The physiological and biomechanical demands of fencing

Elite fencing is a sport which combines both tactical awareness with physical ability. However, until relatively recently, the physiological demands of fencing had yet to be studied. Dr Lindsay Bottoms at the University at Hertfordshire has conducted some of the first studies looking at the demands which elite fencing competition places on the human body, and different nutritional and biomechanical strategies which could give fencers an advantage over their opponents.

Fencing is a sport which requires both immense concentration and tactical ability in order to outwit an opponent, so much so that many have compared it to a game of chess. But when television viewers watch fencing at the Olympics, what they might not realise is the intense physical demands on the athletes.

Fencing swords are among the fastest moving objects in the Olympics, second only to the bullets fired in the shooting competitions. In addition, competitions in the epee category – the largest and heaviest of the three weapons in Olympic fencing, the other categories being sabre and foil – can last up to 11 hours and competitors can aim for anywhere on their opponent's body. This all means that maintaining mental and physical endurance is a crucial part of succeeding at the highest level, as well as rapid reactions and explosive power.

A LAB-BASED PROTOCOL FOR STUDYING FENCING

Despite this and the 30 medals on offer at the Olympics, it's only been relatively recently that scientific studies have been conducted examining ways to improve fencing performance. As a former international competitor in epee, Dr Lindsay Bottoms – the research lead for sport, health and exercise at the University of Hertfordshire – has spent the past eight years researching the physiological demands of fencing, and whether adjusting biomechanics and nutritional intake can improve performance.

However, before Dr Bottoms could accurately study the effects of fencing on the human body, Bottoms had to develop a lab-based protocol, simulating a realistic international fencing competition. Her protocol recreates the typical exertion of a first-round fight with the fencer performing high-intensity footwork for eight seconds, interspersed with nine seconds rest, all over the course of three minutes. Then following a competition-standard break, a further eight fights were undertaken to simulate reaching the final from the last 128 of a competition.

One of her earliest studies applying this protocol was conducted in conjunction with the Polish international fencing squad. It revealed that fencing placed a particularly heavy load on the phosphocreatine system, phosphocreatine being the energy source for muscle contraction which enables explosive movements like the lunge.

Subsequent studies used the protocol to measure a variety of physiological responses including heart rate, oxygen consumption and blood lactate levels in both male and female epee fencers, as well as cognitive information such as perceived exertion. These lactate levels, as well as the distances covered by the fencers, and heart rate intensity during the fights, pointed towards the importance of finding ways for optimising aerobic conditioning to reduce fatigue and improve reaction times during the course of a competition.

CARBOHYDRATE RINSING

Sports drinks have long been known to improve performance by preventing dehydration and replenishing the body's fuel reserves in endurance sports such as running and cycling. But for shorter, high-intensity sports such as fencing, this is not quite so important as our

Measuring expired gases and blood lactate during fencing.

bodies have sufficient muscle glycogen to power the muscles throughout the duration of the competition. However, there may still be a way of utilising sports drinks to improve the body's perception of fatigue and thus maintain sharp reactions during a fencing competition.

The positive impacts of caffeine, such as reduced perception of fatigue, could potentially make all the difference between winning and losing a fight.

Back in 2004, researchers at the University of Birmingham came up with a novel theory which stated that instead of immediately ingesting a sports drink, athletes should first swill it around in their mouth for several seconds. This is because the sugars in the drink are detected by carbohydrate receptors in the mouth which then stimulate brain regions involved in motivation. Their theory appeared to be confirmed by placebo-controlled trials and brain imaging scans and has been put into practice in a variety of sports including football and tennis. At the recent World Cup, many footballers were seen swilling sports drinks around in their mouths before spitting them out.

