FOOTBALL PERFORMANCE II

new goals for success

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

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Contributors

An ex-competitive cyclist, Dr John Bye is now a practising doctor and the director of specialist sports medicine company Alchemy Sports Consulting Ltd

Australian-born Matt Lancaster relocated to the United Kingdom in 2000 and is currently employed by the English Institute of Sport as lead physiotherapist for the London region

Tim Lawson is a competitive cyclist and director of sports nutrition manufacturer Science in Sport

James Marshall MSc, CSCS, ACSM/HFI, runs Excelsior, a sports training company

Jim Petruzzi is a performance coach, specialising in sports science and sports psychology, who works with several professional football clubs and international teams

TJ Salih is a chartered physiotherapist and worked for Tottenham Hotspur Football Club for two seasons, before establishing his own clinic, Back2Normal – www.back2normal.co.uk

John Shepherd MA is a specialist health, sport and fitness writer and a former international long jumper

From the editor

Since the English Premier League began in the 1992/93 season, football has become big business. The money involved, the global scouting networks and the media coverage has sky rocketed consistently for fifteen years. Of course this would not be able to happen if the standard of the sport, the intensity and skill levels, did not improve accordingly.

And what exactly has caused this acceleration in the standard of professional football? The one major cause that springs to mind is the behind the scenes sport science, the vastly improved preparation, analysis, teachings and treatments. That is why we at *Peak Performance* have compiled a second special report for football.

This special report can be divided into three sections. The first three chapters are skill and training based. Firstly the importance of pre-season training is examined, comparing it to the dark ages when balls were left in the changing room. A technical guide to kicking is followed by an article on 40m sprint training and testing, which should be vital to most players needing to catch Thierry Henrys or escape Alessandro Nestas.

The middle three chapters all focus on half-time. Tips on warming up and cooling down are followed by a feature on nutritional advice. The third half-time chapter examines the inspiration managers and captains can provide when the interval arrives.

Finally there are three injury based chapters. The first is a general look at injuries in football, and the supposed increase in top-level injuries (according to the tabloids!). Secondly an article on concussion will have all Peter Cech and John Terry wannabes interested. Finally two football focus articles query injury problems, including one for women.

I hope you and your team enjoy this special report, and in the process become more successful through preparation and application.

Sam Bordiss

Football – how and why effective pre-season training is vital

Effective pre-season football training is not just about running around the football pitch in order to shed those off-season pounds. A much more scientific approach is needed, which combines energy systems training with skill development.

'I wouldn't say pre-seasons are a lot easier now but they're a lot better. All I can remember is you didn't get to see a ball for four or five days. As soon as you reported back for training it was straight into running morning and afternoon. I think if you asked a lot of older players, they would say that's exactly what it was like. The difference nowadays is that you see the ball right away, the first day. Yes, we still do running but it's not so intense, pounding the roads for a couple of hours. It's a hell of a lot different.'

Kevin Philips, Aston Villa striker, 2006

Sports science and modern technology has had a major effect on football training over the past 10 years. Many teams have become much more analytical about their players' work rate in games, and also in training, by introducing tools such as game analysis and heart rate monitors, in order to gain an accurate understanding of the physical demands of players in games.

The structure and training methods in football throughout the season have also changed significantly and the period of pre-season training has seen some of the biggest and most significant changes, due to the importance of ensuring that players starting the season are in the best possible shape, and the need to maintain their fitness throughout the season.

Gone are the days when players would report to pre-season training and told they would not see a ball for two weeks. Small-sided games and ball-related exercises now comprise a major part of training within the modern professional game. A perfect example of this was the preparation that the Korean team adopted in preparation for the 2002 World Cup finals.

In a review, Verheijen described how initially the Korean players could not maintain their desired pace for the full 90 minutes[1]. Players made high-intensity runs less frequently and there were fewer 'explosive actions' as the second half progressed. After a systematic training programme, they were able to maintain a higher tempo for the entire match and the recovery between explosive efforts was dramatically improved.

The energy requirements of footballers

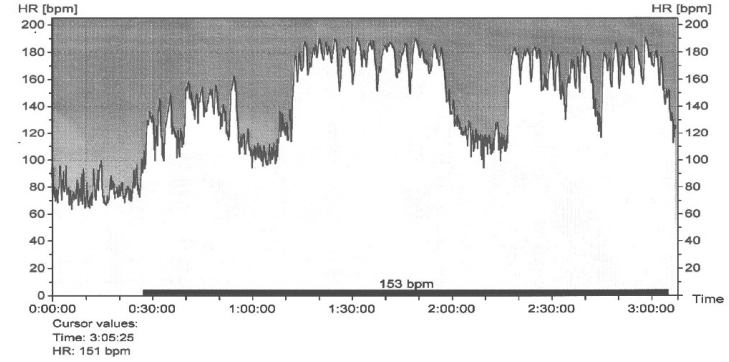
Football incorporates periods of high-intensity efforts interspersed with periods of lower-intensity exercise. The physiological demands of football require players to be competent in several aspects of fitness, which include aerobic and anaerobic power, muscle strength, flexibility and agility.

Overall, the game of football is essentially aerobic with intermittent anaerobic and alactic bursts of energy. Outfield players average heart rates of about 160bpm during football games and operate at 75-80% of their maximum oxygen uptake (VO2max), which is comparable to marathon running. However, football is not characterised by steady heart rates of 160bpm, which are sustained for 90 minutes of play; heart rates are continually fluctuating depending on the nature of the activity the player is performing.

Figure 1 illustrates an actual heart rate plot from a professional footballer using a heart rate monitor taken during a pre-season game; notice the continuously varying heart rate but with high average peak values.

At the professional level, the contemporary game of football seems to be more demanding than suggested in much of the early literature[2], which therefore suggests a more systematic approach to training is needed[3].

Figure 1: Actual heart rate plot of professional footballer



Person	EFC 6	Date	15/07/2006	Heart rate av	153 bpm
Exercise	15/07/2006 14:12	Time	14:12:22	Heart rate ma	190 bpm
Sport	Running	Duration	3:07:30.0		
Note				Selection	0:27:30 - 3:05:25 (2:37:55.0)

A comparison of the work rates of English Premier League players over two seasons (1998-1999 and 1999-2000) with previous observations of top English League players before 1992 shows that today's players cover approximately 1.5kms more ground in a game than their earlier counterparts[4] – a difference that is apparent for all the playing positions.

The data for the 1997-98 season shows that compared with the 1991-92 season, there is also evidence of a faster tempo to the game, including more movement of the ball and shorter breaks in play. This is probably partly due to changes in the rules, such as the omission of the back pass and also advances in sports science and player conditioning.

However, despite the high aerobic demands necessary to sustain work output for 90 minutes, games are often decided on the quality of explosive efforts, which depend on anaerobic and alactic bursts of energy; for example, to get to the ball first, leap above an opponent, spring into a goal-scoring position or to close down an opponent and deny them space to pass or shoot at goal.

The simulation of the exercise intensity corresponding to match play has enabled sport scientists to study a number of aspects of play under laboratory conditions. Observations

highlight the value of exercising with the ball where possible, notably using activity drills in small groups. Small-sided games have particular advantages for young players, both in providing a physiological training stimulus and a suitable medium for skills work. While complementary training may be necessary in specific cases, integrating fitness training into a holistic process is generally advisable.

'A successful pre-season programme is one that incorporates all of the necessary components to enable players to maximise their performance as soon as the season commences'

Principles of pre-season training

A successful pre-season programme is one that incorporates all of the necessary components to enable players to maximise their performance as soon as the season commences, and to be able to sustain peak physical condition throughout the season. These fitness components often vary with the individual player, the positional role in the team and the team's style of play. Other considerations include the physical demands of the game, the current level of fitness of a particular player and what the team is striving to achieve. To meet these requirements, a well-designed pre-season training programme that addresses the specific demands of each footballer is a must. Because of this, it is worth considering physical and physiological tests at the start of your pre-season schedule to see how the players are doing, and to evaluate their preparation plans. These tests give information on the levels of endurance, speed, muscular endurance, strength, coordination, technical, and tactical elements during the preparation period.

A pre-season preparation period covers the period from the beginning of team training until the first official match. The length of these training periods may differ from one country to another. During this training period, physical conditioning should be composed mainly of games and exercises with a ball. The frequency and number of training sessions should be increased gradually as the season approaches[5].

Paul Aigbogun, coach of the San Francisco Seals team, speaks of some of his favourite practices demonstrating how the ball can be incorporated into training for physiological

benefits: 'Some of my favourite practices are crossing and finishing, keep ball, building up to a small-sided game, starting at 1 v 1, building up to 2 v 2, 3 v 3, 4 v 4, probably up to a maximum of 8 v 8. Another one of my favourite practices is attacking team play, 11 v 6'.

Adapting these games to meet the physiological demands of football is important. Football is played by two teams of 11 players performing in an area of approximately 100m by 60m. However, during training, it is common practice to reduce both the number of players on the pitch and the size of the pitch, which has the effect of increasing the proportion of anaerobic/explosive work required. These small-sided games are one of the most common drills used by coaches in football training; whereas in the past small-sided games were mainly used to develop the technical tactical abilities of the players, they are now being employed by amateur and professional teams as an effective tool to improve physiological aspects of the game[6].

Changing approaches to conditioning

Although it's true that footballers cover large distances during a match, it's important to note that football players are continuously alternating between anaerobic and aerobic activity, which allows recovery to take place. As a consequence, football is characterised by one dominant energy system in the body (aerobic) but with the two other energy systems (anaerobic alactic and anaerobic lactic) that enable higher-intensity outputs to play a vital role. Training all three energy systems, therefore, is important.

Traditionally, footballers have used interval training to develop aerobic fitness. However, the use of small-sided games has recently been recommended as an ideal training method for improving fitness and competitive performance in football, because match-specific small-sided games can effectively improve the fitness of the cardiovascular system while mimicking match-specific skill requirements[7,8]. Other advantages include increased player motivation, training the capacity to perform skilled movements under pressure and a reduced rate of training injuries.

