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PSYCHOLOGY

Eustress or you stress: positive stress in sport?

At a glance

This article:
- Examines the underlying reasons for performance-blunting stress and anxiety in sport;
- Describes some behavioural interventions that can help overcome excessive anxiety and makes a number of practical recommendations.

The anxiety-performance relationship is a cornerstone of the sport psychology field, but how much do we really know about it? In this article, Costas Karageorghis and David-Lee Priest explore the latest research findings and consider how sporting contests can be won through the effective management of anxiety.

Key concepts

Sport psychologists often speak in terms of 'activation', which is an athlete's state of readiness to respond to any demand that might be placed upon them. Activation can be heightened by the presence of an audience, verbal stimulation, or exposure to the competitive environment and can be interpreted in either a positive ('it's exciting to get into the final') or negative ('we're anxious because we've not beaten them for two years') way by athletes.

Contemporary anxiety theories, such as that of Professor Graham Jones[1], distinguish between bodily-related' and 'thought-related' anxiety, as well as acknowledging that there is an element of interpretation in one's experience of anxiety.

For example, a sprinter on the blocks might feel the butterflies doing barrel rolls in her stomach, but at the same time have an almost complete absence of anxious thoughts. We would also like to introduce a pertinent concept from outside sport psychology; the term 'eustress' was coined by Canadian psychologist Dr Hans Seyle to refer to positive or 'adaptive stress' which helps us during demanding events and passages in our lives. In other words, stress that is functional serves a purpose.

Two aspects of Jones's model mirror the messages that are preached by motivational experts in the business and financial worlds (eg Jack Canfield, author of *The Success Principles*); namely the importance of positive expectations in bringing about a desired result and the practice of acting 'as if', which is an essential precursor to success. For example, how would you carry yourself, interact with others and organise your time if you were already the champion that you are aiming to become? Many of the world's most prolific sporting heroes began with an awareness of their greatness – Muhammad Ali being the easiest to identify: 'I called myself the greatest even before I knew I was.'

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In this issue

FROM THE EDITOR

Overcoming hurdles in 2011

Another year dawns but despite the fact it's the depths of winter (in the Northern Hemisphere at least!), this is an ideal time to take stock and plan a strategy for even better performance in 2011.

In our lead article, Costas Karageorghis tackles the perennial hurdle of anxiety and stress in sport. According to Costas, the right mental strategy can help you to actually turn stress to your advantage and he explains how.

Meanwhile, I've been looking at another barrier to peak sporting performance – poor nutrition. In the last issue we saw that it's still an issue among many athletes; in this issue, we consider a back to basics practical approach to help you avoiding tripping over those nutritional hurdles and to maximise your performance.

In the third and final instalment of his affordable sports technology series, Alan Ruddock introduces two more cheap and cheerful methods of analysing your performance. He explains how agility and jump training software can be used to help you get ahead of the pack.

No matter how elaborate your 2011 strategies, you'll want to know just how much progress you're making. The good news, according to Alicia Filley, is that a simple technique culled from the financial sector and called 'time series analysis' is easy to apply, clearly revealing your performance trends.

Here's hoping that 2011 has got off for a great start for you; stay with us this year and we'll do our best to help you overcome all your sporting hurdles in the year ahead!

Andrew Hamilton BSc MRSC *editor*

Trait anxiety

There are inherent dangers in sporting competition allied with failing to meet our own expectations, and those of others. Research has shown that these fears, both real and imagined, manifest themselves to a greater extent in some athletes than others, thus forming a stable trait or disposition that can be measured[2]. There is an adaptive reason for this; it suits an evolutionary purpose for some members of a social group to be 'on edge' – they *have* to be in order to survive, whereas dominant members can afford to be more relaxed. The knowledge that the way we experience anxiety is a personal variable has clear implications for practitioners who work with individual athletes. Those working in a team environment may also be able to identify members of a squad whose negative interpretation of events may be affecting others.

It is worth bearing in mind that trait anxiety is linked to other personality dimensions such as sensation seeking[3] and introversion-extraversion[4]. Those who seek sensations, in the form of excitement and variety, are far less likely to experience debilitating anxiety. In fact, the 'thrill' of high activation may prove to be a strong motivating factor for them.

Michael Jordan's take on stress

We have all witnessed examples in the sporting arena where sportsmen and women seem to crumble under the immense pressure, and this pressure can be hugely increased when there's a large audience. The following quote from Michael Jordan, taken from his book *I Can't Accept Not Trying* illustrates his take on stress during high-pressured basketball games. During these games, he had the additional burden of knowing that he had an audience of up to 10 million people.

'If I had stood on the free-throw line and thought about 10 million people watching me on the other side of the camera lens, I couldn't have made anything. I mentally tried to put myself in a familiar place. I thought about all those times I shot free throws in practice and went through the same motion, the same technique that I had used thousands of times. You forget about the outcome. You know you are doing the right things. So you relax and perform. After that you can't control anything anyway. It's out of your hands, so don't worry about it.'

In this example Michael Jordan used a range of different coping strategies, in combination, within a matter of seconds. In order to help to maintain your performance and emotional wellbeing during stressful periods it is crucial that you cope effectively with stress.

Dr Adam Nicholls

Table 1: Common symptoms of anxiety

Cognitive	Somatic	Behavioural
• Indecision	• Increased blood pressure	• Biting fingernails
• Sense of confusion	• Pounding heart	• Lethargic movements
• Feeling heavy	• Increased respiration rate	• Inhibited posture
• Negative thoughts	• Sweating	• Playing safe
• Poor concentration	• Clammy hands and feet	• Going through the motions
• Irritability	• Butterflies in the stomach	• Introversion
• Fear	• Adrenaline surge	• Uncharacteristic displays of extroversion
• Forgetfulness	• Dry mouth	• Fidgeting
• Loss of confidence	• Need to urinate	• Avoidance of eye contact
• Images of failure	• Muscular tension	• Covering face with hand
• Defeatist self-talk	• Tightness in neck and shoulders	
• Feeling rushed	• Trembling	
• Feeling weak	• Incessant talking	
• Constant dissatisfaction	• Blushing	
• Unable to take instructions	• Pacing up and down	
• Thoughts of avoidance	• Distorted vision	
	• Twitching	
	• Yawning	
	• Voice distortion	
	• Nausea	
	• Vomiting	
	• Diarrhoea	
	• Loss of appetite	
	• Sleeplessness	
	• Loss of libido	

In every team unit, it is possible to identify a spectrum of introverts and extroverts. For example, in the many track and field teams we have worked with, the sprinters are often outgoing and gregarious by nature and the distance runners generally coy and prone to nervous tension. The same may be true across certain playing positions in team sports; for example, consider the steely, somewhat solitary character often ascribed to the football goalkeeper compared to his outfield counterparts.

