Introduction To Advances In Athlete & Performance Monitoring

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Abstract

In the last 5 years there have been significant improvements in GPS tracking, wireless data transmission, heart rate monitoring and motion sensing technology. Recently the price and sophistication of systems to allow human performance and fitness to be monitored has fallen to a point where schools, sports professionals and motivated individuals can capture and analyse detailed performance histories. Whilst the simplest of these are in watch based formats there also are higher level systems for providing video synchronisation and live transmission from the field. The youth of today will expect the technology they see on televised sport to be in their schools. The challenge is to build upon the technology and enhance the potential for improved health and physical performance of our population.

This paper compares current technologies and discusses future technology trends in simple language that all can understand. A working example of a latest monitoring system will be demonstrated. Participants will be invited to engage in discussion about their needs to record, measure and easily manage the performance of those under their guidance. Identification of physical performance, talent and development is becoming easier and more sophisticated. The technology exists that would allow an automatic field capture at school level and automatic transmission to a secure national database, but is this what PE professionals want?

1.0 Elements Of An Athlete Monitoring System

1.1 Sensors

1.1.1 Speed

Traditionally speed has been measured with a stop watch. Advances in the latter half of the 20th century saw accurate timing systems for the Olympics and major events, but even now most timing systems available to schools are not accurate. Accuracy becomes critical when the event being timed is relatively short (ie in the order of a few seconds), because the errors are typically only introduced at the points where the athlete starts and finishes and therefore stay constant.
During the 1980s the US Government started to make its satellite Global Positioning System (GPS) available for public use. After 2000 it removed the deliberate position errors that had been placed to protect against misuse. Claimed position accuracy is 10 to 15 metres, but latest commercial use (non specialist) GPS chips can resolve position to +/- 2 metres most of the time, and can calculate speed to 0.1 metres/second. Within the last few years affordable GPS chips were released that can calculate speed and position at 4 to 5 times per second. Specialist GPS systems with extreme accuracy and high update rates are not yet viable for low cost sport monitoring or indoor use.

1.1.2 Heart Rate

The first sports heart rate monitors became popular through the efforts of Polar™ in and their rival Suunto™, both based in Finland. Polar introduced the first wireless heart rate monitor in 1977, and essentially the core technology has been retained, but now includes more features on the watch

interfaces, such as training zones, estimates of VO2MAX and connections to other sensors, such as foot pods and cycle cadence meters.
Recent advances by Suunto™ and Polar™ include more comfortable chest straps, and the use of high frequency (2.4 GHz) ANT coded wireless transmission, to overcome perceived limitations in the traditional low frequency 5kHZ straps.
Heart rate sensing technology is now main stream and included in sports training equipment in gyms and portable athlete monitoring systems.

1.1.3 Distance

Traditionally distance was a pre-measured value (such as a 400 metre track or marathon course), which required timing but no sensing other than human observation. However with the introduction of GPS tracking distance can be calculated, although its accuracy is variable. Latest sport based GPS systems can calculate distance to better than 1%, although older GPS products were not that reliable. Distance measurements are certainly accurate enough to be useful in all teaching applications for schools and are regularly used by trainers of professional athletes.

1.1.4 Acceleration

Acceleration sensors have been available for decades, but only within the last few years have cheap miniature 3 axis accelerometers become available.

1.1.5 Direction, Impact Forces & Body Tilt

Whilst the human observer and video cameras can easily determine direction, it becomes a much more complex problem when only sensors on the body are available. The easiest way to sense approximate direction is by creating an electronic compass. The compass detects the Earth's magnetic field using three sensors and can calculate the general direction and tilt of the human body.

To resolve both direction and tilt requires several sets of sensors, including accelerometers, magnetic field sensors and rotation sensors (ie gyroscopes). Within recent years all of these sensors have become available. Impact forces that might be of interest in contact sports, can be estimated by the same type of sensor arrangement.

1.1.6 Foot Impact

The only way to sense foot impact is by using accelerometers on the body, or a fixed force plate that the athlete runs across. Sports scientists have been writing about the use of accelerometers on mounted to the body for impact measurement for at least a decade. In practice there are very few off-the-shelf systems that can provide accurate foot impact data.

