INTRODUCTION

Sports technologies are part of the growing global sports and recreation industry. In the world of high performance sport, prominent sports stars and elite coaches are increasingly tapping into the world of technology and innovation to advance performance. Innovations in technology are applied across all areas of sports science, sports medicine, sports surgery, sports rehabilitation and sports coaching to enhance elite sport performance. In many ways, the emerging era of the ‘technology driven sport space’ is changing both the way that we practice and the way we connect with sport.

Even at the developmental levels of sport, the benefits of technology for sport are wide-ranging. For instance, the innovative use of technology can help spread expert knowledge about coaching best practice in a fun way. iPads and Smartphone applications can now be used to record images of players in a certain move or shot – such as the triangle offence in basketball or the pull-shot in cricket. Recorded images are then synchronised to play on a split-screen console alongside an image of a famous player, playing the same move or shot. Developing players can easily compare their style with that of their heroes and make adjustments to improve their game. One day we may even see famous athletes like Nasser Al-Attiyah giving coaching tips through mobile apps, such as ways to improve shooting techniques or strategies for athletes to mentally prepare themselves for the intensity of international competition.

Innovation and innovative thinkers drive these visions for the future and both are often viewed as catalysts for growth and success. But what exactly is innovation and how is it applied to high performance sport settings? This article explores existing examples of technology in sport and provides a framework for innovative processes within high performance sport training centres.

TECHNOLOGY IN SPORT

More now than ever, we see and experience technology across all areas of sport, including adjudication and officiating (e.g. electronic touch pads for finishes in swimming competition), sport coverage and broadcasting, stadium and facility development, doping detection, sport safety and workflow (Figure 1). Media technologies (e.g. high speed and infrared cameras) also provide vital information to coaches and officials and entertainment for the viewing public. Technological applications in each
the use of technology to measure and define performance.

For example, at competition level, the use of the stopwatch has been superseded by micro-measurement timing of individual biomechanical actions to assess running gait. In terms of physiology, the use of heart rate monitors is now widespread. Less common, but still often used, are blood lactate and oxygen consumption levels.

Hahn suggests four distinct contexts in which technology is useful to high performance sport (Table 1), with increasing emphasis being placed on

Table 1: Technology and Performance Context.

<table>
<thead>
<tr>
<th>Contexts for technology application</th>
<th>Purpose of technological application</th>
<th>Examples</th>
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<tbody>
<tr>
<td>1. Determining characteristics of elite performers</td>
<td>To provide evidence-based determination of the characteristics of an elite athlete</td>
<td>VO, maximum testing; genotyping; mathematical modelling of performance; force plates; GPS</td>
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<td>2. Identifying talent</td>
<td>To assist in the process of recognising high-quality raw materials (i.e. talented athletes)</td>
<td>Dynamometers; ergometers; strain gauges; angle sensors; communications technology to enable fast transmission of information about talent</td>
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<td>3. Testing and refining performance</td>
<td>To develop skill; to improve decision making; to improve physiological capacity; to analyse individual and team performance; to diagnose, prevent, and manage injury and illness; to complement quality coaching</td>
<td>Technologies to rapidly assess immunological status; athlete tracking devices; Dartfish in individual sports; Sportscode; cooling vests; highly engineered equipment; scientifically advanced race wear</td>
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<tr>
<td>4. Monitoring competition performance outcomes</td>
<td>To objectively analyse individual and team performance and monitor outcomes in training and competition</td>
<td>Video analysis and software programmes</td>
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Figure 1: Technology in sport.
time monitoring of athlete physiological outputs can be used to protect athletes, prevent injury and monitor and manage performance. The advent of wireless tracking and wearable sensors has also enhanced training and competition outcomes. GPS usage is now widespread in sport as it provides quality feedback for performance analysis and monitoring. Furthermore, the recent adoption of information technology has also had a transformative effect on sports performance.