A squad or team is a collective of individuals who are essentially quite similar (they all play the same game), yet different in many ways. For this reason, a 'vitamin model' that entails prescribing a specific intervention across the board (eg meditation), expecting the same results for each group member, is essentially a flawed one.

Managers who recognise individual differences can be seen in action at the highest level – consider the individualised style of either Sir Bobby Robson or Jack Charlton OBE, both of whom proved highly successful at international football level, pitted against the autocratic demeanour of a manager such as Fabio Capello, who has proved far more successful at club level than in the international arena.

Self-confidence

According to Professor Jones, self-confidence is the antithesis of thought-related anxiety. And, as they always say in those old American gangster movies, 'my enemy's enemy is my friend'. So rather than focusing on the sensations of anxiety, which is a self-perpetuating activity, seek to replace self-doubt with positive reinforcement.

The first author's work with leading athletes has demonstrated that in the competitive arena, reactions to events are polarised; you're either

confident of your ability to cope with the demands of the task at hand or you're not – there isn't much of a middle ground. This is why you must display confidence in your own confidence.

The penalty shoot-out serves as the pinnacle of sporting anxiety. Last summer's football World Cup in South Africa gave us plentiful examples of this dramatic dénouement to a sporting contest – Uruguay's sensational win over Ghana being one that stays with us.

In a penalty shoot-out, each player is isolated in a gladiatorial fashion. The stakes are extremely high. There is immense social pressure and a tantalising escalation of tension – the perfect breeding ground for anxiety! We have all seen players whose body language revealed their inner lack of confidence – remember Roberto Baggio's dropped head and horrendous punt, the last kick of USA '94? It may still be travelling!

In a penalty competition, bodily anxiety is extremely high so there can be no middle ground: you're either confident, and therefore thinking about how you're going to score, or wracked with thought-related anxiety and fixating on how you might miss and what that would mean. The closed skill involved is so simple yet it's the psychological (ie self-imposed) pressure of the moment that separates the men from the boys.

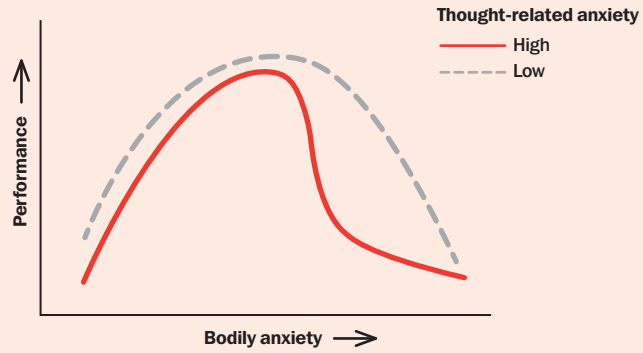
According to a study by researchers based at Hull University[5], confidence in one's own ability may play a key role in the relationship between anxiety and sports performance. While pre-performance measures of thought-related and bodily anxiety did not influence athletes' subjective ratings of their own performances, high ratings of self-confidence and coping predicted low anxiety. For this reason, interventions such as positive self-talk and thought replacement may be particularly helpful to athletes.

Social aspects of anxiety

Social evaluation is a large component of anxiety for many athletes. A great example we recall was that of the guy who quit his day job, practiced darts in his garage for 12 months and built up to throwing 100+ averages. Of course, when he tried to qualify for elite PDC tournaments his game fell apart, so much so that he almost became a danger to bystanders. He wasn't used to playing in a social environment and being subjected to such close scrutiny. This example teaches us two important things. First, athletes should be exposed to the sort of social (sometimes hostile) atmosphere of competition in their training. Second, don't quit your day job!

Competitive and training environments have their own social dynamics with unique challenges. Indeed, for some athletes the key to controlling anxiety might lie in their relationship with others in the training group. A good example is that of jump jockeys – because of the inherent danger of their sport, there is an especially high degree of camaraderie among them. This may be functional in controlling their understandable anxiety.

Figure 1: Catastrophe theory predictions of performance under conditions of high and low thought-related anxiety



In flat racing, which is far less dangerous, the jockeys are noticeably cooler and more distant in their personal relations with each other[6]. Work from outside sport psychology has also taught us that anxiety has a knock-on effect on mental judgement, and can lead people to interpret neutral stimuli as being threatening in nature[7]; a symptom of anxiety you may be able to spot among your charges or team-mates.

'For some athletes the key to controlling anxiety might lie in their relationship with others in the training group'

Catastrophe theory

A momentous development in the annals of sports anxiety research came at the hands of Prof Lew Hardy and his associates at the University of Bangor who developed the cusp catastrophe theory which details the influence of anxiety on athletic performance[8]. Using an intriguing mathematical model, they demonstrated that anxiety is a dynamic process (which unfolds over time), and that decrements in performance caused by anxiety are not necessarily gradual or *continuous* but may be subject to a dramatic nosedive. Essentially, when thought-related anxiety is high, increases in bodily anxiety lead to a nosedive in performance (see figure 1).

England's exit from the 2010 World Cup fits this description – a domino-like fall from grace in

Table 2: Learning by analogy examples

Sport	Analogy
Tennis	Hit backhand like throwing a Frisbee
Golf	Accelerate through the hitting zone like a rollercoaster on a dip
Basketball	Follow your free throw into the basket like casting a fishing line
Football	When you jump for a header load your thighs like springs
Lawn bowls	Swing your arm through like a pendulum to release the wood
Cricket	When seam bowling let your arm follow-through like the sail on a windmill
Snooker	Take the cue through straight like a piston
Javelin	Release the javelin like you're cracking a whip

which the our national side twice conceded a brace of goals in quick succession. Hardy's work emphasises that catastrophes can be averted and managed by reducing bodily anxiety (relaxation) and boosting self-confidence, both of which offset a sudden collapse.