1.1.7 Stride Rate

In practice the recent advances by Suunto™ (who released a "foot pod") to measure foot movement rely simply on the same type of technology as a pedometer. The NikePlus™ wireless running monitor that integrates to the Apple iPod uses similar technology. Essentially pedometers contain an accelerometer which picks up peaks in body movement. The technology is quite simple and can be prone to errors. The best monitoring systems available can provide continuous stride rate using software to calculate step rate.

1.1.8 Blood Oxygenation & ECG

Typically this has been available in hospitals and lab based sports testing facilities. With the advent of ANT wireless technology the inclusion of blood oxygen sensing should start to appear in the next few years as hospital sensors get adapted for portable use.

1.1.9 Body Temperature

Body temperature is very easy to capture in portable devices, but is usually not included. Some specialist equipment such as the Zephyr™ bio harness (NZ made) does include temperature monitoring.

1.2 Data Capture

1.2.1 Stop Watch And Viewing By Teacher / Trainer

We started the session by noting how the traditional methods of athletic performance centred around time and distance. Distance is reasonably easy to measure for vertical or horizontal. Timing is everything when it comes to competitive sport, but arguably the accuracy to Olympic levels is not necessary in education. However recent trends with field equipment, such as the Swift™ timing gates and FusionSports™ system made accurate timing more affordable. These systems are relatively expensive compared with GPS technology, but offer high accuracy on short sprint testing.

1.2.2 Video Camera – Standard And High Speed

The price and size of domestic video cameras has sharply decreased since 2004, whilst the image quality and resolution has increased dramatically. Standard video cameras scan at 27 to 30 frames per second, which is fine for general education. The success of SiliconCoach in the international market is confirms the benefits of the technology. To provide measurements for sport scientists on top athletes requires high speed cameras. At the consumer price level Casio's EX-F1 offers high speed burst recording from a still camera. JVC also does a true video camera (GR-DVL9500U) with a very high scan rate (up to 240 frames per second with special software).

1.2.3 Direct Sensors Connect To The Athlete

This category includes sports watches with heart rate monitors, foot pods, GPS loggers, accelerometers and anything worn on the body. Direct sensing is more complex to develop due to the need to integrate two or more components of hardware and software and to find a comfortable and unobtrusive fit to the body. Video technology is more advanced to date, but the focus on body mounted sensing and live (wireless) data transmission should see the direct sensing systems rapidly advance within the next five years. The merging and integration of video and direct body sensing is already occurring and can only become more so.

1.3 Data Management

1.3.1 How Do You Gather Your Information?

Sometimes the simplest systems are still effective. Written records work for less complicated tasks, and a low number of transactions, but as soon as teachers have to deal with larger groups then data gathering and storage using PCs or PDAs generally will be quicker, easier and more accurate.

The real tool that allows records to be managed is a database. The Excel spreadsheet is one of the simplest forms of database which most teachers will have been using for years. Spreadsheets are easy to use and quick to edit information, but have serious limitations for security, record keeping and management of data. Behind every good software programme and website you are certain to find a database. The best ones are so easy to use that their complexity is all but hidden; for example the Amazon.com™ shopping site, or TradeMe™.

The lesson here is that technology does not need to be hard to learn. A well designed system should do most of the work for the user, but appears simple.

1.3.2 The Rise of the Notebook PC & Cellphone

Tablet PCs were launched in 2003 with the promise of improving direct entry of data in the field, offering full PC functionality in a size larger than a PDA. Even though tablet PCs are still available they have not ever reached the popularity or performance that was claimed by their makers. Meanwhile notebook (laptop) PCs have continued to fall in price and size to the point that they are the dominant form of data processing. PDAs have largely been wiped out by mobile phones.

The reason for the trend is simple. Mobile phones fulfil a universal need to communicate and the addition of other functions was cheap to implement. Mobile phones that interface to sports systems include heart rate and in built GPS arrived in 2008. They have still major limitations as data management systems for other than individuals, but are improving rapidly.