Scientific research has established that five-a-side football drills on a pitch measuring 50m x 40m can produce heart rate responses within the intensity range previously shown to be effective for improving aerobic fitness and football performance (performing running interval training at 90 to 95% of maximal heart rate)[9].

Examples of principles in practice

Pre-season anaerobic training – One approach is to work on general anaerobic conditioning using quality interval training, which can be performed by performing football-related activities. In practice, that means alternating maximum speed sprints with very light jogging or walking. Workouts should last about 20-30 minutes and consist of 7-10 second sprints and 30-50 seconds of low-intensity jogging or walking, giving an aerobic/anaerobic training ratio of 5:1. For example, you could play 1 v 1, where one player is defending a goal on the edge of the 18-yard line. The other player sprints at full pace from the other 18-yard line, receives the ball on the halfway line and sprints towards the goal aiming to get a shot on target. He then jogs backs and repeats the same drill.

An example of this was a training drill that Bansgo conducted with Zambrotta while he was assistant coach at Juventus. The drill was for Zambrotta to play the ball from the edge of his own box to a midfielder, sprint and then receive the ball inside the opposite half and run with the ball, cutting back inside and striking it with his left leg. The aerobic/anaerobic training ratio was 5:1 – *ie* very specific to football.

Pre-season speed training – Here's an example of a speed drill that combines skill and fitness training. Divide the players into two equal groups, placing them both in a single line formation, and have the two players at the front of the two groups facing each other at a distance of about 20 metres apart. Player A (the player at the front of the line) from group one passes the ball to the other player A (the player at the front of the line in group two) and sprints to the other side to the

Summary of energy systems in football:

1 **Anaerobic alactic, high intensity.** Duration up to 15 seconds; used in explosive efforts and short sprints, kicking, tackling etc;
2 **Anaerobic lactic, moderate-high intensity.** Duration of 15-120 seconds; used in longer sprints and sustained high-intensity efforts (heart rate around 90% of maximum);
3 **Aerobic moderate to low intensity** 120 seconds plus used while jogging, walking, recovery between harder efforts etc.

Aerobic activities	Anaerobic activities
Walking	Most tackling and contact situations
Walking backwards	Jumping
Jogging quickly	Accelerating and changing direction
Running at speeds less than maximum pace	Running at speeds greater than maximum pace

back of group two. Player A from group two receives the ball, controls and passes the ball then sprints to the back of group one. Each player repeats this with the emphasis being on speed. After passing the ball, it should take about 3 seconds for the player to sprint 20 metres, with a short rest before performing the exercise again.

Pre-season aerobic training – Examples include drills lasting 2-3 minutes with a work/rest ratio of 1:1 working at low intensity or continuous low-intensity work over a period of 20 minutes. Alternatively you could play a small-sided game such as 4 v 4, though if you wanted to work solely on the aerobic system, these games would need to be played at low intensity to keep aerobic activity to a minimum.

As a rule of thumb, training should involve regular use of the ball wherever possible as this will not only help develop the specific muscles involved in match play, but also improve technical and tactical skills and help keep players interested. This is where small-sided games offer an advantage and many coaches such as Marcello Lippi, formerly at Juventus, and winner of the 2006 World Cup with Italy, are big believers in the positive effects of small-sided games.

Constructing a football-specific pre-season training session

The following is a guide you can use to help you plan your own pre-season training sessions. As well as simple running drills, you can also incorporate the relevant work/rest/intensity combinations into football-specific drills

Speed

Exercise (secs)	Rest	Intensity	Repetitions
2-10	5 times exercise duration	Maximal	2-10

Building speed/endurance

Exercise (secs)	Rest	Intensity	Repetitions
20-40	5 times exercise duration	Almost maximal	2-10

Maintaining speed/endurance

Exercise (secs)	Rest	Intensity	Repetitions
30-90	30-90 seconds	Almost maximal	2-10

Aerobic high intensity

Exercise (mins)	Rest	Intensity	Repetitions
2-5	Same as exercise duration rate maximum	90%+ of heart	4-6

Aerobic low intensity

Exercise (mins)	Rest	Intensity	Repetitions
8-10	1-2 minutes rate maximum	70-80% of heart	2-4

Summary

Small-sided games and football-related activities, as highlighted, have a number of benefits. Footballers love nothing more than to play football, and while the physiological aspect of football is one of the most important factors in players performing at their best, incorporating functional activity, small-sided games, and football-specific activity is bound to make sessions more enjoyable for the players while improving their physical fitness to meet the demands of the game.

Jim Petruzzi

Jargon buster

Alactic – the energy pathway which permits athletes to work at very high intensity for over 10-15 seconds without lactic acid production or the use of oxygen

Anaerobic lactic – Short duration (1-2 minutes) high-intensity energy pathway involving the breakdown of glycogen (glycolysis) in the absence of oxygen, with the formation of ATP plus lactic acid

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Training for kicks – just how can you improve kicking performance?

On the face of it, kicking a ball seems the simplest thing in the world. However as we will discover, powerful, accurate and injury-free kicking doesn't just happen by accident; it requires the right mental approach combined with appropriate skill development and physical conditioning

Have you ever wondered why you seem to have two left feet, or why you're prone to hamstring strains when it comes to kicking a ball? And where you should look when you are about to put the ball in the net from the penalty spot? Although it's something we take for granted, the ability to kick is like any other sports skill in that it can be developed and improved. And like other sports skills, improvement requires the correct mental, as well as physical, approach.

Using the mind to improve kicking

Mental training can play a vital role when it comes to improving kicking technique and one of the most important training methods is visualisation, which involves running through the performance of a sports skill in the mind. For this to be most effective, the skill should be practised at real speed; visualising a skill at slower speeds can be detrimental, as it can 'pattern' this skill in the brain at a 'less than optimal' velocity – *ie* the motor system becomes better at executing the action, but only at lower speeds.

When visualising a kicking skill, you should find a quiet spot,

'When visualising a kicking skill, you should find a quiet spot, relax and run through it in your mind in varying conditions and states of fatigues'

relax and run through it in your mind in varying conditions and states of fatigues. For example, an elite rugby goal kicker could visualise slotting the ball between the posts from a position that is least preferred (*eg* on the 'wrong' side of the posts), in the wind and rain, in front of a TV audience of millions and against particular opposition.

Regular visualisation will bolster confidence, physical practice and maximise the potential for successful kicking. To aid visualisation a 'script' can also be established. Basically, this is a set of instructions that the athlete runs through repeatedly in their mind as they visualise the kicking action.

Here is an example that could be used to support the visualisation used by a football penalty taker:

- I will place the ball calmly and securely on the spot;
- I will look at the goalkeeper to assess his position, inhale, and turn around and walk back nine steps;
- As I do this, I will breathe out and remind myself of where I am going to place the ball;
- I will pause, turn towards the goal, and look at where I am going to place the ball;
- I will see the ball going into the net where I want it;
- I will breathe in and slowly out (centring – see opposite) before I start my run;
- I will start my run;
- I will strike the ball cleanly with the in-step of my foot, placing the ball to the left of the keeper, low and hard into the corner;
- I will not lift my head or eyes until the ball is on its way into the back of the net.

Visual acuity

How does David Beckham bend it? The former England captain is one of the world's greatest dead ball specialists. He has a unique kicking action, which has been attributed to his specific lower leg physiology, enabling him to give the ball more spin, curl and dip. His ability to wrap his kicking foot around the

Centring

Centring can be useful for those involved in field kicking sports to control nerves or anxiety that can develop at certain times during a game, for example, when taking penalties in rugby and football.

Centring uses a breathing technique that was developed by Tibetan monks over 2,000 years ago. Sports psychologists believe that if you practise the skill, preferably in front of a mirror, for a minute a day for two weeks, you will master it for life and will only need to practice it once a week thereafter to maintain it.

How to do it:

1) Stand with your feet shoulder-width apart;
2) Relax your upper body, paying particular attention to your neck and shoulders;
3) Focus on the movement of your abdominal muscles;
4) Breathe in slowly and deeply and see your stomach extend;
5) Focus and relax. Let your body feel heavier as you continue centring.

ball is enabled by his non-striking leg seemingly being able to bow almost stick-like, as he strikes the ball. This drives his kicking foot into the ball in a very unique manner.

So what do you do without Beckham's legs? Well, research has indicated that the angle of the approach run when taking a kick will have a significant effect on kicking biomechanics (the greater the angle the greater the ability to impart swerve, dip and curl)[1]. And deciding where to place the ball before striking it is crucial, as is where and how you actually look when you strike the ball.

Japanese researchers considered the latter in regard to short and long in-step kicks[2]. Players were asked to aim at a target; the top three scorers were defined as the 'high-score group' (HSG) and the three low scorers were defined as the 'low-score group' (LSG). Analysis indicated that:

- The HSG was characterised by longer 'quiet eye' durations (constant focus gaze) on the target prior to kicking;
- The LSG spent less (quiet eye) time focusing on the target prior to kicking;
- The HSG score group kept their eyes down for longer when

they struck the ball, specifically keeping focused on a point between the ball and target.

This research corroborates the accepted wisdom of looking at the ball when kicking, and not where it is going to be kicked when striking it. This is to avoid lifting the head (and in the case of the research above raising the eyes), which alters the biomechanics and accuracy of the subsequent kick.

Preferred versus non-preferred kicking foot

Most of us have a preferred kicking foot and a team of researchers from Denmark have looked at the possible biomechanical reasons for this[3]. Seven skilled soccer players performed maximal speed place kicks with their preferred and non-preferred leg. The kicks were analysed with high-speed video recording equipment. Among numerous variables, the rate of force development in the hip flexors and the knee extensors (quadriceps) was measured using a dynamometer.