Choking under pressure is a phenomenon allied to the 'catastrophe', and a recent review from Gloucester pinpointed several interventions aimed at reducing its occurrence[9]. Chief among these was the approach of learning by analogy (*see Table 2*) rather than by a series of explicit rules which are consciously referred to by the athlete and can therefore be displaced in situations of high anxiety. Another proven intervention strategy is the use of a pre-competitive routine which allows the athlete to switch off from potential distractions in order to focus squarely on their decision-making processes.

Behavioural interventions

A piece of research carried out recently at Brunel University showed that short-term interventions of less than seven minutes delivered prior to performance can reduce thought- and bodily-related anxiety in athletes[10]. This study tested the *matching hypothesis*, which states that interventions should be matched to the type of anxiety that an individual athlete usually experiences (eg thought-related vs bodily anxiety).

In a nutshell, thought-related interventions reduced both thought-related and bodily anxiety, as did bodily ones, so the matching hypothesis was somewhat disproved. However, we maintain that matched interventions may prove effective over a longer period of time (eg several weeks).

What brief interventions did we use to good effect? The quiet place technique entails envisioning yourself in a location of ideal tranquility and attending to various sensory aspects of this. The second intervention was a shortened form of Benson's progressive muscular relaxation, which involves sitting comfortably, closing your eyes, focusing attention on the mechanics of your breathing, then tensing and relaxing each muscle group of your body in turn.

Finally, ever wondered why Sir Alex Ferguson is such a prolific chewer of gum? The latest research from Cardiff University[11] suggests that the canny Scot is actually administering a behavioural intervention on himself! Chewing gum improves alertness, instils positive feeling states, quickens reactions times and heightens selective attention.

So, *can* stress be beneficial?

Former javelin world record holder, Steve Backley, was adamant that the stress of competition improved his performance by at least 10%, and said, 'I never think of stress as a negative thing... I think that as soon as you admit to stress being a negative factor then it will be'. This quote underlines the essential ingredient of interpretation in the stress-response during competition; ostensibly Backley is a strong advocate of the eustress notion.

Stress, anxiety and competition at the highest level are synonymous; like walking in the rain and getting wet – you cannot do one without expecting the other. Angel Cabrera, the 2009 US Masters golf champion, said of the three-way playoff that decided the title 'at this stage of the tournament, anyone who says they are not nervous isn't human'. Billie Jean King, that grass-court great, went a step further in suggesting that stress is an indirect marker of success: 'pressure is a privilege'.

Dr Costas Karageorghis PhD, CPsychol, FBASES is a reader in sport psychology at Brunel University, and co-author of the book Inside Sport Psychology (available from Human Kinetics Publishers 2011; ISBN: 978-0-7360-3329-9)

Dr David-Lee Priest PhD is a freelance writer and research analyst working in the domain of sport and physical activity. He is the author of Against All Odds (available from Racing Post Publishers 2008; ISBN: 978-1-9051-5394-7)

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'Stress, anxiety and competition at the highest level are synonymous; like walking in the rain and getting wet – you cannot do one without expecting the other'

Practical implications

- Self-confidence plays an important role in banishing competitive anxiety so take a tip from sporting greats and remember to act 'as if';
- Be mindful of the fact that anxiety has a genetic basis and therefore some athletes are more prone to feeling anxious than others – it's how they deal with their anxiety symptoms that is the telling factor;
- Replicating the social environment of competition as closely as possibly in training is a good way to develop appropriate anxiety-control techniques;
- There are several potent techniques that allow athletes to manage anxiety that include the quiet place technique, progressive muscular relaxation' and learning skills through analogy (see table 2).

Nutrition: why a ground up approach can work

At a glance

This article:

- Explores possible reasons why some athletes make basic dietary errors;
- Describes a hierarchy of nutritional needs' approach and provides a number of practical suggestions to put this into practice.

In the last issue, we saw that despite a generally improved understanding of sports nutrition, many sportsmen and women are still making basic nutritional mistakes. In the second part of this article, Andrew Hamilton suggests a possible solution to help keep athletes on the straight and narrow.

They say that knowledge is power. But can you have too much of a good thing? Over the past 20 years, our understanding of the nutritional needs for the exercising body has grown dramatically, and thanks to the internet, much of this information is more freely available than ever. If that weren't enough, the revolution in sport nutrition has spawned a wide array of sports supplement products to help you along the way. So why is it that many athletes are still making elementary mistakes when it comes to their basic diet and what can be done to prevent them?

Logic and emotion

On the face of it, sports nutrition seems pretty straightforward; identify the biochemical pathways in the body relating to performance, work out what's needed to optimise them and translate this into dietary recommendations. The problem with this approach is that human beings are complex individuals, not machines. Our food choices aren't just governed by knowledge and logic, but also by our social and educational, backgrounds, psychological factors such as emotional responses as well as the economic and practical circumstances in which we find ourselves[1-3].

'Our food choices aren't just governed by knowledge and logic, but also by our social and educational, backgrounds, emotional responses, and the economic and practical circumstances in which we find ourselves'

In recent years, a number of approaches have been developed whose goal is to improve the day-to-day nutritional habits of athletes. For example, in *PP280* the transtheoretical model of behaviour change (TMM) was discussed as a method for helping coaches and nutritionists to change the nutritional behaviours of athletes in their care. This approach focuses on the decision-making abilities of the individual, and has been found to be useful in determining a nutritional counselling strategy[6,7].

As good as theories such as TMM are, many readers don't have the luxury of a coach or nutritionist to help them perfect an optimum eating plan. At the same time, however, the sheer volume of information about nutrition and supplementation can overwhelm even the savviest athlete looking to improve his or her nutrition. To some extent, this confusion is understandable; at its cutting edge, sports nutrition is a complex and constantly evolving science involving huge numbers of variables, and sometimes it's hard to see the wood for the trees.