The translation of technology innovation from one sport (or industry) to another sport is also commonplace. For example, carbon fibre technology straight from Formula One racing has been used to improve the performances of Paralympic Bocce players. Similarly specialists in seat design alongside leading car manufacturers BMW have created a highly responsive and manoeuvrable wheelchair for Paralympic basketballers. The next-step is to increase the conversion of these types of innovation from elite sport to community sport for the benefit of the recreational sport participant.

Australian initiatives in sports science and engineering have also transformed the sport of boxing with the introduction of automated impact sensing systems (AISS). Box Tag is a modified and low risk form of competitive boxing in which impacts to the head and any impacts above a moderated level of force are prohibited. The sport is highly dependent on technology as contestants wear vests that have been specially manufactured to incorporate stripes of silver-coated nylon thread, through which a low level electric current can be run, and standard gloves with patches of conductive material affixed to their surfaces. When two parallel stripes make contact with the conductive portion of the glove, a change in electrical resistance occurs and impacts can be detected. This provides for more objective measures of performance.

Evidently, increasing reliance, demand and availability of technology are important determinants of competitive advantage and improved sport experiences. Wide-ranging technological and product innovations that are actively developed and implemented in sport are a means to achieve competitive advantage through new or improved practices, processes and/or techniques. However, future improvements will be dependent upon the extent to which a technology innovation addresses a performance gap by meeting the pre-identified needs of individual athletes, coaches and expert support staff.

WHAT IS INNOVATION? DRIVERS OF INNOVATION AND THE INNOVATION PROCESS

“Innovation” is a source of competitive advantage to sport organisations. It is broadly defined as the introduction of a new idea or behaviour in the form of a technology, product, service, structure, system or process on to the market. It is a different process to “invention” and involves the implementation and/or adaptation of new knowledge. Technology is only one form of innovation and refers to the mechanical arts or applied sciences collectively and their application.

A recent National Press Club discussion on research and innovation in Australia revealed that major drivers of innovation include:

- challenge (e.g. scarcity and threat) and
- facilitation (e.g. availability of funding, infrastructure to support innovation and a willingness to take risks).

The removal of legal, administrative and sociological barriers to innovation is also regarded as a critical ‘facilitator’ of innovation6.

Innovation is a source of competitive advantage to sport organisations
In the context of elite sport, innovation may be driven or 'facilitated' by the inadvertent knowledge sharing that is generated by collaboration and partnerships between athletes, coaches, scientists, commercial enterprises, institutes of sport and/or knowledge-driven institutions (e.g. universities). New ideas that are developed in collaborative spaces and supported by cultures of innovation can be transformed into technological applications that are tested in the market or 'sport space' to facilitate competitive advantage.

Innovation can also stem from the 'challenges' posed by the intensity and rigour of competition in the international sport environment. Innovation may be required to address the needs of athletes, coaches and sport scientists to effectively plan, monitor and evaluate athlete performance using technology in the daily training and competition environment.

Identifying and understanding drivers of innovation can provide a platform from which to explore technology opportunities and address performance gaps. Regardless of the source of an innovation, the innovation process traditionally follows a series of steps to either generate an innovation (such as a new product or process to resolve a problem) or adopt an innovation (carry out activities to further the use of an existing innovation).

The stages of innovation are broadly categorised as:
1. Identifying knowledge or performance gaps (foreseeing or recognising a problem).
2. Conducting research to develop knowledge bases.
3. Creating or adopting solutions for the problem.
4. Establishing and testing lines of enquiry.
5. Creating support for the solutions

BUT HOW CAN THIS PROCESS PROVIDE A 'COMPETITIVE ADVANTAGE'?

One of the most crucial steps in the innovation process is identifying and assessing needs through the eyes of athletes, coaches and expert support staff within high performance sport organisations. Being aware of a need or opportunity for change is considered to be a significant driving force of the innovation process and a precursor to the incorporation and success of an innovation.

**Identifying and assessing need: conducting a needs assessment**

Conducting a needs assessment involves deconstructing an identified need into its component parts to determine solution requirements (Figure 3). Based on this understanding, the needs assessment process ends before selecting or developing any technology intervention, yet provides the necessary data for developing solutions and delivering useful results.