'When visualising a kicking skill, you should find a quiet spot, relax and run through it in your mind in varying conditions and states of fatigues'

Not surprisingly, higher ball speeds were achieved with the preferred leg. The researchers attributed this to higher foot speed at the point of ball impact and a consequential 'better inter-segmental motion pattern' (*ie* smoother kicking action). Specifically, in terms of muscle recruitment/action at foot-strike, this was related to the angular velocity of the thigh.

Research carried out on kicking in Aussie rules football also vindicates the importance of skill when it comes to kicking optimally with either foot[4]. The researchers concluded that, 'Kicking a football accurately with a certain velocity over a certain distance is dependent on the speed of the kicking foot and the quality of the contact between the foot and the ball – qualities that are primarily skills led.'

Any football player wanting to achieve parity between their kicking legs should therefore emphasise skill and, to coin a well used phrase in coaching, follow the mantra that 'perfect practise makes for perfect performance'. They should also begin early, during the 'skill hungry years', between the ages of 8 and 12, when the body and mind can most rapidly learn the correct motor skills.

Kicking conditioning

In most sports, improving strength and power improves performance. So does the same apply to kicking? Greek researchers examined the effects of a football strength and technique conditioning programme on the kinematics (movement of the body/limbs) and electromyographic (EMG) muscle activity during in-step kicking[5]. Ten amateur football players made up the experimental group (EG) while 10 other players served as controls.

The EG followed a 10-week football-specific training programme. This combined strength and technique exercises. All participants performed an in-step kick using a two-step approach. The researchers recorded:

- Kinematics in the form of three-dimensional data;
- EMG readings from six muscles in the swinging (kicking) and support legs prior to and after the training programmes;
- Maximum isometric leg press strength;
- 10m-sprint performance;
- Maximum speed on a bicycle ergometer.

The researchers discovered that compared to the controls, the EG improved significantly in relation to maximum ball speed and the linear velocity of the foot and ankle, and the angular velocity of all the joints during the final phase of the kick (it has

Improving football-specific endurance can benefit kicking

Numerous studies point to the importance of specific football conditioning when it comes to maintaining kicking accuracy under conditions of fatigue[6,7]. Although beyond the scope of this article, players and coaches should work on performing various kicks in training, when the player is fatigued.

Example of a relevant drill

Two players stand 10m apart and perform in-step passes to each other, in an alternate left foot/right foot pattern. After the completion of 20 passes, they turn away from each other and sprint 20m round a cone and back to where they started to perform a further 20 passes.

been previously noted that faster foot speed/limb speed results in longer and more powerful kicking).

However, training had insignificant effects on EMG values, apart from an increase in the average EMG of the vastus medialis (thigh muscle that contributes to leg extension, *ie* kicking). Additionally, maximum isometric strength and sprint times were significantly improved after training. This led the researchers to conclude that '…the application of training programmes using soccer-specific strength exercises would be particularly effective in improving soccer kick performance.'

Eccentric exercises to beat hamstring kicking strain

The Nordic hamstring exercise

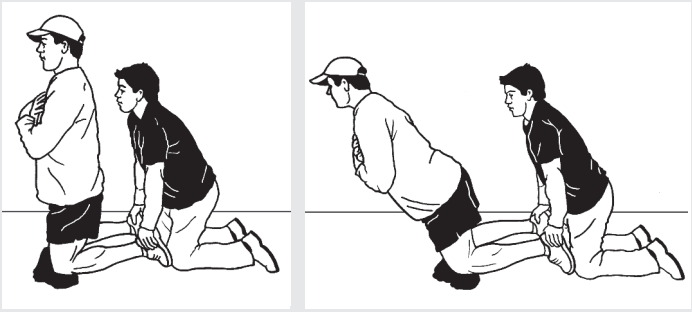
Kneel and keep your trunk upright and head looking forward. Get a training partner to firmly hold your ankles. Lean forward and 'use' your hamstring muscles to prevent yourself falling to the floor. Have your hands ready in case gravity takes over. This is a tough exercise and should be progressed to with caution *(see figure 1, below)*.
Do: 4 x 5 repetitions

Eccentric action emphasis hamstring curls

If you have no experience of eccentric hamstring work, then it's worth building relevant strength by performing eccentric hamstring curls on a machine before performing the Nordic exercise described above. This is done by emphasising the lowering of the weight during the exercise; lift the weight to a 'one' count and then gradually lower to a slow 'five' count.

Use a weight that allows you to perform 6-8 repetitions (*ie* a 'heavy' weight) and perform 4 sets.

Figure 1: Nordic hamstring curl



However, not all the research backs this up.

Further research from Denmark considered three different 12-week strength training protocols on 22 elite football players[8]. Four groups were established:

1. A high resistance (HR) group who performed 4 sets, 8 reps at 8RM loading;
2. A low resistance (LR) group who performed 4 sets, 24 reps at 24RM loading;
3. A loaded kicking movement group (LK) who performed 4 sets, 16 reps at 16RM loading (loaded kicking drills include those using elastic bungee or power chords, which wrap around the foot and allow the kicking action to be performed against resistance);
4. A control group (CO).

When peak isokinetic, concentric and eccentric force was measured, the researchers discovered that isokinetic knee joint strength was unchanged in the LR, LK, CO groups. However, the HR strength training players experienced greater eccentric and concentric force generation capability when kicking. However, despite this apparent kicking strength gain, actual kicking performance estimated by maximal ball flight velocity was unaffected – contrasting with the findings of the Greek team.

Researchers concluded that only the heavy-resistance strength training induced increases in isokinetic muscle strength, and that the actual value of this training was likely to be more about injury prevention – specifically in terms of providing stability to the knee joint during fast extension (kicking) movements.

Thus it appears that experienced footballers can benefit from specific training, but the effects appear to be peripheral to the actual enhancement of kicking power. The heavy weight protocol does seem to offer a pathway to increased power but this may not translate directly into kicking distance due to the specifics of the kicking action and the high skill requirement. It seems therefore that (as with most technical sport skills) enhanced strength must be constantly married to technique if this is to translate into improved performance.

Conclusion

Specific conditioning methods seem to be slightly peripheral (particularly for experienced players), while high resistance weight training has its advocates and can be useful in terms of injury prevention, as can eccentric hamstring exercises. However, it appears that the biggest factor for improving kicking ability in terms of accuracy and distance are repeated, technically correct practices, with consideration paid to where to 'look'. Mental training can also be highly beneficial.

John Shepherd

Jargon buster

Electromyographic activity – The measurement of the electrical activity in muscles. The more there is the greater the amount of muscle fibre recruitment
Isometric – Muscular action involving no movement – *eg* in the shoulders and chest when holding a static press-up position
Isokinetic – Muscular action involving concentric and eccentric action at a constant speed
Concentric muscular action – The shortening of a muscle under tension
Eccentric muscular action – The lengthening of a muscle under tension

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Short and sweet – why all footballers should consider 40m sprinting!

Many footballers will go through a battery of fitness tests throughout their career. One of the most widely used is the 40m-sprint (the 40-yard dash in the USA), which is used to test speed. There is no need for a footballer to sprint for much more than 40m considering the length of a football pitch. And if your 40m is dramatically improved then it is likely your 5m, 15m and 25m times will too. So here's how to gain that extra yard.

While it's true that there are other speed tests that are relatively easy to administer and which provide immediate feedback for coaches and athletes, the 40m test is so prevalent in sporting circles that athletes may benefit from training plans that improve their 40m sprinting, as well as their linear speed to assist their sporting performance. Indeed, in the USA, whole training programmes, websites and camps are devoted to "improving your 40".

This data is relevant to football where players are not only required to run bursts of similar distances during the game, but also need to have high top speeds and good acceleration; *eg* being first to a ball or racing back to get into defensive position.

Running, jumping or squatting?

In order to improve running speed over 40m shouldn't you just practice running 40m? Inevitably, practicing any skill that is going to be tested will result in improvements in untrained subjects as a learning effect takes place. However, developing

strength through weight training exercises such as the squat, or power through exercises such as plyometrics or jump squats has also been advocated as an alternative to just running.

As usual, research is not 100% clear on the answer, mainly due to the design of the studies and the use of "recreationally trained" or "untrained" subjects (such as university students) who are usually male, instead of well-trained athletes. The training effect demonstrated in these studies may therefore not be especially relevant for those who are better trained or are female.

What is clear however is that running the 40m requires acceleration over the first 15m, which is improved by forward body lean and short but quick strides with minimal ground contact time and with a large force[3]. From 15m to 40m, stride length increases, with the rear leg fully extended, pushing off the track with the toes and then drives forward with a high knee action. Squatting and jumping exercises that reproduce either a quick ground contact time or allow the triple extension of the hip, knee and ankle are most commonly used. These include jump squats, cleans and bounding drills.

Decreasing the ground contact time without increasing the ability to increase force proportionately will result in slower linear speed because the acceleration produced will be less. Developing power with resistance training is usually achieved by either using heavy weights (70-90% 1RM) and low velocity or lighter weights (30-50% 1RM) and high velocity movements. Both have been found to be effective when using squat, hip extension and hip flexion movements in improving 20m acceleration time[4].

Improving maximal leg strength may prove to be crucial in improving speed in untrained subjects, but less so in experienced athletes. This is due to the fact that a large increase is needed in leg strength before a corresponding increase in speed is seen. A large strength increase is easier to achieve in untrained subjects than those who have been training for 10 or more years.

In trained subjects, squatting immediately before sprinting

may produce an acute effect over 40m due to post-activation potentiation (PAP)[5]. One set of three heavy squats at 90% 1RM were effective in reducing 40m sprint time in college American football players compared to three squat jumps with a 30% 1RM load. A 4-minute rest period was enforced between the exercise and the sprint. However, this is not recommended for untrained subjects as the squats would have an unduly fatiguing effect and reduce the ability to produce power.