Back to basics

One possible solution is to adopt a much more 'back to basics' approach – ie concentrate on getting the absolute dietary basics right before thinking about any finer details of optimum sports nutrition. Probably the most common mistake athletes make when thinking about nutrition is to worry about supplements such as exotic sports drinks and creatine before putting the fundamental dietary building blocks in place.

A good way to develop a successful nutrition strategy is to think in terms of a 'hierarchy of nutritional needs'. You can picture this as a pyramid, with the widest layer at the base representing the most fundamental dietary needs and successive layers above representing progressively more specialised needs. However, these more specialised needs should only be considered once the (more basic) layers below have been put in place. Figure 1, overleaf, shows a pictorial representation of the hierarchy principle.

Level 1: constructing a 'good health diet'

As you can see, the hierarchy of needs pyramid has five layers. By far the most important layer is the

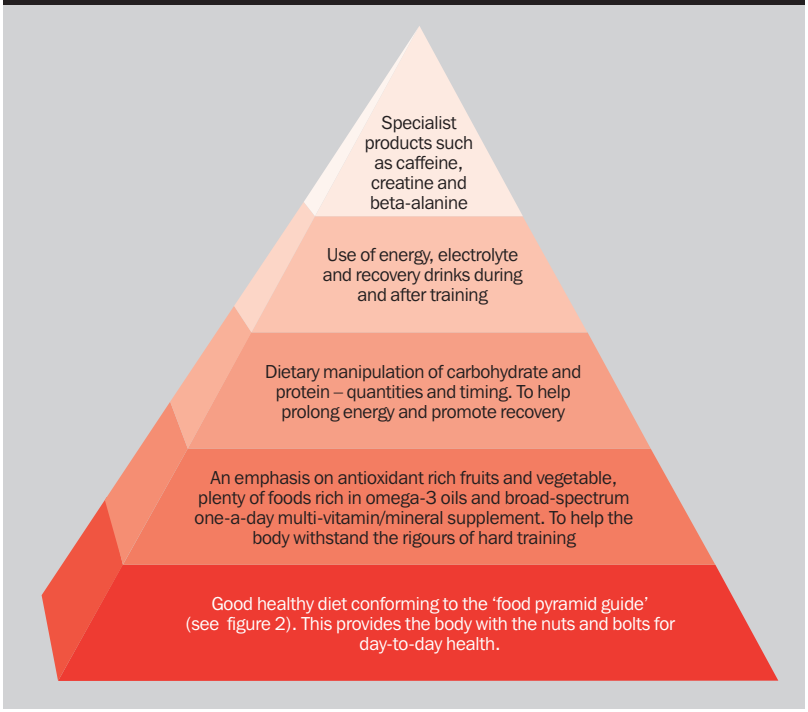
Can more nutritional interest be a bad thing?

Compared to their sedentary counterparts, athletes tend to have more interest in nutrition, not least because nearly every serious sportsman and woman is acutely aware of the link between nutrition and performance. However, this increased interest by no means guarantees better eating habits, and paradoxically, may even worsen them.

For example, studies have shown that athletes often adopt rigid training diets that predispose them to undernutrition, fatigue and injury. Disordered eating affects a substantial number of female collegiate athletes, and is becoming more prevalent among young male athletes, too[4].

To make matters worse, some athletes falsely believe that supplementation can substitute for a good basic diet. But apart from this flawed 'health in a bottle' way of thinking, many supplement users remain in the dark about supplement use. For example, a recent Australian study found that the majority of supplementing athletes did not know their supplement's active ingredient(s) or mechanism of action[5]. Moreover, only half of the athletes knew the recommended supplement dosages!

Figure 1: Hierarchy of needs. Each level should only be considered once the level below has been satisfied



one at the bottom because everything else is built from here. This 'good healthy diet' layer of the hierarchy pyramid is itself constructed from the food pyramid guide, which is shown in figure 2 below. The food pyramid emphasises the importance of grains, fruits and vegetables as the foundation of the diet, and is accepted by leading scientists and nutritionists as a sound basis for a healthy diet.

Figure 2: The principles of the food pyramid guide

Use these principles to fulfil the level 1 (base) requirements of the hierarchy of nutritional needs pyramid (figure 1 above)

Level 2: defence and protection

Sportsmen and women put their bodies under considerably more stresses and strains than the average couch potato. Layer 2 of the hierarchy of needs pyramid, then, is about further tweaking your day-to-day diet to help your body resist illness and breakdown. This is achieved by ensuring that your fruit and vegetable intake emphasises those particularly rich in antioxidants (to counter the 'oxidative stress' that intense exercise can produce in the cells of the body). As a rule of thumb, the darker and more vividly coloured the fruit or vegetable, the more antioxidant protection it provides. However, it's also important to choose a variety of these high-antioxidant foods rather than just consuming one or two because the different array of antioxidants they contain will work synergistically in the body. Table 1, right, lists some high-ORAC (high antioxidant) foods.

Another component of defence and protection is to ensure you consume plenty of omega-3 oils (shown to enhance immune function)[8]. To optimise omega-3 intake, you should consume at least a couple of portions of oily fish (salmon, mackerel, sardine, herring, trout, pilchard etc) a week and also include nuts and seeds in the diet, especially, walnuts and pumpkin seeds, which are especially rich in omega-3. In addition, if your lifestyle is hectic, you can take a one-a-day broad spectrum multi-vitamin/mineral for extra protection.

Level 3: dietary manipulation for energy

With levels 1 and 2 in place, you're ready to start attending to the nitty-gritty of sports nutrition. However, before you reach for a tub of sports drink or similar, you need to think about something more fundamental – manipulating your diet to optimise fluid intake for adequate hydration and carbohydrate for energy.

Fluid needs are heavily dependent on ambient temperature and humidity, and of course, the duration and intensity of your training. As a rough guide, aim to commence training/competition fully hydrated (your urine should be no darker than a pale straw colour) and then rehydrate fully afterwards. A useful tip for rehydration is to weigh yourself before and after training/competition; for every kilo of bodyweight lost, you should aim to drink 1.5 litres or more of fluid to replenish the losses.