Generating or adopting an innovation without conducting a needs assessment is a fundamental mistake, because determining the solution before identifying the performance problem (e.g. a gap in results at the individual level) is similar to attempting to improve performance before really being aware of what initially needs to be addressed. Therefore, needs assessment is a focused performance-improvement tool and can be considered a proactive planning activity. Proactive approaches to identify and assess need can lead to success in innovation.

**Application to high performance sport training centres**

In elite sport settings, new technology must meet the increasing demand for athlete services to provide a competitive advantage for sporting organisations. In order to sustain the highest levels of performance and excellence, the following four key strategies and recommendations for technology innovation are provided:

1. Conduct a needs assessment and needs analysis to provide a framework for innovation (e.g. Riot et al). High performance sport training centres must effectively identify requirements at all levels of the support system. A technology...
needs assessment and analysis should therefore consider:

- The perspective of multiple stakeholders.
- Perceived need in various performance and situational contexts to effectively develop new directions and manage risk (Table 2).

Stakeholders can help identify need by considering the various contexts for technology innovation in elite sport. Seeking different perspectives and considering varying contexts can lead to the generation of creative ideas to address performance gaps.

2. Assess opportunities for development and/or adoption of new technologies on the basis of their cost, relative to their expected benefits and the availability of resources needed to ensure their effectiveness.

High performance training centres can avoid the issue of ‘a solution in search of a problem’, by identifying knowledge and performance gaps through a needs assessment. This process optimises an organisation’s resources and processes. Innovations also need to be appropriate for the unique context of the adopting organisation to ensure effectiveness.

3. Collaborate and network with sport providers (e.g. coaches, high performance directors), technology firms and researchers to build an innovation culture and address opportunities.

In order for innovation to thrive, the broader environment in which it takes place must be encouraging and supportive. Organisations rarely innovate alone. Innovation is a highly interactive, multidisciplinary process which increasingly involves co-operation and partnerships between a growing and diverse network of organisations and individuals in elite sport settings.

The greater the number of intra-organisational networks, the greater the response to innovation adoption and innovation success. For example, linking knowledge obtained from elite athletes and sport and science organisations with researchers and sports technology firms can, in entrepreneurial terms, increase the ‘value’ of technology innovation. Through these networks, organisations can exchange knowledge and resources needed to encourage innovation and promote the diffusion of new ideas.

4. Innovate and commercialise new sports technologies

High performance sport training centres are part of an increasingly competitive sport space and the pace of competition is even faster where technology innovations are incorporated. Faced with more competitive organisational models, improved athlete services, better technologies and challenging performance strategies by competitors, building innovation capability becomes an important, if not vital, strategy for high performance sport training centres to find greater efficiencies in utilising their resources.

The existing body of sports researchers, sporting organisations and active technology firms in Qatar provide an ideal starting point for successful development and commercialisation of technology innovation. Qatar’s existing innovation ecosystem can be used to facilitate closer collaboration amongst sport researchers and firms involved in commercialising new technologies applicable to sport.

**TAKE-HOME MESSAGE**

So, how innovative are you? Innovation is a pathway to greater competitiveness. Supported by innovative thinkers, elite sport organisations can minimise barriers and maximise opportunities for commercialisation of new ideas. This article has provided an overview of technology use in elite sport and a framework for technology innovation and innovative practice. When moving forward with innovation it is important to consider the individual needs of elite athletes, coaches and their expert support staff before generating or adopting an innovative solution.

Needs assessment is an important part of technology innovation. As a tool for policy and decision makers, the proposed technology and innovation framework strengthens the ability of sport to innovate as necessary and strategically to achieve performance goals. The process of identifying and prioritising needs can help to address gaps between current and desired results and provide a distinct competitive advantage. To conclude, technology innovation should be an enabler of performance in sport, rather than a goal in itself.
References

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Image: Sebastian Vettel of Infiniti Red Bull Racing looks at a mobile tablet device during practice for the Malaysian Formula One Grand Prix