1.4 Learning The Technology & Speed of Set up

1.4.1 How Easy Is The Hardware & Software To Set Up In The Field In Short Time?

In an ideal world technology is easy to learn, and requires little human input to deliver benefits. The two best examples of this are the telephone and television. Arguably computers are not that easy to learn, but have become dominant because of their vast range of benefits for a low cost. Therefore most monitoring technology in the future will continue to have PC based software or hardware within the system. This does not preclude the use of PDA and cellphone based systems, which are much better at downloading information than being used to input data.

1.4.2 Can You Handle Multiple Athletes Together And Still Maintain Continuity Of Your Teaching?

The leading sport technology systems presently only handle one athlete at a time, and cope with groups by adding more sensors, more timing gates and more effort to analyse the results. Recent trends include the integration of groups of athletes into a single system, such as Suunto™'s heart rate monitoring system. Zephyr™ Technologies do a more advanced version of this with their bio-harness for military training.

Recent advances by GPSports™ in Australia suggest that monitoring of speed, position, heart rate and other athlete functions can be delivered in real time. The cost of these systems is beyond most schools at present, but will probably be affordable within 3 years.

2.0 Wireless Technologies

2.1 Bluetooth

Bluetooth was designed by engineers at Ericsson in 1994, as a short range wireless data transmission system for connecting devices. Although Bluetooth is common in the phone industry it did not become reliable until after 2002. It has undergone three generations of development (Bluetooth 3.0 released April 2009), including improvements in transmission range and data. Bluetooth has been used in sports monitoring technology, although it is still not an ideal choice. Competing simpler systems such as ANT have been adopted by a major alliance of sport technology companies.

2.2 Wireless data radio

Certain parts of the radio spectrum is available for free use. The traditional method of data transmission over radio has existed for many decades. It is very feasible and cheap to use simple radio transmission, similar to what you are familiar with in your cordless telephones, car remote controls and baby monitors. We believe that the simplest method is probably the best for allowing many athletes on the same field to be monitored together.

2.2.1 WiFi, WiMax

Without going into the technical details it is fair to say that these wireless technologies have found wide acceptance in home and office computing networks, and are ideal for secure large data transfer, but are too expensive and complex for athlete monitoring.

2.2.2 GPRS, 3G (GSM technologies)

Cellular telephone technology does have some place in sports monitoring, because of the wide coverage of the networks and generally good reliability. It is possible to send small amounts of data reliably, but complex real-time events such as a soccer or rugby game or track race are typically beyond what these networks could reliably deliver.

3.0 How Can We Bring This Together?

3.1 Using The Internet – Social Networking, Shared Databases, Added Analysis

It is clear that the current population under 25, plus a reasonable number of those older, are communicating via social networking sites and that this trend is likely to become even stronger. Television is struggling to retain its revenues, but still offers the "richest viewing experience", owing to the popularity of large panel televisions and the convenience of staying at home.

All sport in New Zealand is really struggling for funding, with the exception of cricket. Women's hockey and basketball are without the previous SPARC funding, and even rugby is facing reduced spectator attendance. The reality is that sport is a business and to fund development of athletes requires large amounts of money. The sports that create the most television coverage are cricket and soccer, and consequently have generated huge revenues for the governing bodies worldwide.

Looking at motorsport it is conceivable that live monitoring of athletes and games could rejuvenate the more popular sports by providing live athlete data on performance statistics; speed, acceleration, body forces, heart rate and activity level. It may also be the early end to careers of players who do not perform?

3.2 Central storage – private or public ; with or without selective access rights.

The issues of ownership of data stored on public domain websites, owned or operated by private companies, non profit organisations or government is still a debate that has not been resolved.

We suggest that PENZ looks towards government for funding of database and web resources, but the question that needs to be addressed early on is "can education, health and sport agencies funded by government actually collaborate well enough to be effective?" The Mission On policy of recent years possibly did not have the effect or impact intended? It may be that sports organisations start to lead the way. A shining example of this is the creation of the RideStrong website by BikeNZ. Future tools include the ability of members to upload data from cycling for storage and display on the website.

Whilst legislators may worry about security and privacy aspects it appears as though many people are willing to join social networks. The question is how PENZ could participate or collaborate, either by means of their own site or partnering with individual sports?