Carbohydrate needs are no less important. If you've got level 1 in place, you'll already be consuming a carbohydrate-rich diet. However, as training volumes rise, you may well need higher intakes. Your exact needs are dependent on your body mass and your training volume and intensity. However, as a very rough guide, a 70kg athlete exercising at around 75% of maximum heart rate (steady state aerobic zone) can expect to burn something in the region of 600-1,000Kcals per hour depending on fitness. Some of this energy

(about a third) will of course be derived from fat stores, but this means you'll be burning around 400-700Kcals of carbohydrate per hour. This equates to around 125-175g of carbohydrate that will need replenishing per hour. You should therefore aim to top up your dietary intake of carbohydrate-rich foods accordingly.

Level 4: sports drinks

Manipulating diet to meet training needs is vital, but once training or competition extends beyond two hours, 'on the move' nutrition becomes vital. As ever the key requirements to maintain performance are fluid and carbohydrate. While it's perfectly possible to meet these requirements with water and snacks such as dried fruits, bananas etc, the fact remains that a properly formulated carbohydrate drink can give you a real advantage, especially when your work rate is high. This is because it can be absorbed much more rapidly than whole foods and with minimal gastric distress, and it can also deliver the fluid and electrolyte minerals your body needs. The net result is that you can work harder for longer.

Table 1: Antioxidant content of various fruits and vegetables. The higher the ORAC score, the richer the antioxidant content

Food	ORAC units per 100g*
70% cocoa solid dark chocolate	13500
Pomegranate	10500
Dried prunes	5770
Red delicious apples	4270
Raisins	2830
Kale	2410
Blueberries	2400
Garlic	2320
Blackberries	2040
Spinach	1700
Brussels sprouts	1580
Strawberries	1540
Alfalfa sprouts	1450
Broccoli flowers	1290
Raspberries	1220
Beets	1170
Plums	949
Red bell pepper	810
Oranges	750
Corn	720
Cherries	670
Onion	560

*Sources: US Dept. of Agriculture; Brunswick Laboratories; Journal of American Chemical Society

Using the food pyramid guide to construct layer 1 of the hierarchy of needs pyramid

The base tier of the food pyramid guide consists of unrefined carbohydrates, such as wholemeal bread and pasta, wholegrain cereals and rice, potatoes, lentils, beans etc (see figure 2). These should make up about a half to two thirds of your calorie intake, while in the next tier up, the protective and nutrient-rich fruits and vegetables should form the second largest component of your food intake – ideally you should be eating 2-4 servings of fruit per day and 3-5 servings of raw or lightly-cooked vegetables.

In the third tier up are protein foods such as meat, poultry, fish, eggs, beans, nuts, milk yoghurt and cheeses. These should make up about 25% of your calorie intake. The top tier consists of fats, oils, sweets, processed/junk/fast food and confectionery. These foods should be minimised and used as treats rather than as staples They contribute very little in the way of nutrients or fibre and evidence has linked over-consumption of these foods to a number of health problems, including obesity, heart disease and cancer.

Remember, the concepts described here should be used to help you construct layer 1 of the hierarchy of nutritional needs pyramid – you can think of them as a pyramid within a layer of a bigger pyramid!

The other sports drink that can be particularly useful at this level is a 'recovery' formulation. Recovery drinks aim to supply everything needed by the muscles for recovery after hard or prolonged training, but their main ingredients are 2 or 3 parts carbohydrate to 1 part protein. Studies have shown that muscles are best able to rapidly absorb carbohydrate for the re-synthesis of glycogen, and amino acids (from protein) to replace and rebuild muscle fibres in the period immediately following training and for up to about 2 hours afterwards[9,10]. The beauty of recovery drinks is that they can supply precisely the right combination and ratio of carbohydrates and proteins, at the right time and in a form that's convenient to prepare, easy to drink and rapidly assimilated.

Level 5: ergogenic aids

The top tier in the hierarchy of needs consists of proven ergogenic aids such as creatine, beta-alanine and caffeine. When used appropriately, these can boost both anaerobic power and endurance performance and are therefore worthy of consideration for competition. It's ironic that many athletes worry about ergogenic aids before ensuring the foundation layers of the hierarchy of needs are fulfilled. However, it can't be emphasised enough that the potential gains these specialist supplements offer are relatively modest compared to those afforded by levels 1-4 below. Indulging in level 5 and taking these supplements without the foundations in place will result in nothing more than expensive urine. So get those building blocks in place before you worry about fancy supplements!

Andrew Hamilton BSc Hons, MRSC, ACSM is a member of the Royal Society of Chemistry, the American College of Sports Medicine and a consultant to the fitness industry, specialising in sport and performance nutrition

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Analysing your performance: time to get trendy

At a glance

This article:
- Defines time series analysis and explains its current applications;
- Describes how the statistical method can be used to analyse sports performance.

Time series analysis is frequently used to track trends in the economy and predict future stock market performance. In the first of a two-part series, Alicia Filley explains this statistical method and how it can be useful in evaluating the effectiveness of your training and maximising performance

Time series analysis is a statistical application used to detect trends in inventory, sales, and the economy. A time series is a set of data points that occur over regular intervals of time, such as the closing value of the stock market each day. There are two goals of analysing a set of time series data points. The first is to identify any relationship, or trend, among the points. The second is to forecast what might happen in the future based on the past trends within the data.

Analysing time series data

When collecting data over time, there is often significant variation among the data points. Translating the data into something meaningful requires 'smoothing' the data, which brings the outlying variations into line with the other data. For instance, if you were to record and graph the high temperature in Houston, Texas every day at the same time for the month of March, you would also see some large variations in temperature during that time (see figure 1).

A simple method of smoothing the data is basic averaging. However, averaging weighs all data points equally, resulting in a flat data curve with no evidence of a trend as noted in the monthly average in figure 1. A moving average however is a statistical technique that takes into account the history of the measurement. In other words, it gives more weight to the current measurements than the ones in the past. When calculating the moving average, old data points drop away from the calculation as new ones are added.