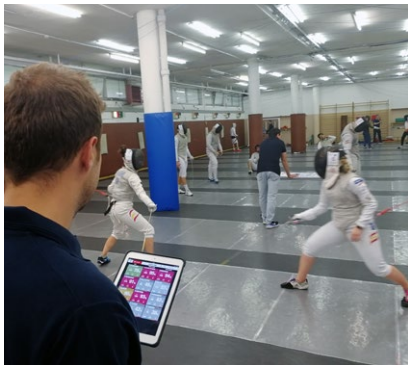
In the past couple of years, Dr Bottoms has conducted studies which suggested this could apply to fencing. By mouth rinsing with a carbohydrate drink, 12 club level fencers were found to have improved accuracy when lunging – the most common form of attack in fencing – compared to a matched placebo during simulated fights, a marginal gain which could make all the difference at the end of a 10-hour competition day.

But the carbohydrate content is not the only ingredient in sports drinks which could have a beneficial effect for fencers. While caffeine has traditionally had negative connotations in association with sporting performances due to long-held beliefs that it could have negative thermoregulatory effects, more recent research has shown that it doesn't cause water-electrolyte imbalances. Therefore, the more positive impacts of caffeine, such as reduced perception of fatigue, could potentially make all the difference between winning and losing a fight. This was confirmed by another study by Bottoms in which caffeine supplemented sports drinks were found to improve lunging accuracy during simulated fights. However, it should be noted that these sports drinks are thought to be more suitable for adult competitors, than junior fencers.

Thermal imaging during fencing.

TWEAKING BIOMECHANICS

Lunging is an integral part of fencing, but few scientists have broken down the exact biomechanics of the action and studied which muscle groups need to be conditioned to maximise speed and power. However, by using 3D cameras



Measuring fencers heart rate responses and movement data during competition by using a Polar Team system.

to quantify which body movements are most essential to a fast lunge, Bottoms has conducted a series of studies examining ways in which lunging technique can be optimised.

This research found that sword velocity is both determined by the degree of flexion in the back leg at the beginning of the lunge – so starting from a low stance is crucial – and the extent to which that leg straightens during the lunge. In addition, hip flexion of the leading leg, the ability to rapidly extend the sword arm, as well as shoulder flexion – keeping the arm high and aiming for the opponent's upper chest – are all crucial to achieving high sword velocity.

IMPACT

Through conducting the first studies to really delve into factors that could improve fencing performance at the highest level, Bottoms has identified a variety of measures which could be useful for elite fencers to study, particularly in the lead-up to the Tokyo 2020 Olympics.

While carbohydrate and caffeine supplemented drinks could reduce mental fatigue during lengthy competition days, working on strengthening and conditioning the muscle groups on the front and back legs, such as the hamstrings and quadriceps, as well as the shoulder flexor muscles, could greatly improve speed and power when launching attacks. In addition, this could enhance the aerobic conditioning needed to maintain performance over the course of multiple fights in succession.

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Behind the Research

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Research Objectives

Dr Lindsay Bottoms has spent the past eight years researching the physiological demands of fencing and aims to explore whether adjusting biomechanics and nutritional intake can improve performance.

Detail

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Bio

Dr Lindsay Bottoms is the Research Lead for Sport, Health and Exercise at the University of Hertfordshire. She has researched extensively in fencing performance. Lindsay competed internationally at Epee, having competed for England at the Fencing Commonwealth Championships in 2010 and won a bronze medal at the 2014 championships. She is now a team manager for the junior national teams and the England Team Manager.

Collaborators

- Dr Jonathan Sinclair – University of Central Lancashire
- INEFC-Barcelona Sports Sciences Research Group

Students:

- Mrs Georgina Rowlett (University of East London) and Dr Kim Gregory (University of Bath)

References

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Personal Response

What future studies could be done into the biomechanics of epee fencing technique and how could they further improve performance?

" Investigating the positioning of the back foot in the en garde stance is a future study to determine whether it affects load of the knee and the weapon velocity. Currently, we are having discussions regarding 'traditional footwork' vs bouncing footwork in epee and how best to train this. "