Sport, either through participation or spectatorship represents a significant part of everyday life and plays a key role in our health and wellbeing. It’s also big business. Estimates suggest that sport now represents a £20bn-a-year industry in the UK. When this is considered with the fact that most sports exhibit many of the characteristics of complex safety-critical systems, it’s perhaps not surprising that ergonomics theory and methods are increasingly being used to optimise sports systems. This relates not only to enhancing sporting performance but also to injury prevention, product and equipment design, performance assessment, and wider sports systems issues such as doping, corruption, the spectator experience, and sports governance.

The role of ergonomics in optimising sports performance has long been recognised. Following initial applications in the 1980s there is now a significant body of sports ergonomics research covering a diverse set of issues across different sports. A notable feature of recent applications is that systems ergonomics theory and
methods are beginning to emerge as powerful tools in the sports context. Systems ergonomics, it seems, has much to offer in sporting circles.

To demonstrate this, we present an overview of our recent systems ergonomics applications in football, running, rugby and cycling. The intention is to demonstrate the utility of systems ergonomics in sport and to inspire the ergonomics community to initiate further sports ergonomics applications.

**Teamwork and decision-making in cycling pelotons**

Cycling pelotons represent complex, highly dynamic systems comprising multiple human agents such as riders, Director Sportif and mechanics, and non-human agents such as bicycles, vehicles and bicycle computers. They exhibit emergent properties, non-linear interactions, multiple control and feedback loops, loose and tight coupling, distributed teamwork and rapid decision-making. As such, they provide the perfect context in which to examine distributed teamwork and decision-making.

We recently applied the Event Analysis of Systemic Teamwork (EAST) framework to examine the performance of an elite women’s road racing team during Australian National Road Series races. Based on observations of pre-race planning and the race and post-race cognitive task analysis interviews, EAST was used to construct task networks (showing the tasks conducted by team members), social networks (showing the interactions between team members) and information networks (showing the information used by team members). Together the networks show the relationships and interactions between tasks, information and team members throughout the race.

Whilst the analysis provided important insights relating to teamwork and distributed situation awareness theory, important implications for enhancing future performance arose. The findings suggest that race plans that are agile, adaptable, and contain a series of well-defined contingency plans, will enable teams to respond effectively when faced with variable tactics from opposing teams. In addition, the importance of verbal and non-verbal communications was emphasised even when riders may be spread throughout the peloton without the ability to communicate directly. This suggests that teams should investigate strategies for rapid and effective communications during races. Future work incorporating testing of ergonomics interventions during a season-long study is currently being planned.

**A systems approach to running-related injury**

Globally, the popularity of running for recreation and fitness has increased considerably. However, despite the widespread application of epidemiological and scientific investigations to understand why runners sustain sports injury, limited progress has been made in terms of our ability to identify discrete causal mechanisms. This is primarily due to limitations with methods and analysis associated with epidemiological and scientific forms of inquiry.

Even when research applications are free from systematic bias (that is, there is sound internal validity), the process of isolating risk factors for injury at the intrapersonal level of the runner will give us only part of the broader causal picture. In other words, distance runners sustain a given injury, not necessarily because of faulty biomechanics or maladaptive training-related behaviours, but rather because system-wide processes have indirectly influenced the immediate decisions and actions of runners. This might lead runners to increase their application of running load and/or decrease their tolerance to withstand it. In order to expose the underlying systemic factors that contribute to running-related injury at the population level, alternative research approaches are required.

Systems ergonomics could provide such an approach. We adapted the Systems Theoretic Accident Mapping and Processes (STAMP) method to model the Australian distance running system. The resulting control structure model shows the current control and feedback loops within the Australian distance running system. The model depicts: a) who shares the responsibility for running-related injury in Australia (from the runner all the way to government levels), b) what controls are currently in place to prevent or manage running-related injury, and c) where potential contributory factors exist. This big picture perspective provides both a novel and compelling view of the factors that might contribute to running-related injury. A fully validated model of the Australian distance running system, which is currently being developed, will help to identify practical system-wide opportunities for running-related injury prevention.

**Performance analysis in football**

Performance analysis (PA) in elite level football is well established and plays a key role in supporting coaching practice. There are various PA methods available that enable assessment of the physical, technical and tactical elements of football performance. One criticism of PA methods is that they tend to be reductionist, focusing on components of performance in isolation. Consequently, football performance has not previously been described in its entirety, including all the components underpinning performance along with the relationships between them. In response to this, McLean used the first phase of Cognitive Work Analysis (CWA), Work Domain Analysis (WDA), in a first-of-its-kind application to develop a model of the elite ‘football match’ system.

Aside from the comprehensive description of football match performance, the model has three important implications for PA in football. First, the WDA confirmed that football is a complex sociotechnical system, which has important implications for how we should analyse performance. Second, the WDA identified aspects of performance...
that are not currently measured by PA methods, yet were deemed important for coaches by the Subject Matter Experts involved in developing the model. Third and finally, the findings demonstrate a research-practitioner gap, whereby existing PA measures may be not useful in practice for the coaches. It was concluded that new PA measures and methods are required to bring PA in line with coaches’ needs. Importantly the analysis of the football match system provided by WDA will provide the basis for the development of these new methods.

**Concussion identification and management in rugby**

Increasing attention is being placed on the link between brain injuries caused by concussion sustained in sporting activities and the development of serious long-term health issues. From a systems ergonomics perspective, sports concussion and its management are considered as emergent properties arising from the interactions between factors across the system’s hierarchy including policy and guidelines, rules and regulations, culture, training and equipment. Clacy recently applied a systems ergonomics approach to examine how sport-related concussion is currently managed (that is, prevented, identified, and treated) in amateur rugby union in Australia. This involved using Rasmussen’s Risk Management Framework to explore the management strategies employed by participants across the rugby system. The most frequently mentioned strategies were in relation to proper training, technique correction and education. A notable feature of these three strategies is that their effective implementation requires action from participants from across the entire rugby system, as opposed to those at one level alone. When considered together, the findings of this research identified specific junctures in the amateur rugby system that are currently preventing the effective communication, internalisation, implementation and enforcement of concussion management.

**The future**

The future is bright for ergonomics in sport. Ergonomists have a significant role to play in understanding and optimising recreational, amateur and elite sports systems. A notable feature of the applications discussed is that, as well as the benefits for sport, there have been benefits for the discipline whereby ergonomics theory and methods have been refined and even extended through applications in a new context. As sports systems continue to become more complex, more competitive, and more technology-centric, the requirement for ergonomics research and practice will increase significantly. We heartily encourage further ergonomics applications in sport. Sport and society will benefit, as will our discipline.

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**Further reading**