The moving average in figure 1 calculates the average over a block of five days. Every day a new data point is added and an old one drops off. The variations then are presented as curves that begin to show evidence of a trend – a warming trend at the beginning of the month followed by a cooling trend that begins to shift to warmer again toward the end of the month.

Jargon Buster

Postactivation potentiation
The physiological phenomenon that results in an increased power output in a muscle after volitional muscle contractions performed at a high intensity, despite fatigue.

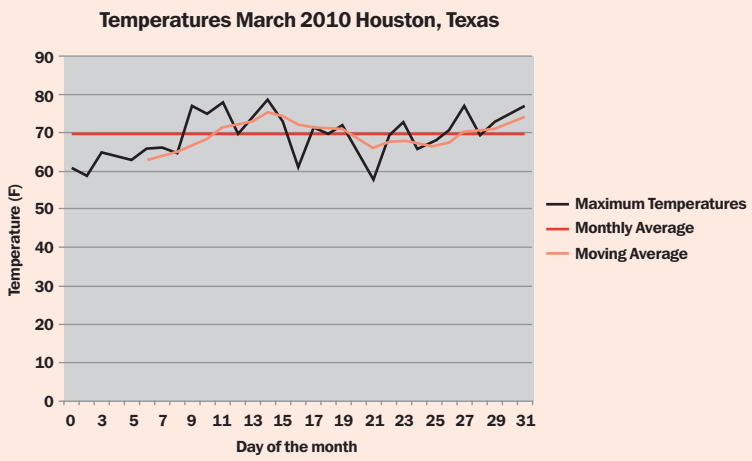
Time series analysis in sport

These same simple statistical principles can be used to monitor training effectiveness for one athlete, a particular training method, or an entire programme. Researchers at the University of Southern California used time series analysis to evaluate the performance trends of ten male subjects during three different resistance exercise sessions [2]. The researchers were interested in detecting **postactivation potentiation** and fatigue effects within the exercise sessions. Their study showed how using a moving average to analyse the raw data collected during the high-power resistance sessions eliminated the 'within-session variability', revealing an overall trend.

The raw data, collected using motion analysis, showed large variability in the average barbell power for sets at 75%, 85%, and 95% of an individual's one repetition max (see figure 2). The reason for such variability can be physiological, psychological, or measurement error. With weightlifting, variability in performance is known to occur between supervised and unsupervised training as well as with or without verbal encouragement[2]; sometimes an athlete just isn't firing on all cylinders while at other times he or she may be 'in the zone'.

The evaluation of the data using time-series analysis confirmed to the researchers that indeed the athletes were performing at a level that invoked a postactivation potentiation and fatigue pattern. Only by smoothing the data using the moving average was a trend detectible within the raw data.

Figure 1: Temperature graph of daily maximum temperatures in Houston during March 2010[1] 20101



Note how the actual maximum temperatures vary widely but when smoothed using basic averaging, the temperature graph becomes flat, with no evidence of a trend. Smoothing using a moving average however brings the variations closer to the actual average while revealing trends within the data.

Advice from an expert

Many athletes are turning to gadgets and gizmos to formulate their training programme. While technology can provide useful tools for athletes, Loren ZF Chiu, PhD, CSCS, at the University of Alberta, cautions athletes to investigate the science behind the applications.

'Many people confuse technology with science,' says Dr Chiu. He advocates using time series analysis as a way to evaluate the effectiveness of training and the trends in performance. Technological applications can be useful in the collection of time series data.

Having objective data gives coaches the ability to quantify performance over the appearance of performance. 'Coaches must stop adjusting training based on perception. If someone has an off day, time series analysis gives you the ability to see how that day's performance fits within the overall trend over time,' says Dr Chiu.

Calculations

The calculations for moving averages and the resulting graphs are easily carried out using an Excel spreadsheet. The challenge for sports programmes, according to Dr Chiu, is to measure and record data. One way to start this within your programme or club is to provide every athlete with a journal. Trainers can assist athletes with recording times, measurements, number of tackles, distance covered, or any other data point that is important to the performance of a particular sport.

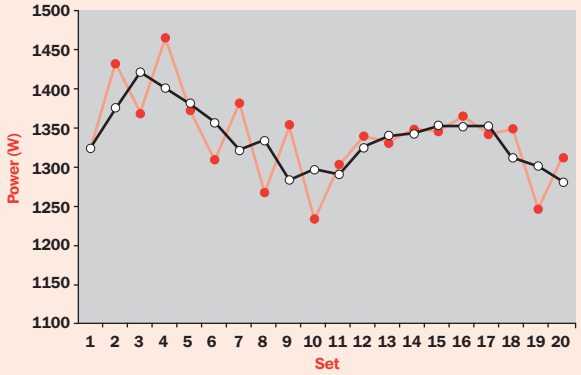
If your athletes or trainers are 'techies' then it gets even easier. Record data points via a smart phone or mobile device, and email them to whoever is the designated data input person for the team. If you are part of a university-based team, work with your computer science programme to write applications, or apps, that pertain specifically to the data you want to collect.

Data can then be manually entered or directly imported into an Excel spreadsheet and results displayed quickly. Graphs and data can be uploaded to the internet on team websites, giving athletes and trainers rapid access with their mobile devices. Just remember, the technology is only as useful as the science behind it.

In the future, it's possible that athletes will begin a data file in school and carry that with them into their college or club career. Coaches will be able to evaluate the results of previous training methods on performance. They would be able to note when injuries occurred and what the training and performance trend looked like at that time, perhaps avoiding future injury.

Symptoms of overtraining might be detected earlier with this type of performance analysis. Successful training techniques would be recognised and broadened. The future could even see coaches using statistical analysis to forecast where an athlete's performance will be at competition and adjust the training schedule accordingly. Dr Chiu cautions, however, that forecasting will only be appropriate after a significant amount of data has been collected and analysed.