The recovery phase

Most studies have looked at training the drive phase of the sprint action; however, training the recovery phase could be just as important. One study using untrained subjects improved 40yd times over 8 weeks by using elastic bands to improve hip flexor strength for the recovery phase[6]. The subjects tied the elastic band around their ankles and then reproduced the high knee lift against the resistance of the band. The subjects improved hip flexor strength by 12% and decreased their 40yd time by 9%.

The idea of reproducing this action under load is sound, but it is unlikely to work in trained subjects due to the limitations of using elastic bands. Unlike using free weights or cables, which require a large initial force to overcome inertia, bands have little inertia at the beginning of the movement, but resistance increases towards the end of range. This results in early deceleration, which is counterproductive in most athletic movements.

Sprint training protocols

As the 40m is a very specific running test, and most training time is limited, the running drills need to be very effective. Running a series of 40m sprints, with "walk back recovery," which is common in team environments, may not produce the best results. Instead, carefully managed rest times that allow recovery of the phospho-creatine energy system should be used. This will then help the athlete run at their top speed for each sprint in the training session. Rather than run the same set of drills in each session, it may be best to include some over-speed and uphill sessions as well as normal sessions.

Sample 40m sprint training programme for soccer

Concentrating on 4 areas: technique, strength, sprinting, plyometric training (energy system conditioning is assumed to be done as part of the team training sessions thought the use of small sided games)

A – Off season

Technical drills to be done for 10 minutes as part of soccer team training warm ups.

Strength (2 sessions per week)
Squats 4 sets of 3 reps @ 90% 1RM 2mins rest between sets
Jump squats 4 sets of 5 reps @ 30% 1RM 2mins rest between sets
Cable leg drive 4 sets of 5 reps @ 30% 1RM 2mins rest between sets

Plyometrics (2 sessions per week)
Double leg bounds 10m; progress to 20m
Tuck jumps continuous 2 sets of 10 reps
Single leg bounds for distance 10m; progress to 20m
Single leg bounds for speed 10m; progress to 20m

Sprints (2 sessions per week)
Session 1
Alternate each week between resisted sprints towing a 10kg weight or an uphill run of 40m at 3 degrees. 4 resisted\uphill sprints, 3mins rest between reps. 4 flat 40m sprints at full speed, 5mins rest between reps.
Session 2
4 downhill sprints for 40m at 3-degree decline, 3mins rest between reps. 4 flat 40m sprints at full speed, 5mins rest between reps.

Sample week for a player who does 2 team sessions in the off season; player does 2 sprint sessions, 2 plyometric sessions and 2 strength sessions each week.

	Sun	Mon	Tues	Wed	Thurs	Friday	Sat
Session1	Rest	Sprint1	Plyo1	Rest	Plyo2	Rest	Strength2
Session2	Rest	Rest	Team	Strength1	Team	Sprint 2	Rest

B – In season

Sample week for in-season training; only one strength, plyometric and sprint session per week in order to avoid fatigue (because of the high number of matches being played)

	Sun	Mon	Tues	Wed	Thurs	Friday	Sat
Session1	Rest	Sprint	Rest	Match	Rest	Plyo	Match
Session2		Strength	Team		Team	Rest	

Incline or running with resistance is designed to increase ground contact time and reduce stride length, which may be useful in the initial 15m of acceleration. Downhill running or overspeed training is designed to increase stride length and reduce ground contact time, important in the 15-40m phase of the sprint. When using inclines, declines, resisted or overspeed training methods, it is important to observe running mechanics. Too much incline or resistance will result in severely altered running styles and poor posture, which then has a detrimental effect when the resistance is removed. The same is true for decline or overspeed training (being towed).

Two recent studies had different views on this. The first used a protocol of towing (over-speed sprints), pushing (resisted sprints) and normal sprints and compared the three groups over 22m[7]. The subjects were untrained college students and the sprint sessions were conducted three times a week for 6 weeks and consisted of sprinting 22m five times.

All three groups improved their times at their own protocol (*ie* the resisted group got better at running against resistance) but the transference to flat speed was greatest in the normal sprint group and then by the overspeed group. The short-term nature of this study indicates that the adaptations to the training were neuromuscular in nature; the subjects became more efficient at their drills. This may not have transference to sport specificity, but if you are trying to get good at a one-off 40m test, then training at that speed for 6 weeks may help. However, in the longer term, you are unlikely to get better results by just doing that.

The second study combined uphill, flat and downhill running into the same session to provide resisted, tempo and overspeed stimulation to the subjects and compared that to just uphill, flat or downhill sessions (without resistance or towing)[8].

The researchers designed and built a wooden platform that had a 20m flat portion, a 20m incline at 3degrees, a 10m flat portion at the top, a 20m decline at 3 degrees and then a flat 10m at the end. The combined uphill\downhill group ran this 80m total six times with 10 minutes rest between sprints, three times

a week for 6 weeks. The other groups ran the same total distance, but in shorter bursts using the same platform, so they ran 12 sets of 40m combing the flat and either the down or the up portion of the platform.

At the end of the six weeks training, the subjects were tested over 35m and the combined uphill/ downhill group showed a 3.4% increase in top speed with the downhill group showing a smaller 1.1% increase. The flat and uphill training groups made no significant changes to running speed after 6 weeks of training. The key factor distinguishing between the downhill only group and the combined uphill/downhill group is that the latter had their neuromuscular system overloaded, then unloaded and then assisted. This loading and unloading in the same session could be the difference and is worth trying in training.

Other benefits of practicing 'the 40'

Regular sprint training can lead to better sprint times, but could it also be used as a training tool in itself leading to other physiological improvements. Plyometrics are often used as an effective training method to help reduce ground contact time for sprinters and jumpers. A Croatian study compared a sprint training protocol with a plyometric protocol over ten weeks and looked at the effects on drop jumps, countermovement jumps, squat jumps and squat strength as well as 20m sprint time and 20yd shuttle runs[9].

Both groups improved their jumps but the sprint group also improved their isometric squat strength and their speed and agility scores. This study showed that sprinting could be used as a training tool that has similar or better effects than plyometrics. The same researchers also analysed anthropometric characteristics of the two groups and found that the only significant change was a 6.1% reduction in body fat in the sprint group[10].

Summary

Assumptions may be have to be made in designing training protocols for well trained athletes due to the paucity of research using trained subjects. However, it does appear that once a well

Testing 'the 40'

Whilst testing the 40 is theoretically quick and easy to administer, experience shows that it can't always be done. One major problem is the weather. Indoor facilities that have a 50m space in a straight line (you have to allow at least 10m for safe deceleration at the end) are rare. Outdoors, the surface has to be dry to allow foot purchase and should be consistent between tests to establish reliability. Athletic tracks that have surface water on them become very slippery and injuries could occur.

Wind is also a factor, with tail, head or cross winds all affecting the times. If you are just conducting one test to establish who is quickest on your team, then wind is not a problem because the conditions are the same for everyone. But, if you are using the data to monitor progress over time or comparing to players from other parts of the country, then conditions become important.

Equipment used could be handheld stopwatches or electronic light gates. If using handheld times, then up to 3 testers should be used and an average between the 3 scores recorded[12]. If using electronic gates, make sure you have spare batteries, as they can become depleted quite quickly. Mark out the distance with an accurate tape measure and ensure you get metres and yards correct – I have seen the two confused and some very fast scores recorded!

Allow athletes sufficient time to warm up, providing a general and then specific warm up with speed drills. Then allow each athlete three attempts to run their quickest score, with rest time between each attempt. The starting position is important, from a 2 point or 3 point stationary start; on the line or 75cm behind the first electronic gate. The times recorded will be different for each protocol, but the consistency between tests is crucial- everyone must follow the same protocol. There's no evidence that athletes competing against each other over 40yds run faster than when running against the clock (or vice versa), so whichever method is easier for you to administer should be used[12].

developed strength base is in place with sound sprint mechanics, the use of different sprint speeds and drills followed by normal mechanics at top speed is more effective than running just flat speed drills.

In untrained subjects the most effective way to improve 40m speed over the short term (circa 6 weeks) is to practice the test and coach the running style well. This will be effective once, but

for those athletes who are tested regularly, a solid strength base needs to be developed in combination with power exercises either in the gym or using plyometrics.

It's worth commenting on the use of time spent on sprint drills. Most coaches who have limited access to their players will not allow players to spend even 10 minutes doing nothing in their training session; taking up a whole evening doing 6 maximal sprints over 40m with 10minutes recovery will not therefore go down well. Try doing that on a rainy night in January and your players won't like it much either! Doing 20 sets of 40m sprints with 'walk back recovery' may look busier and the players will be tired, but it won't help their 40m speed either! Working lower body strength and power in the gym however will have a twofold effect of improving sprint speed and also overall conditioning, which will help in contact and collision sports.

James Marshall

Jargon buster

Postactivation potentiation – An increase in the contractile property of muscle after a series of previous contractions due to a combination of chemical, neuromuscular and mechanical changes in the muscle[13]

Phosphocreatine energy system – Generates ATP for immediate efforts of activity from two to seven seconds in duration

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Cool down or warm up? Maximising the impact of your half-time break

Maintaining an optimum body temperature is vital for maximising sport performance. But what are the most effective half-time strategies when the mercury rises and how can you combat second-half fatigue and injury?

Having grown up playing football, my early recollections of the half-time interval are dominated by one thing – oranges. Each week either the forwards or the defenders would supply the oranges, which were sliced into quarters by a dutiful parent and left waiting in a bucket for the team to grab as they entered the changing rooms. Of course, modern science would dictate that the tiny amounts of antioxidant, fructose and carbohydrate contained in our quarter orange could not significantly enhance our second-half performance. Still, on oranges alone we felt we could fly.

