MONITORING MOTO GP RIDER'S PHYSIOLOGICAL STRAIN

A ROLE FOR THE SPORT SCIENTIST?

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INTRODUCTION

In 2008 the first ever night-time Moto GP Grand Prix was held in Doha following the construction of permanent outdoor lighting, and in doing so establishing the Qatar event as one of the most spectacular on the Moto GP calendar. With an 18-race series visiting 14 countries, four continents and pan-global television coverage, Moto GP is the premier motorcycle racing World Championship. Although piloting is both physically and mentally challenging, motorbike research has until now primarily focused only on injuries and risk factors of the sport[1]. With little regards for Moto GP riders as athletes, their capabilities and the physical load of races are seldom the focus of scientific research. In this article, we will make the case for new investigations in the area of motorcycling science and for the burgeoning role of technology.

THE STRESSORS UNIQUE TO MOTORCYCLING

When designing a race bike, the engineer has objective information available about the structural limits of the machine and the safety tolerances of important components. However, motorcycle performance depends not only on the characteristics of the bikes but also the psycho-physiological capabilities of riders. Unfortunately the scientific knowledge regarding riders' physical load falls behind the science of analysing and improving bike performance and related equipment. Instead, riders have battled the stereotype that bravery and talent are enough to successfully ride in Moto GP and that modest physical effort is enough.

> ***Wearable technologies could revolutionise the world of Moto GP***

Motorbike riders do not run, jump and/or throw during competition. Therefore, what they are actually doing may not look particularly athletic to those unfamiliar with the challenges of motor-sports. However, a closer look reveals that the 'rider-athlete' must execute numerous motor and cognitive skills simultaneously, with elevated cardiovascular strain, persistent thermal stress and repetitive G-loading. The rider must remain calm and focused on the bike's performance, the variances of the course (e.g. bumps, chicanes, changing track conditions), with his competitors only centimetres away, while travelling at speeds sometimes up to 350 km/hour. Needless to say, in this sport, there is no room for error as even a small mistake can be fatal. One tragic example is Marco Simoncelli who died after an accident during the 2011 Malaysian Grand Prix in Sepang.

We currently have little information on the levels of endurance and strength required in top-level riders due to the high speeds, sharp accelerations, rapid decelerations during braking and inclination of the bike on curves[2,3,4]. Nonetheless, many riders have anecdotally commented on the physical challenges of driving a motorcycle:

"Fitness makes a big difference on the bike," said Nicky Hayden. "Once you physically get a little tired, you mentally start making mistakes and that's when you get hurt. And when you fall off these bikes, it doesn't exactly tickle."

PHYSIOLOGICAL DEMANDS IN MOTOR-SPORTS

Cardiovascular strain

Although limited objective data during motorbike track racing exist, some scientists have attempted to quantify the cardiovascular strain experienced by riders. In one of such study it was reported that during a ~30 minute circuit race, heart rates (HR) fluctuated between 190 and 200 bpm (an average HR close to 90% of the estimated maximal HR)[5]. In motocross, 87% of the riding time is spent above 90% of riders' maximum HR[6]. While some researchers postulated that the elevated HR is related to the intense physical demands of high-speed driving[7,8], others attributed the elevation in HR to increased sympathetic nervous system output and changes in hormone levels due to anxiety and other emotional responses[9]. Whatever the exact underpinning sources, overall the rider-athlete undergoes rather similar (squash[10]), if not greater (football[11] or tennis[12]), cardiovascular stress than 'traditional' athletes.

Muscular efforts

The stable body position of the rider is established primarily by isometric contraction of the neck, abdomen and legs. Upper limb strength is also a relevant factor in motorcycling since riders use their left hand to pull the clutch lever and their right hand to pull the front brake lever and to control the throttle[7]. Therefore, the increased energy requirements as races progress are most probably related to the increased muscular activation required to maintain the rider's balance on the bike.

Thermal strain

In the laboratory, the impact of excessive body temperature and its negative impact on exercise capacity and cognitive function are well-documented[13,14]. Although the risk of thermal stress on riders' safety and various aspects of performance are

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likely, it still needs to be established. With riders typically wearing a layer of safety garments such as a safety suit, as well as undergarments, boots, gloves and, obviously, a helmet, the part of their body that is exposed to the environment is not much more than their eyes, assuming the visor is up[15]! Such protective clothing limits heat dissipation, exacerbating the physiological and thermal strain, which can reduce force production capacity and induce significant cognitive impairments[16]. Add to this the fact that racing is often performed in warm conditions (such as those in Sepang), making the likelihood of developing 'uncompensable' heat stress (i.e. situations where the body is unable to maintain a thermal steady state) an even more realistic scenario.