Figure 2: Smoothed data for average barbell power



Data was gathered for ten subjects performing 20 sets of 1 repetition in the clean pull, at 95% of their 1 repetition max[2]. Closed circles = raw data; open circles = moving-average fitted data. The moving average smooths the variability in the data and shows a typical downward trend in power with fatigue, followed by a rise in power output demonstrating a postactivation potentiation pattern.

Practical applications of time series analysis

Start by deciding what parameters are important to your sport. What would you like to improve? Some examples are sprint times, pitch speed, vertical jump height, 1 repetition max, etc. Decide how often you will record these measurements and what method you'll use to do so. Will you need a 3D motion lab to evaluate movement patterns once a month, or simply measure your sprint times with a stopwatch every week? Find a method of recording your data that works for you and commit to maintaining your data log for at least three months. By that time you should have enough data to illustrate performance trends.

Conclusion

Time series analysis is a method of evaluating a series of data collected over consistent intervals of time. The application of time series analysis to athletic performance is new and full of potential. Using simple tools such as a stopwatch and an Excel spreadsheet, you can collect data, evaluate training methods and monitor performance.

In the next issue, I'll give you the formula to calculate a moving average and show you how to express your data in charts that reveal meaningful data trends. Time series analysis is a very simple way to evaluate performance; however, don't let the simplicity fool you. The technique opens up exciting possibilities for making training decisions that improve performance. The challenge is to start collecting and recording data today!

Alicia Filley, PT, MS, PCS, lives in Houston, Texas and is vice president of Eubiotics: The Science of Healthy Living, which provides counselling for those seeking to improve their health, fitness or athletic performance through exercise and nutrition

'The challenge for sports programmes is to measure and record data. One way to start this within your programme or club is to provide every athlete with a journal'

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Affordable technology: jump to it!

At a glance

This article:
- Discusses the importance of vertical jump power and agility in sport performance;
- Looks at two low-cost systems that can measure these parameters.

In parts 1 and 2 of this series on affordable sports technology, Alan Ruddock has presented some inexpensive methods to analyse your performance, determine your readiness to train and assess muscle function. In the third and final part, Alan introduces two further pieces of technology that can be used to assess performance and to train for two integral components of sport performance – jumping and agility.

A lot of time has passed and technological advances made since Dr Dudley Sargent (1849-1924) introduced his pioneering methods of teaching physical education in North America. Yet part of his legacy – the 'Sargent test' – or as it is more commonly known the 'vertical jump test', remains a fundamental component of sport physiology testing and training.

The vertical jump has stood the test of time because of its simplicity of administration and interpretation of results. It is also easily adaptable and there are several well documented versions of the test deriving from the two main types of jump:
1) squat jump (SQJ);
2) counter-movement jump (CMJ).

The squat jump primarily assesses the ability of the neuromuscular system to stimulate the lower limb extensor muscles to forcefully contract in a **concentric** manner to propel the body vertically upwards. The counter-movement jump, on the other hand, includes an **eccentric** (downwards) contraction and thus **stretch-shortening** component prior to the concentric phase. In other words, the SQJ isolates the muscle from the elastic components in the CMJ. Importantly, the test reliability of both the SQJ and CMJ has been reported to be acceptable, meaning that results obtained in different tests can be meaningfully compared[1].

The performance in jump tests has been shown to be strongly correlated with other measures of performance such as sprint speed and strength within a range of different sports including soccer, American football, rugby and volleyball[2]. Furthermore, modified jump tests such as box jumping have also been strongly correlated with track and field performance[3].

Although these jumping exercises are used as performance tests, there's also evidence to suggest that jump training (usually plyometrics) can improve lower body muscular power and running economy in endurance athletes[4]. Despite the relatively low resistance (from body weight) in these exercises, high rates of force development and peak forces achieved during jumping are thought to provide the stimulus for physiological adaptations.

Jargon Buster

Concentric
When a muscle attempts to shorten and produces force

Eccentric
When a muscle attempts to lengthen while producing force

Stretch-shortening
Rapid switch between eccentric and concentric contractions

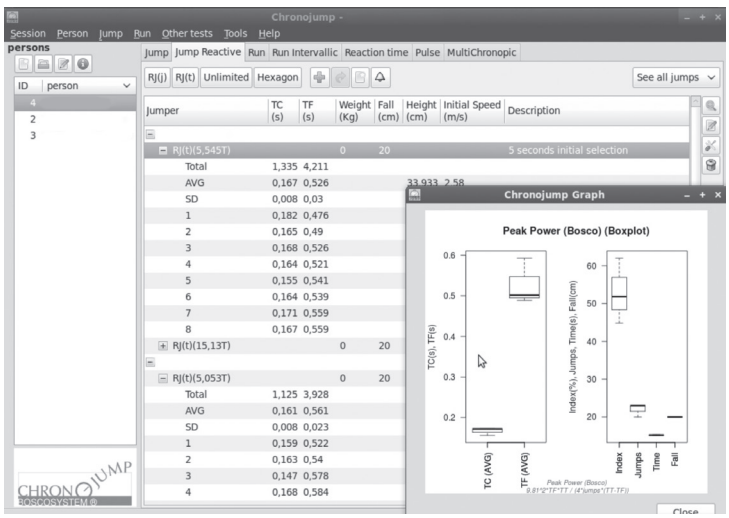
ChronoJump (http://chronojump.org)

The original Sargent jump test is easy to administer but it's not ideal for all situations. Subsequently, various electronic 'jump mats' have become popular, which make vertical jump assessments very easy to carry out. Essentially these mats work because they contain a contact switch; when contact between the athlete and the mat is broken during a jump a timer is started and the timer stops when the athlete makes contact with the mat again. This time (known as 'flight-time'), is then used in an equation to predict jump height.

Despite this seemingly simple technology, most jump mats are quite expensive and out of the price range of many athletes and coaches. However, a team from Spain have designed a simple system at a low cost (around £120), which comes with some really useful software. The Chronojump system (*see figure 1*) is made up of three main elements:
- the software (which is free to download);
- the chronopic timing system;
- the jump mat.