While sucking on an orange may have once provided a sufficient half-time recuperation strategy, succeeding in team sport often requires much greater attention to detail. Any half-time strategy should address two key aims:

- Enhance second-half performance;
- Effectively manage the incidence and impact of injury.

Reviewing the available science can help when devising a half-time strategy. However, the practicalities of the sport you are involved with are just as crucial. How long is the half-time break? How likely is a half-time substitution? What is the injury

profile of the sport? Could a half-time strategy impact on the incidence of second-half injury? And don't forget the coach. What does the coach think?

It's probable that more games have been won by a half-time tactical change or moment of inspiration delivered by the coach than have been by cooling the ice buckets to precisely 8° – or should that be 11?

Ultimately, the half-time interval provides a paradoxical challenge: to recover from the first half while at the same time preparing for the second. Should we be cooling down or warming up?

Cooling down

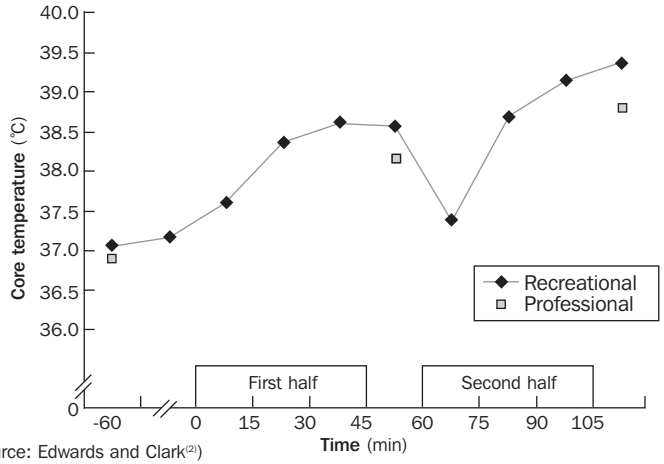
There is clearly a trend amongst sports people, particularly within elite sport, to make use of cooling strategies. Various methods of cooling, such as ice bath immersion and contrast water therapy form the staple of many post-exercise recovery strategies. Pre-cooling has also been employed for some time, particularly by endurance athletes, and millions of viewers worldwide witnessed UK runner Paula Radcliffe donning an ice vest prior to the Athens marathon.

'Any half-time strategy should be well planned, structured and efficient to give the coach and performance staff the best possible opportunity to focus on tactics and motivation'

But what about half-time cooling strategies? The unusually high temperatures during the 2006 World Cup in Germany demonstrated the difficulty of sustaining a performance level throughout a game in high ambient temperatures. Could a half-time cooling strategy help? Is cooling between bouts of exercise different to cooling after or before a single exercise session? And does the intermittent and varied intensity of activity during football make cooling less relevant than for continuous endurance sports? If half-time cooling is to help performance, it is worth looking to science to gain a brief insight into temperature change and regulation during team sports.

An American study utilised a probe contained within a pill swallowed by the subjects to compare the thermal responses between American footballers and cross-country runners during training in temperatures ranging from 28 to 34°C[1]. The footballers wore full padding, making direct comparison between

Figure 1: Change in core temperature from rest to full time in recreational and professional soccer matches
Note the lower rise in core temperatures at the end of the first and second halves in professional players



(Source: Edwards and Clark[2])

the groups difficult. However, as expected, both groups had a significantly higher core temperature following practice. But while prior to training it was the footballers who had significantly higher temperatures than the cross-country runners, after training the cross-country runners had the higher temperature. Among the cross-country runners, core temperature increased steadily throughout the continuous training, while for the footballers, it rose and fell depending on the intensity of their practice.

Interestingly, despite a higher core temperature after training, the cross-country runners exhibited better hydration levels than the footballers. Exercise type, intensity and metabolic rate may be a more significant determinant of core temperature than hydration status alone, making an appreciation of the physical demands of individual player positions, as well as the overall game, important when considering a half-time cooling strategy. The pattern and effect of temperature change and regulation may be quite different between midfielders and goalkeepers, for instance.

A similar study compared the core temperature of recreational university footballers with that of professionals from an English Championship team[2]. Both games were played in more comfortable ambient temperatures, ranging from 16 to 19˚C. Core temperature was taken before the game and immediately after each half. For the recreational players, measurements were also taken at 10-minute intervals throughout each half. The results of this study are shown in Figure 1. For the recreational players there was a significant rise in core temperature during both the first and second half of the game, despite temperature returning almost to resting levels after the half-time interval. In contrast, while there was also a significant increase in core temperature during the first half for the professional players, their temperature stabilised during the second half and did not rise significantly further by the end of the game. Put simplistically, the professional players were probably acclimatised to the demands of the game and demonstrated a greater capacity to self-regulate their temperature through more pronounced sweating.

In general terms, your pattern of temperature change and regulation during the second half of a match is likely to be determined by a complex interaction involving your level of acclimatisation to both the demands of the game and any extremely hot weather conditions you are forced to play in. Of course, nothing is quite as straightforward as it seems, and rather than slowing down directly because of a rise in core temperature, generated by the production of heat within your muscles, your brain may actually regulate the rate at which your temperature increases by limiting muscle recruitment and consequently limiting how hard you can keep going[3]. The pace at which you play may actually be set quite early during the match, based on an anticipatory response to ensure that you do not reach a dangerously high temperature later on in the game. Of course, the intermittent pattern of intense activity in most team sports makes this regulation and pacing a constantly changing, dynamic process.

Your brain regulates exercise output to protect against

excessive body heating. How effectively your body is acclimatised to coping with heat production, particularly on extremely hot days, will largely determine how able you are to keep going in the second half.

If you choose to instigate a half-time cooling strategy, particularly on hotter match days, you are essentially hoping to delay any rise in second half temperature and trick your brain into allowing you to keep running harder for longer. As mentioned though, pacing and work rate are ultimately set by your brain and no half-time cooling strategy can expect to entirely override your level of acclimatisation. It may be that the greatest benefit of cooling during half-time, particularly on extremely hot days to which you are not well acclimatised, is to help you feel more comfortable during the break and better able to focus on performance and the coach's instructions.

'How effectively your body is acclimatised to coping with heat production, particularly on extremely hot days, will largely determine how able you are to keep going in the second half'

Practical considerations

Any pre-cooling methods that aim to lower core temperature cannot be done quickly or easily. The good news is that cooling your skin, without a corresponding lowering of core temperature, can help to improve self-paced performance, even in warm, humid conditions. A study conducted at the Charles Sturt University in Bathurst, Australia showed that cooling the skin helped subjects to cycle almost a kilometre further in a 30-minute self-paced laboratory test[4].

The bad news is that, like the majority of studies which look at pre-cooling, this study was concerned with performance of continuous exercise; cooling was carried out before and not between bouts of exercise, and the cooling involved a procedure that was time-consuming – in this instance immersion in cold water (8-11˚C) for 60 minutes! That's a heck of a half-time break. Better news is that a recent study looked at only 12 minutes of cold-water immersion between bouts of continuous exercise[5]. Subsequent self-paced running performance was enhanced by this cooling strategy, but even 12 minutes of cold-water immersion is unrealistic for most half-time breaks and the relevance to team sports remains questionable.

If you are going to use a half-time cooling strategy, utilise simple methods such as ice-packed towels draped around your shoulders. Try submerging your hands in cool water or simply removing your playing vest or any excessive protective clothing. For professional teams, a half-time change of kit may be beneficial.

Finally, have ice bags available for players to commence icing any suspected injuries as soon as they enter the changing rooms. Half-time is a convenient opportunity to assess any first-half niggles and it makes sense to start icing while you wait for the club doctor or physiotherapist to assess you properly. If you have to make a decision about an injury yourself, ask three simple questions and be honest in your replies:

- Can I cope with the discomfort during the second half?
- Will I be able to contribute properly to the team?
- Will there be any consequences later on if I do continue to play?

Risking further injury during a World Cup final is one thing, but it's not worth compromising your long-term health and livelihood for the sake of a Sunday pub league game – really!

Warming up

It is beyond the scope of this article to look critically or in detail at the components of an effective warm-up. Frequently, however, many people attempt to draw an association between the incidence of injury and lack of an appropriate warm-up. If this were the case, then it could be expected that the majority of injuries occur early in a playing period, as players will become more, and not less, warm as the game progresses. Could this justify a warm-up strategy during the half-time break? Science doesn't answer this question explicitly, but it does help to construct some considered views, which may help when devising a suitable half-time strategy.

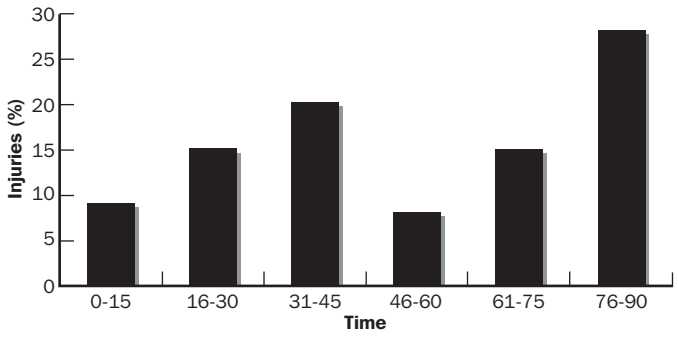
Let's start with the epidemiology of injuries. The Football Association (FA) performed a large study between July 1997 and May 1999, spanning two entire seasons of English football. Club doctors and physiotherapists from 91 of the 92 football league

clubs returned audit forms to the FA researchers, providing information about the injuries suffered by their players.

Two of the most common injuries reported were hamstring strains[6] and ankle sprains[7]. The graph below illustrates the timing of all hamstring injuries reported during matches. A graph detailing the timing of ankle sprains during matches is remarkably similar. Far from the majority of these injuries occurring at the beginning of a playing period, when the subjects were less likely to be warmed, the FA found that nearly 50% of the reported injuries occurred during the last third of each half. For hamstring strains, the period immediately after half-time was actually identified as having the lowest incidence of injury. While no data was recorded from these studies concerning the nature of warm-up before the game or during half-time, it is evident that fatigue plays a considerable role in the incidence of these injuries.