4.0 What Will The Immediate Future Hold?

4.1 Live Athlete Results On TV And Web: It Is Here Now And Is About To Become The Norm.

It is already possible to provide some level of live analysis during sports events. SportsData™ in Australia has created a business on collecting and selling data and analysis from sports events. Video coverage is well advanced, but the ability to make on-the-fly analysis of player and athlete movements is arguably more difficult than to capture data from sensors and broadcast that by wireless.

The two stand out successes in sport monitoring have been America's Cup yachting and Formula 1 motor racing. There have been some monitoring using speed readings in tennis, soccer and cricket, but it is conceivable that advanced player monitoring for live television coverage will become common over the next two to five years. This immediately opens the same sport coverage to social networking sites.

Present systems from Australia (GPSports™ and Catapult™) are capable of providing live data from GPS systems worn on the body. VX Sport™ has a system planned for release in 2010. It is inevitable that within a few years this technology will be available cheaply for PE teachers to use in schools.

4.2 VX Sport Field Unit – Research Project 2008

The Visuallex™ Sport "Field Unit" was designed to provide accountability to both school and community based programs searching to improve the health of the nation, through measuring, monitoring and management of fitness data collected using the field testing unit.

Over the years there has been a number of initiatives aimed at improving the lifestyles of young New Zealanders by improving their nutrition and getting them more involved in physical activity. Simple fact is that obese children are more likely to become obese adults, thus increasing the risk of associated diseases, especially type-2 diabetes, of which New Zealand has an epidemic, heart disease, hypertension, some forms of cancer, and joint and skeletal problems.

Acknowledging the facts is one thing, but doing something about it is another. The direct costs of obesity to the health sector has been estimated at $247.1million annually, or 2.5 percent of health spending that year. More than 50 per cent of New Zealanders are now either overweight or obese, and more than 30 per cent of New Zealand children can be classified the same. This is why we must make the change in our youth in combating the corporate health of New Zealand today.

While we cannot turn back the clock, we can draw on our experiences of when we were children and explore new innovative ways to make a difference and we believe that it is in New Zealand's best interest to produce children who are physically fit, highly motivated to participate in physical activity and who are willing to join in games and other events. One of the initiatives recent government programmes in 2008 involves using human/health impact assessments, when proposing new policy or legislation. Similar approaches are popular internationally to promote population health and getting active. The researchers believe that the field testing unit could provide all New Zealand schools with a huge advantage in assessing what is working and how to best structure our curriculum and an approach that would be a world first.

The field testing unit is similar in size to a clock radio and is able record the most widely used fitness tests such as speed, power, endurance, reaction time and agility. All this in as they happen, in real time. This data can then be sent to the teacher's computer anywhere within 100m of the tests without cables or additional equipment. In fact the total size of the package does not exceed a

briefcase. As the database increases, so too does the amount of feedback we can provide teachers within seconds of the test.

From the information collected, the researchers established an online database to manage the information and provide reports that could be based on age, gender, ethnicity or schools decile ranking. For the school itself they would have an exercise history for every pupil during their time at the school and this information could be shared if a pupil was to move. The ideology behind this is to create a nameless national database that we can learn from and create a list of standards for common fitness tests, leading to a greater awareness and have a greater influence to change behaviour. This in itself could provide means for an international study on youth activity trends never seen before on this scale.

5.0 What Needs To Improve?

5.1 Communication Between Government, Universities, Polytechs, Schools And Sports Bodies

In the last few years that we have been researching athlete monitoring technology it is clear that there is a lot of duplicated effort within the academic research area, and significant disconnection between government funding bodies and the sports, and within certain sports themselves.

Recent changes in government policy seem likely put more emphasis on sporting achievement and participation in schools. The health trends in the developed world, including New Zealand, need no introduction. Children face a bleak future of poor health in middle and old age due to bad diet and nutrition, occupations that are sedentary.

As teachers and sports professionals PENZ members have a unique opportunity to see the health and sporting talent of New Zealand's young people.

5.2 Leadership From Professionals: PENZ Members Can Make A Difference

Throughout this presentation there is a core theme; collaboration. It will take a collective effort from PENZ members to bring a clear message to health and education forums.

At this point the formal part of the presentation is complete. I would like to invite you to discuss your needs as teachers and sport professionals. Let us look at how technology can offer solutions to make your work more enjoyable and enhance your existing skills and knowledge?

Thank You.