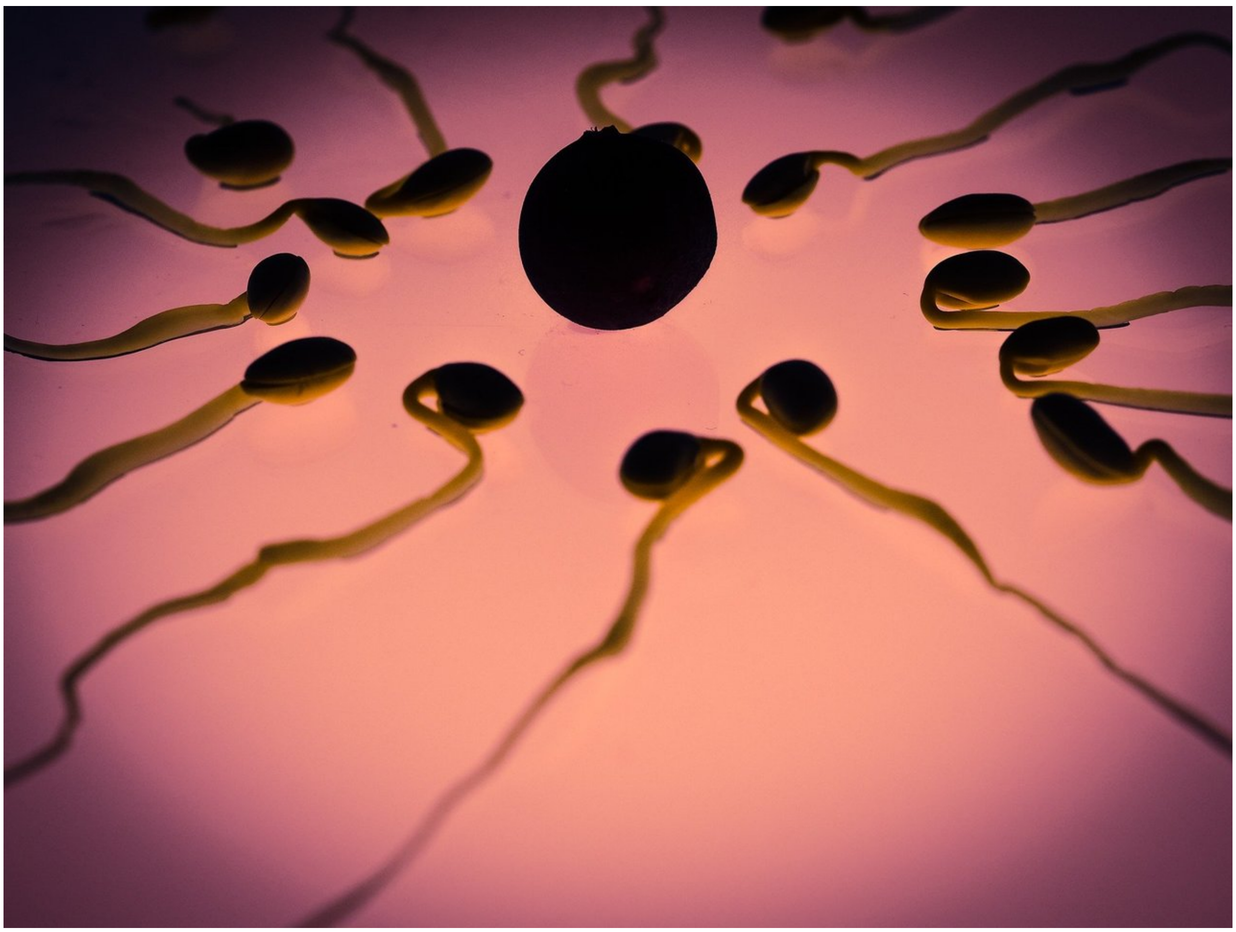

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Sperm cells moving their long tail to swim through the body in search of an egg is a familiar image, but a fully 'powered' tail may not be the key to success, according to a new UK study which could be crucial for improving the outcomes of assisted fertility treatments.

Propulsion of sperm and how the cell uses its tail to move through the thick fluids of the reproductive tract to reach and fertilise an egg has been well studied. However, the role of the specific parts of the tail, including the inactive area at the very tip, which it is thought, lacks the structure needed to generate motor activity, remains unclear.

A multi-disciplinary team of mathematicians and scientists from the University of Birmingham used mathematical simulations to analyse the effect that this inactive region has on the overall movement of the sperm and how this contributes to the speed and efficiency of the cell's motility. The study is the first modelling simulation study to investigate the detailed effects of this area, which measures just 3 microns—or 25 times smaller than the width of a human hair.

Results showed that instead of hindering the cell, the inactive region at the end of the tail actually enables faster and more efficient swimming. Simulations showed as much as a 430% increase in efficiency and a 70% increase in velocity in sperm cells with an inactive end region of the tail compared with cells where the tail was fully active. It is thought that the research could offer key insights into what enables a sperm cell to function.

Lead researcher Cara Neal, a Ph.D. student from the University of Birmingham's School of Mathematics said, "It seems counter-intuitive that a region of the flagellum that does nothing can have such a large effect on cell propulsion, but that is exactly what we have found. This effect would have been difficult to uncover without the use of mathematics in an interdisciplinary team.

"The importance of mathematical modelling becomes particularly apparent when you consider the vast number of cells involved—from 100 million sperm in human ejaculate we must understand the characteristics of the 10s that manage to reach the female gamete."

Professor David Smith, professor of applied mathematics at the University's School of Mathematics said: "Sperm have a challenging task—to generate energy and swim thousands of times their own length, and very few of them actually make it to the egg. Our model suggests that this tiny end piece region that was previously ignored shapes the whole swimming stroke into something more effective and efficient—just like in Formula 1, minute 'design' details can be the difference between winning and losing!"

Dr. Meurig Gallagher from the Centre for Systems Modelling and Quantitative Biomedicine said: "Sperm must be expert swimmers to navigate distances of several thousand times their own body lengths through the varied fluid environments of the female reproductive tract in search of an egg. With this research we have shown that a neglected part of the sperm anatomy (the inactive end of the tail) plays a significant role in ensuring sperm maximise their swimming speed and efficiency, which is essential for successfully completing this journey."

Co-author, Dr. Jackson Kirkman-Brown from the Institute of Metabolism and Systems Research at the University of Birmingham and the Centre for Human Reproductive Science at Birmingham Women's Hospital said: "The importance of the sperm tail propelling the cell has been clear since Van Leeuwenhoek initial studies in 1677, but actually how exactly a sperm swims is something only recently being unravelled in depth.

"This work is fascinating because it points to something that medicine and sperm science has totally ignored—the 3 micron long end-piece (of the tail) – potentially being the key to how a successful sperm may reach the egg. This is will draw diagnostic attention to something unexamined and opens the exciting possibility of new diagnostics to understand fertility problems."

The next stage of the research will involve the integration of these findings into the software used for the simulation to investigate how this effect persists in simulations of complex fluid environments such as the step-change between semen and cervical mucus.

Provided by University of Birmingham

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