Another large prospective study, this time looking at 12 of the 13 professional rugby union clubs playing in the English premiership during the 2002/3 and 2003/4 seasons, reported the timing of all injuries sustained during match play[8]. Once again, the majority of injuries were sustained during the latter stages of each half, particularly the second half. It is hard to escape the conclusion that fatigue presents a greater risk to you than not warming up adequately before the second half.

Figure 2: Time of hamstring strains sustained during match play



(Source: Woods *et al*[6])

Suggested half-time strategy

Phase I
- Commence hydration strategy
- Injury identification and management
- Ice available immediately
- Assess injuries
- Notify coaching staff of performance impact
- Implement any injury management
- Rest

Phase II
- Coaching/performance input

Phase III
- Set arousal level
- Prime motor system

Unfortunately, this leaves you sounding a bit like you are built like a car – burn all the fuel reserves in your muscles and you can't accelerate any more. As you may guess, fatigue, like temperature regulation, is a little more involved than this. Fatigue is often defined as an inability to sustain force production within a muscle or group of muscles. The distance covered and amount of high-intensity running towards the end of a top class football game has been shown to be lower than at the beginning[9]. Other changes may also occur, such as modifications in the way you recruit muscles or your ability to balance. Certainly, it is unlikely that you are quite as fast or agile at the end of a game as you were at the beginning. But what is the fatigue mechanism leading to this reduction in your performance? Could an understanding of this process help in determining your half-time strategy?

Peripheral fatigue is the term given to changes that occur within the muscles over time, compromising performance output. Physiologists and nutritionists have looked closely at the reduction in muscle energy stores during the course of a game and certainly it is reasonable that a reduction in glycogen levels limits your capacity to sprint at the end of a game. However, it is generally accepted that fatigue also has a central component. Central fatigue refers to a reduction in the ability of your brain and nervous system to command or drive your muscles to work and help you perform at your best. It is widely considered that

due to the widespread and complex connections within your brain, motivation, mood and arousal also impact on central fatigue. This may explain the observation that football players can experience fatigue temporarily during a game.

An interesting view on fatigue is offered by a group of South African scientists who have undertaken work considering the sensation of fatigue[10]. Rather than occurring within the muscles, they suggest that fatigue is a sensation derived from feedback to the brain, such as the speed at which you are burning energy reserves. Just as changes in core temperature serve as a stimulus for your brain to regulate muscle activity, the sensation of fatigue may also form part of a constantly shifting regulatory system that determines how hard you can continue to perform in the second half of a game.

After periods of rest or less intense play, while you won't have replenished all the glycogen reserves you have used, the rate at which you are depleting them may have lowered and you will be able to raise your performance level for a short period of time again. Your best chance of addressing fatigue during half-time may be to strive to remain motivated and set your arousal level appropriately for the second half. Sometimes this may actually mean calming down. It is probably not a coincidence or simply a matter of better conditioning that the victorious team always look fitter and fresher at the end of a match. Giving your central nervous system a last-minute wake-up may also be worthwhile, perhaps with a short series of maximal sprints as you return to the field.

Summary

Ultimately, half-time should be about performance. If you are going to implement any strategy, make sure it is planned, structured and efficient to allow the coach maximum time to focus on tactics and team matters; this really will make the biggest difference. Who knows, not only might you surprise yourself with your second-half performance, you might even get picked for the following week's game!

Matt Lancaster

Jargon buster

Contrast water therapy – Repeated, alternate immersion (whole or part) in cold and hot water

Epidemiology – The term used for studies that look at the incidence, circumstance and consequence of injury or illness in terms of statistical associations among larger populations or sample sizes

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What's best for maximising 90-minute performance?

The half-time nutritional strategies employed by many football teams often rely as much on tradition, fashion and even sponsorship deals as they do on sound science. But with sports like football becoming so high profile, nutritional strategies are becoming increasingly sophisticated, with many teams employing full-time nutritionists and sport scientists. Increasingly, top teams are using specialist sports drinks and other products with an emphasis on different priorities for different positions and individuals.

The traditional approach to half-time nutrition usually involves a cup of tea and a slice of orange, and like many nutritional practices that have stood the test of time, this almost certainly has some merit. Similarly, other foods such as high-carbohydrate cakes, confectionery and even jelly babies have been advocated because they contain useful energy. Some scientific papers have even recommended snacks like pretzels because they contain high levels of sodium[1].

However, these kinds of products may also contain other ingredients that are not entirely beneficial for sports performance. For instance, it may not be possible to measure the performance detriments of hydrogenated vegetable oils or trans-fats in a single game but their negative effects on health are well documented, which is why they're banned in several countries. Similarly, colourings and other additives are often contained in these kinds of products, which have at least been associated with disruptive behaviour and poor concentration in school children, if not some of the crazy on- and off-ball fouls often seen on TV[2]!

So what are the main factors to consider when planning nutrition in the half-time interval? Since the first World

Congress on the Science of Football was held at Liverpool in 1987, there has been much published research on the physical demands of football and other team sports, and the nutritional status of participants. Fluid, electrolyte and carbohydrate needs have been studied during training and in match simulations, as well as the effects of dietary manipulations on sport-specific skills. Fatigue has been observed as a transient phenomenon during matches and general performance declines towards the end of matches. However, the underlying factors responsible for fatigue during football are still not fully understood[3,4].

There have been very few studies that have looked specifically at a nutritional intervention at half-time and its effect on performance in the second half. An as yet unpublished study, presented at the 2006 American College of Sports Medicine annual meeting, showed that players who had been fed a mixture of protein and carbohydrates at half-time performed worse in the second half than those given a carbohydrate drink. However, the principles for effective nutritional strategies need to be deduced from the research based on the demands of the game and the factors known to limit physical performance. Case studies are therefore important.

Physical demands of football

The energy cost of competing in a match is much higher than an even-paced run of the same distance, as there are numerous changes of pace with many periods of intense activity, which is typically associated with heavy demands on carbohydrate energy supply[4]. Within football, different league standards are often associated with different activity levels, with the premiership clearly differentiated from lower levels by the increased volume of high-intensity play[3].

Outcomes in team sports are highly influenced by skill, so it is also important to consider factors that may influence skill and concentration when considering strategies to optimise performance. Often these factors go hand in hand with carbohydrate depletion, associated with reduced exercise capacity and poor concentration – effects that may be compounded by

dehydration. Both dehydration and muscle glycogen depletion have been associated with injury and accidents, so efforts to prevent these affecting performances could have repercussions well beyond the immediate match.

One of the main difficulties in discussing nutritional strategies for the half-time interval in order to optimise performance in the second half is that the factors may vary according to the state that players are in prior to the match. In the early 1990s, scientific publications commenting on nutrition for football tended to suggest that even when players were consuming sufficient calories to meet their energy needs, they should consume more carbohydrate in order to recover between training sessions and to maximise muscle glycogen stores prior to a match[5,6].

More recent publications, whilst stressing the importance of replenishing muscle glycogen stores between training sessions and the potential benefits of carbohydrate loading for matches, have also warned about the over-consumption of carbohydrate if optimal body composition is to be achieved[7].

However, studies using dietary analysis continue to suggest that many soccer players are failing to consume sufficient carbohydrate to optimise carbohydrate stores[8] and two Spanish studies published in 2005 suggested that the eating habits of young players were so poor that nutritional intervention and education was necessary in order to improve general healthy dietary practices[5,6].

The impact of carbohydrate supplementation during the half-time interval could well depend upon the prior eating habits of the player. Similarly, the rehydration needs, and therefore the efficacy of half-time rehydration strategies, will depend on the pre-game hydration status as much as the playing conditions and player work rates. Researchers from Pennsylvania State University recently investigated the effect of dehydration and rehydration on basketball skill. Urine tests showed that some subjects taking part in the experiment were already dehydrated when they arrived at the experiment venue, even though they had been encouraged to stay well hydrated the day before each trial[9].

'Both dehydration and muscle glycogen depletion have been associated with injury and accidents, so efforts to prevent these affecting performances could have repercussions well beyond the immediate match.'

This situation is probably reflected in real game situations, especially where squads are not monitored closely in their build-up to games. Sport nutritionists working with Premier League football clubs have noted that players often turn up to training less optimally hydrated during cold weather than in the hotter months. This may be because players give hydration less priority when the sun is not shining and are unaware of the increased water vapour losses in cold conditions.

The growing use of under-pitch heating also means that more games can be played in very cold air temperatures, where water vapour losses are significant. If well-monitored players at high levels of sport are often sub-optimally hydrated, there's a good chance that players in other leagues are starting matches in a sub-optimal state and will therefore be in a worse state at half-time than necessary.

Just enough and no more

Scientific studies of sub-elite sportsmen and women show there is much to be gained by replacing fatty, energy-dense foods with more carbohydrate[10,11]. However, at the very elite end of sport, nutritionists are fine-tuning energy and hydration provision to provide just enough.

This is to maximise power-to-weight ratio; each gram of carbohydrate stored as muscle glycogen is bound to 3g of water, so if a player starts with 500g of muscle glycogen and this is used during the game it will release 1.5kg of water. This released water is important when considering the fluid and energy requirements at half-time.

While dehydration resulting in a loss of body mass of 2% or greater can result in reduced endurance exercise capacity, and sprinting and sport-specific skills can be adversely affected by losses of 3% or more[3,9], players are able to tolerate a level of dehydration. There's no merit in encouraging players to consume more fluid than required to maintain performance, because this would be the equivalent of sending players out with a weight vest! However, any change in body mass should not be calculated by the difference between that immediately prior to

the match and half-time, but instead baseline body mass should be established by early morning measurements taken before any carbohydrate loading has taken place[12].