The software is where all the performance data is displayed and stored and allows you to perform an extensive range of jump tests. It can also be used as a jump-training tool by setting jump height or contact time limits and setting the audible warning 'bleep'. Interestingly, the Chronojump software has been developed as an open-source programme, which means that users who are dab hands at programming

Figure 1: Sample screenshot from Chronojump



can modify the programme to suit their specific requirements. Indeed, the manufacturers present information on their website detailing the potential use of the Chronojump system to measure bar velocity during weightlifting as well as running speed.

Agility

A player who can perform some seemingly magic trick at high speed to confuse or break through the opposition impresses us all. We usually think of these players as being agile. It's hard to define what agility actually is because there are usually a number of discrete components packaged into a series of one or more movements. However, some of the qualities required for agility include[5]:

- fast reactions;
- rapid acceleration (from stationary or while moving);
- fast directional acceleration;
- rapid deceleration and/or stopping speed;
- quick change in movements;
- perceptual and decision making skills.

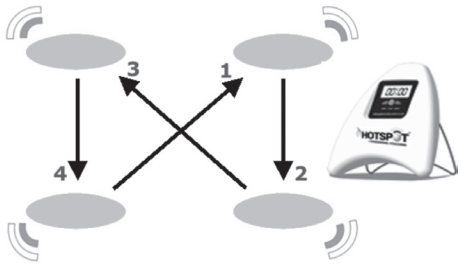
There are a number of different tests to quantify the physical components of agility and a simple online search reveals over 20 such tests. If you're choosing an agility test, you should always consider which one best replicates the specific movements within your sport.

Despite the amount of available agility tests there has been relatively little published literature detailing their reliability, but the tests that have been reported generally to have high reliability. Due to the physical qualities required to be agile listed above, studies have reported strong correlations with other performance measures such as vertical jumping and short sprints (10-30m) but lower correlations with measures of lower body strength and power. However, when more complex agility tests are used (for instance, when the inclusion of multiple changes of direction and response to a random stimuli or a distraction is included) the relationships between agility and other performance measures are much weaker.

This notion is supported by research, which suggests that training for agility by sprinting in a straight line is a poor method[6]. Not surprisingly, the best way to improve agility is to train specifically for it by using movements that contain multiple changes in direction, acceleration and deceleration drills, randomised reactions (visual and verbal) and specific agility movement techniques within the context of your sport[7].

Tests for agility are usually quantified by time and the simplest, most common way to measure time is by using a stopwatch. However the human error when using a stopwatch is variable and in the region of 0.1-0.2 seconds, which could potentially confound your ability to make an assessment of real change in performance of your athletes over short duration tasks. In addition, it's difficult to define the specific areas of strengths and weaknesses of your athletes within an agility test using a stopwatch.

Figure 2: Hot Spot agility system



Touch sensitive discs are laid out for the athlete to run over while the timing unit collects the data

For example, an athlete might have fast acceleration but poor deceleration and change of direction skills. An overall fast time in an agility test that contains straight line accelerations may mask these deficiencies. Ideally, you would isolate the different components of the test to quantify the athletes' ability to perform these specific skills, but this is difficult with the use of a stopwatch.

The alternative is either to film your athletes (this introduces additional time constraints) or the use an electronic timing gate system, but the cost of these systems is often prohibitive. We also know that training various components of agility is important to improve agility and that rapid feedback of performance is integral to the training process. Yet feeding back the time taken to complete a particular drill is often difficult in certain situations.

Hot Spot Agility

(www.gameseducation.co.uk)

Hot Spot has the potential to alleviate these common problems. The Hot Spot system comprises of a number of touch sensitive discs that you can place on the training surface. These discs then communicate using wireless technology with a central timing unit (see figure 2). The discs are touch-sensitive so that when even the smallest featherlike touch is sensed and recognised by the central timing unit.

Touch sensitive discs are laid out for the athlete to run over while the timing unit collects the data

The system works quite simply by athletes running over the discs while the timing unit collates and displays the information. The major advantages of Hot Spot are that it is portable, has an unlimited array of training and test scenarios (you are limited only by your imagination and the generous 50m range), provides immediate feedback of total time and split times between discs and there is even an option to count contacts within a specified time range.

The Hot Spot system price starts at an affordable £135, much cheaper than electronic timing gate systems. Moreover, the developers of Hot Spot are committed to providing accessible technology for sport and fitness and are already planning adaptations to the original Hot Spot system.

'Performance in jump tests has been shown to be strongly correlated with other measures of performance such as sprint speed and strength within a range of different sports including soccer, American football, rugby and volleyball'

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Alan Ruddock MSc, CSCS is a researcher at Sheffield Hallam University, UK.

WHAT THE PAPERS SAY

Reports by Andrew Hamilton BSc Hons MRSC ACSM

The perfect tackler

What makes for perfection when it comes to tackling in rugby? That's the question Australian scientists set out to discover in a study just published. The researchers investigated the tackling ability of junior elite and sub-elite rugby league players, and then determined the relationship between selected physiological and anthropometric characteristics and tackling ability in these athletes.

Twenty-eight junior elite (average age 16.0 years) and 13 junior sub-elite (average age 15.9 years) rugby league players underwent a standardised 1-on-1 tackling drill in a 10m grid. Video footage was taken from the rear, side, and front of the defending player. Tackling proficiency was assessed using standardised technical criteria and in addition, all players underwent measurements of stature, body mass and fat, acceleration (10m sprint), change of direction speed, and lower body muscular power (vertical jump).

As might be expected, the junior elite players had significantly greater tackling proficiency than sub-elite players. Moreover, the elite players tended to be taller, heavier, leaner, and have greater acceleration, change of direction speed, and muscular power than the sub-elite players. However, further analysis showed that 10m acceleration times and lower body strength were correlated much more strongly with tackling success. Furthermore, when analysis was performed to determine which of the physiological and anthropometric characteristics actually predicted tackling ability, only fast acceleration met this criterion.

The researchers concluded that fast acceleration (and to a lesser extent) lower body muscular power contribute to effective tackling ability in junior rugby league players. They also suggested that strength and conditioning coaches should emphasise the development of acceleration and lower body muscular power qualities to improve tackling ability in their players.

J Strength Cond Res. 2010 Oct 9. [Epub ahead of print]

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