During times of persistent physical activity and heat stress, when the cardiovascular system is challenged, there is a disproportional increase in HR even though exercise intensity remains relatively constant; this is known as cardiovascular drift[14]. Should this condition persist, the rider is at risk for the early onset of fatigue and eventual performance deficits. It has been shown that in a laboratory setting, the combined use of both heat acclimation (4 days of repeated heat [50°C] exposure [1 hour/day]) and task familiarisation (via race simulation) during which pilots performed a simulated rally drive could improve the driving and psychomotor performance of rally drivers[17]. Although no such data exists with motorbike riders in an actual race situation, performing a daily acclimation protocol in the week prior to competing in a thermally challenging race might be a practical way of optimising the psychomotor skills of riders, which could help to improve riding performance and safety.

HOW CAN SPORT SCIENCES HELP THE 'RIDER-ATHLETE'?

Until now, riders and their trainers have largely been left to their own devices to figure out the stressors and the areas of specific training focus. The potential advantages of using the data gathered from on-track free practice and qualification sessions and/or official races include the possibility to:

- Alert the team in the pit when the rider is likely to make a mistake because of premature fatigue.
- Develop laboratory-based simulations representative of the rider's actual physiological response rather than anecdotal reports.
- Replicate conditions that the rider may participate in or encounter, taking full advantage of the principle of specificity.

Several caveats have to be considered when studying the physiological aspects of motorcycling competitions. First, the difficulty of designing the experimental apparatus which does not interfere with the safety and performance of the rider, obstacle riding, electronic control system of the bike (create electro-magnetic interferences), or alter the aerodynamics or performance of the bike during the unique setting of the race. Second, the hectic atmosphere of competition generally does not promote the co-operation of riders and the control of variables that can affect the data collection process, in addition to the fact that riders are generally reluctant to participate in experimental settings under competitive conditions. Along the same lines, professional motor sport teams are often reluctant to allow the collection of experimental data on their riders, especially when they could be advantageous to their opponents. Finally, because the power and mass of the motorbikes undoubtedly affect the technical aspects of riding and reportedly have a different physiological impact on the riders[18], the results must remain racing-specific and therefore may not be necessarily transferable to other motorbike disciplines and races.

TECHNOLOGICAL ADVANCES

Wearable technologies could revolutionise the world of Moto GP. A collaboration between Aspetar, Qatar Science and Technology Park and LCR Honda, one of the top Moto GP teams, enabled the real time quantification of the strain experienced by the rider-athlete during a practice session following the 2010 Spanish Moto GP in Jerez. Wireless communication protocols enabled the rider's cardiac (mean HR and time spent at high-intensity in reference to maximum HR), thermal (core, skin, helmet and suit temperatures and dehydration), neuromuscular (dominant and non-dominant handgrip strength) and cognitive (reaction time, short and long-term memory) strain associated to motorbike racing to be collected. The results highlighted that Moto GP riders experience a considerable degree of cardiac stress during racing, which was associated to a thermal load that has the potential to alter neuromuscular and possibly cognitive performance.

"This data is very important. It allows us to better train the riders and together

with the manufacturers, the suppliers of racing stuff, we can study and improve the protection of the rider, the clothes of the rider," stated Lucio Cecchinello, Honda LCR team manager.

"Moto GP relies on combining the latest technologies with talented riders to gain a competitive edge. By working with Aspetar and Qatar Science and Technology Park we hope to characterise the physical strain imposed on our riders under different conditions and develop the appropriate countermeasures to ensure they not only reach the start line in peak condition, but are able to perform at their best." added the Italian rider, who founded Team LCR in 1996.

During laboratory tests, the usefulness of a helmet with a cooling system to help keeping rider's head temperature cooler has been evaluated, which may potentially preserve decision-making capabilities while racing. Effective, non-obtrusive, wearable devices are quickly becoming a reality with a huge potential consumer and allied health market estimated to be worth billions per year. Therefore, it is not unfeasible to foresee that technology will soon allow Moto GP teams to monitor their riders' physiological stress over the same wireless networks they currently use to obtain the vast amounts of motorbike performance data. The possibility of integrating these data would ultimately improve safety and the overall performance of man and machine.

IN SUMMARY

With the miniaturisation of sensors and the advent of portable data storage devices, the prospect of quantifying the thermal, cardiovascular and perceptual stresses unique to the Moto GP in real time during actual race events is no longer problematic. Beyond the individual stressors (e.g. increased HR, core temperature or G-loading), what would be even more meaningful to evaluate is the way that the individual stressors interact with one another and the effect of those interactions on the rider's driving performance. In uncovering this information there is an opportunity to design training programmes that more accurately apply to the Moto GP rider and the stresses experienced and, from a health perspective, possibly avoiding accidents that are caused by riders' fatigue.

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