Although there are some reports of footballers losing up to four or five litres per hour of sweat in very hot and humid environments and up to three litres in temperate climates, sweat losses closer to two litres per hour are probably more typical[1,3,12]. In such cases, a half-time fluid consumption of between 500 and 800mls should be sufficient to prevent a decrease in body mass greater than 1% during the second half.

Individual differences

Recent publications studying the sweat response and water and electrolyte needs of footballers have noted that there are wide individual differences amongst the same teams that were not position dependant[1,12]. In an ideal world each individual would have a specific fine-tuned nutritional strategy, but this can be almost impossible in the squad culture that tends to exist in everyday training situations.

Nutrients, especially electrolytes, may prevent fatigue and reduce muscle cramps in the second half. The most important electrolyte lost in sweat is sodium and research has shown a wide individual variation in sodium losses – as low as the equivalent of 1g of salt to over 6g in 90 minutes. Assuming that players start a match with reasonable sodium stores, most players are unlikely to be become performance limited due to sodium depletion during one match; the main role of sodium in a half-time situation is to encourage fluid uptake in situations where large fluid volumes need to be consumed at half-time (because sodium stimulates thirst).

However, 6g is the suggested total maximum daily salt allowance recommended by the UK Food Standards Agency and there has been considerable pressure from the government for food producers to reduce the amount of sodium in food[13]. It is not clear if 'high sodium sweaters' are so because they consume a high-sodium diet or for other reasons. It is clear, however, that sweat losses of 6g in 90 minutes cannot be

sustained unless consumption is increased beyond the current recommended daily maximum. Unseasonably hot weather and reduced sodium foods may combine to leave players potentially short of this important electrolyte.

Research on many games players suggests that the status of other nutrients is often poor[8,11,14], and minerals such as zinc, magnesium and calcium (found as electrolytes in sweat) and other minerals such as iron[15] may be sub-optimal prior to matches. Whilst a player suffering from fatigue or cramps due to poor nutrition prior to the match may benefit from carbohydrate/electrolyte supplementation at half-time, it's probably better to improve diet between matches rather than try to patch up poor general nutrition with a half-time fix.

Half-time carbohydrate

In players starting with an adequate nutritional status, fluid or electrolyte losses are not usually a limiting factor in performance towards the end of games. However, carbohydrate shortfalls are almost certainly responsible for fatigue in games, irrespective of player position or standard. Low carbohydrate levels can compromise mental skills as well as physical performance, and there is consensus that carbohydrate supplementation can improve performance. Muscle glycogen stores are generally quite low at the end of games, and even when overall stores are not depleted, carbohydrate may be depleted in specific limiting muscle fibres[3].

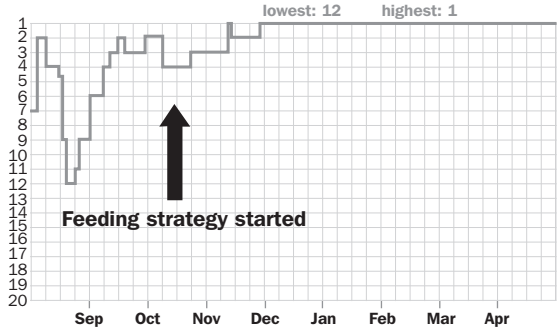
Carbohydrate supplementation to replace lost muscle glycogen makes sense and has been shown to help prevent deterioration in the performance of soccer players in simulated matches[14] and to improve performance in soccer- and basketball-specific tests[9,16]. However, gastric-emptying studies have shown that the activity levels in competitive games are such that they are likely to delay gastric emptying and possibly reduce the effectiveness of carbohydrate drinks given immediately prior to or during matches[17].

To counteract slow gastric emptying, glucose polymers (maltodextrins) have been recommended for many years; they

CASE STUDY

Accrington Stanley Football Club is most famously associated with nutrition via a long-running milk commercial. However, medical and support staff were keen to use scientific sports drinks in order to improve energy levels in the latter parts of games. The strategy needed to be simple to administer and integrate into a squad, have good acceptability and be cost effective. A simple feeding strategy based upon each player drinking 500mls of a 12% glucose polymer/ fructose solution (SIS PSP22) prior to the match and at half-time was initiated in October 2005.

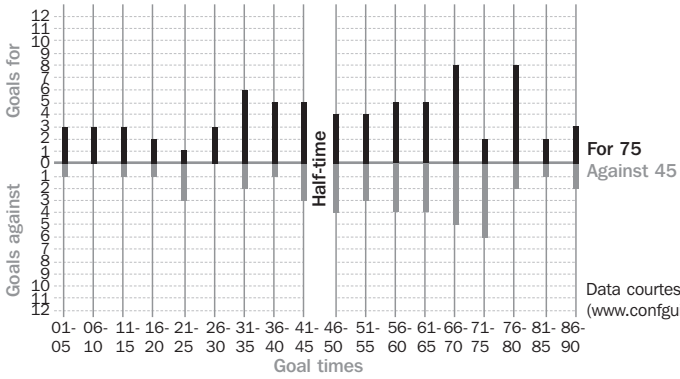
Accrington Stanley 2005/6 league position



Data courtesy of Confguide (www.confguide.com)

The feeding strategy was thought to be a major contributing factor to Accrington's league title success and record-breaking unbeaten run. Medical and support staff point to the timing of 'for' and 'against' goals as evidence; rather than running out of energy, Accrington were scoring more often and conceding less in the latter 15 minutes of each half.

Goal times (minutes) and numbers 2005/06



Data courtesy of Confguide (www.confguide.com)

have a lower osmolality than simple sugars, can improve gastric emptying and are relatively light on the stomach[18]. Recent research from Birmingham University suggests that energy drinks using multiple energy substrates may result in improved energy delivery to the muscles[19]. Combinations of maltodextrin and fructose would therefore seem to be a sensible combination to form the basis of a half-time nutritional strategy, combining good gastric emptying with the benefits of multiple energy substrate transport across the small intestine.

Half-time is, however, relatively short and care should be taken to maximise the opportunity to refuel when gastric emptying is not limited by intense match activity. Isotonic energy gels can be a practical solution, providing players with a bolus dose of carbohydrate as they leave the field, gaining valuable recovery time over a team waiting until they reach the changing rooms to get drinks. Although this article is about half-time nutritional strategies, it also makes sense to use any natural breaks in the game to take on carbohydrate, and fluid/electrolytes in hot conditions.

It's worth cautioning against a 'one size fits all' policy with regard to player nutrition. A strategy of ensuring that each player consumes at least 400-500mls of 10-12% glucose polymer/fructose solution is a good baseline for half-time refuelling. In hot conditions, and for players with very high sweat rates, more fluid may be needed to prevent dehydration reaching detrimental levels. Fluid requirements can be checked by comparing half-time weights to baseline measures in training matches, and players should be encouraged to fine-tune their thirst perception using this feedback. When 800mls or more of fluid needs to be drunk at half-time, it is possibly useful to consume solutions containing at least some electrolyte, especially sodium.

Inappropriate and devious strategies…

The most inappropriate nutritional strategy must go to the Sunday league team who were sponsored by a brewery and really did drink a pint of the sponsor's lager at half-time. Apparently they all thought they played better in the second

half, but no one had done the match analysis and they were keen for it to stay that way!

The most devious nutritional strategy involved the use of high-tech sports drinks and gels for the home team but sugar-free cordial and sweeteners rather than sugar for the tea that the league rules obliged them to provide for the visiting team. A lesson perhaps for visiting teams and sports people to be self-sufficient, but it was surprising how long the home team were able to get away with this tactic by explaining that 'Sugar is not healthy and you wouldn't want your guys getting fat would you?!'

Summary

Do

- Try to take account of individual needs as well as those of the squad more generally;
- Maximise muscle glycogen restoration by getting carbohydrate in as soon as possible;
- Modify hydration according to weather/activity levels;
- Remember that in fast games, sweat rates can be at or close to maximal, even in cold conditions;
- Remember that additional water vapour losses can be significant in extremely cold weather and that the advent of heated pitches means that more games are now played in very low air temperatures;
- Tailor half-time nutrition to individual needs – especially important in hot conditions when there may be large differences in sweat rate and composition;
- Consider caffeinated beverages for players who have not been involved in play for long periods. Some teams have reported positive effects of caffeine, and because of the possible beneficial effects on attention and vigilance it could be particularly useful for goalkeepers in matches when they are not involved in play for long periods in games.

Don't

- Wait until the half-time period to fix dietary problems that should have been fixed before the game or several weeks before the game;

- Drink to maintain pre-match body mass. Baseline body mass should be calculated from morning weigh-ins. This is likely to be considerably lighter than pre-match weight. Try to drink a sufficient amount so that weight does not drop by more than 2% of the morning weight;
- Take more carbohydrate or fluid than is necessary. More is not necessarily better and around 120-150g of carbohydrate is probably ample during a 90-minute game. Any carbohydrate calories consumed above that required increases chances of fat gain and any fluid intake above that required to prevent a performance drop will reduce physical performance by virtue of the increased mass of fluid that has to be carried around;
- Carry out other nutritional strategies at the expense of carbohydrate delivery or hydration.

Tim Lawson

Jargon buster

Osmolality – The concentration of particles of a substance per unit volume in a solution (as opposed to weight of substance per unit volume)

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Don't just walk the walk – talk the talk!

The half-time period in a match is not just about refuelling and physical therapy. It's also an absolutely crucial time for the coach and team to gather their thoughts and prepare mentally for the challenges of the second half. The importance of effective communication is hard to overestimate

Looking back to half-time in the 2005 European Champions League final, with Liverpool 3-0 down to AC Milan, according to his Liverpool colleagues, captain Steven Gerrard was in a state of disbelief and was ready to concede defeat. Afterwards, all he could remember of half-time was the manager getting his pen out, writing down the changes he wanted on the board and telling the team to try and get an early goal, as that could make the opposition nervous. But Gerrard said that, to be honest, he just couldn't concentrate. There were all sorts of things going through his head. He just sat there with his head in his hands. He really thought it was over.

The half-time period in a game tends to create an emotional experience amongst the players and the coach. A full review might take place a day or two after the game, which can be generally analysed free of the emotional reactions associated with the game itself. However, at half-time the outcome of the game is yet to be decided. The interval is only around 15 minutes in duration, and is the only direct opportunity the coach will have to speak to all the players and to influence the second-half performance and result.

The half-time team talk will, of course, depend on the score and the coach's perspective of the match. It is also important to note other variable factors, such as the context of the game – *eg* is it a cup match in which the loser gets knocked out? Is it a

league game and what are the league positions of the teams contesting the game? Is one team an overwhelming favourite to win the game? Is the team winning but not performing well?

Football, in particular, is a game with many psychological demands, such as confidence, motivation and concentration, and these demands can be influenced by the situation in the game at half-time. For example, if a team is winning 3-0 and performing very well, it will go into the half-time break with a different psychological perspective from that of the team that is losing. However, if the same team is winning 2-0, and just before the half-time break the losing team score and make it 2-1, the psychological perspective of both teams would be different; the losing team would gain renewed optimism by scoring the late goal, and the team conceding the goal may become frustrated! Half-time is also psychologically important because it's the first time in the game that the players have an opportunity to reflect consciously for a sustained period on the game.

'Coaches can learn a lot about the development of the game at half-time by listening and asking the members of the team questions to prompt a two-way discussion. However, while coaches are typically good at talking, being in charge and giving instructions, they are often poor listeners'

The coach's role at half-time

The main goal of the coach during the half-time interval is to influence positively the second-half performance as much as possible. The coach may give the players feedback on how they are performing individually or collectively as a team, and discuss technical, tactical and physical aspects of the game, including formations, styles of play, changing tempos and pitch conditions.

A key element of a successful half-time talk is communication. This is a two-way process that consists of giving and receiving information. Coaches can learn a lot about the development of the game at half-time by listening and asking the members of the team questions to prompt a two-way discussion. However, while coaches are typically good at talking, being in charge and giving instructions, they are often poor listeners.

It is also important to note that communication is not only verbal. As early as the late 1960s, research in communication had indicated that non-verbal behaviour (*ie* body language) plays an important role in communication[1-3]. Researchers have determined that just 7% of what we communicate is the result

of the words that we use or the content of our communication; 38% of our communication to others is a result of our verbal behaviour, which includes tone of voice, timbre, tempo and volume; and 55% of our communication to others is a result of our non-verbal communication, our body posture, breathing, skin colour and our movement.

Leadership styles

The leadership style also has a major influence on the effectiveness of a half-time team talk. There are several types of leadership styles, including 'authoritarian', 'democratic' and 'laissez-faire' *(see box overleaf)*. It is possible for coaches to use different methods in different situations, and it's important to note that personality types, cultural behaviour and other factors also contribute to coaching styles.

Some coaches display a combination of the different leadership traits, whereas others favour one style in particular. A good coach will adapt his or her leadership style to expectations, knowledge, experience and group members. For example, if a group is hostile, the leader may prefer to adopt an autocratic style. If the group is friendly the leader may choose a more democratic, person-centred style. Problems can arise if strategies for preparation used by the leader do not match the group expectations of the team.

Psychology of half-time substitutions

As with other factors in a match, like scoring a goal or a poor refereeing decision, the psychology of a second-half substitution can change the tactical aspect of the game and give an insight to what the manager's state of mind may be. For example, if a team is winning 2-0 at half-time and the manager of the winning team substitutes an attacking player with a defensive player, this could be perceived as being a negative tactic, and possibly that the manager doesn't have confidence in the team to carry on playing the same style; or as a statement by the manager saying 'we are going to hang on to our 2-0 lead, rather than seize the initiative and extend the scoreline'.

Comparison of coaching styles: 'Big Phil' Scolari and Sven Goran Eriksson

Two very different styles of leadership were clearly evident at this year's World Cup finals in Germany: the Portugal manager Phil Scolari's autocratic ('do as I say') style and the England manager Sven Goran Eriksson's democratic (involve the players in decision-making) style. The autocratic style, which fits in with Phil Scolari's approach, can be broken into two types – 'telling' and 'selling'. The democratic style, which fits in with Sven's approach, consists of 'sharing' and 'allowing'.

Autocratic style – telling (Phil Scolari)

- The coach decides on what is to be done;
- The players are not involved in the decision-making;
- The coach defines what to do and how to do it.

During a game it is clear to see that Phil Scolari is very dominant, authoritative and animated, consistently yelling instructions to the players in the team.

Autocratic style – selling (Phil Scolari)

- The coach decides on what is to be done;
- The coach explains what is required and the objectives;
- The players are encouraged to ask questions to confirm understanding;
- The coach defines what to do and how to do it.

During the game situation, the coach explains the object and purpose of each tactical manoeuvre.

Democratic style – sharing (Sven)

- The coach outlines the training requirements to the players;
- The coach invites ideas/suggestions from the players;
- The coach makes the decision based on the players suggestions;
- The coach defines what to do and how to do it.

Democratic style – allowing (Sven)

- The coach outlines the training requirements to the players;
- The coach defines the training conditions;
- The players brainstorm to explore possible solutions;
- The players make the decision;
- The players define what to do and how to do it.

In practice, many coaches will use a variety of styles and types depending on the coaching situation.

The criteria in deciding who to take off depends on the context of the match, and there are many tactical factors that could influence whether a player should be substituted, and who to bring on at half-time. However, substituting your captain when he or she may not be playing well can have a massive impact on the team's mental state. It may, for example, have a negative effect, producing the belief in the team that the coach is panicking. It can also be a good idea to bring on a substitute who regularly performs well against the opposition you are playing – this may induce panic in the opposing team.

'Substituting your captain when he or she may not be playing well can have a massive impact on the team's mental state'

Sometimes a team's performance isn't always reflected in the scoreline. If the team is playing well and goes into the interval losing against the run of play, is it worth keeping faith in the team to carry on performing well in the second half and hoping that the breaks will come, or does the manager make changes and risk disrupting the flow of the game thereby affecting the team's performance?

Using neuro-linguistic programming in half-time psychology

Essentially, neuro-linguistic programming (NLP) is the study of excellence in how we think, how we behave and how we communicate. It provides a series of techniques, skills and methodologies that can be used to create strategies to enable us to fulfil our potential in all areas of our lives. The brain not only controls the application of skills and strategic movements, but it also affects actual body movements that people used to consider automatic. NLP can help sportsmen and women to gain control over what many consider to be 'automatic' functions of our own neurology. Research has shown that imagining an event can produce the same effect on structures in the brain as performing that event in reality!

For example, research carried out at the University of Chicago into visualisation in basketballers divided a number of people into three groups[4]. Each was tested shooting a number of penalty shots (free throws) in basketball.

The groups were then given different instructions:

- Group 1 did not practise penalty shots for 30 days;
- Group 2 practised shots every day for 30 days;
- Group 3 practised shots only in their mind (visualisation) for 30 days.

After 30 days the three groups were tested again:

- Group 1 showed no improvement at all (as expected);
- Group 2 showed a 24% improvement (not especially satisfactory given that they had been practising with the ball for one month);
- Group 3 improved by 23% (impressive considering they had not even seen a ball for 30 days!).

Applying NLP at half-time

NLP can be applied at half-time in a number of different ways, just by using the principle of positive instruction. Stating what you want rather than what you don't want can have a powerful positive effect on the mind, but many coaches still tell players what they don't want, producing negative thoughts.

'When you shoot don't miss the target' might be the instruction from the coach to player, but would it not be better to instruct the player when he shoots to hit the target? If somebody asks you not to think of the colour black, what immediately comes to mind? The very thing you were asked not to think of! Phrases such as 'don't foul', 'don't lose the ball', 'don't lose the game' can all be replaced by more positive instructions.

Here are some half-time techniques that can be used in sequence to create the right state of mind for the coach and the players. These techniques are 'dissociation', 'reframing' and 'anchoring'. They are aimed at creating a logical state of mind for the coach at half-time and getting the players to go out into the second half in peak mental state to achieve their desired outcome.

Dissociation

Dissociation is about recreating a past experience from the perspective of an onlooker or observer. This means that the person does not re-experience the original emotion but instead

experiences the detached emotions of an 'observer'. This enables the coach to think logically and not emotionally. The technique of dissociation is useful just before half-time, so the coach can think logically and not emotionally when delivering the half-time team talk.

Reframing

Reframing is the process of shifting the nature of the problem. It is the process of changing a negative statement into a positive one by changing the frame of reference used to interpret the experience. If all meaning is context dependent, changing the context will change the meaning.

Depending on the situation at the end of the first half, we can decide from what perspective we want to go out in the second half. A perfect example of a reframe was in the 2005 European Champions League final when Liverpool's manager Rafa Benítez urged his players to 'go out and score the first goal and see what happens from there'. If he had said 'go out and score three goals' the size of the task may have been too great. Another possible reframe is when a team comes in losing; the coach can reframe the situation by asking them to wipe the first half from their minds and just focus on winning the second half.

Anchoring

An anchor is a stimulus that creates a response either in you or in another person. When an individual is at the peak of an experience during an intense emotional state, an applied specific stimulus can establish a neurological link between the emotional state and the stimulus. Anchoring can occur naturally or be set up intentionally and can assist in gaining access to past states and linking the past state to the present and future. Anchors can be used by both coaches and players to produce a state of mind or mood needed for a given situation *(see box, overleaf)*.

Jim Petruzzi

Installing an anchor

- Decide on the state you want to anchor – *eg* being calm and relaxed, confident, motivated etc;
- Choose an anchor (or anchors) that you wish to trigger that state – *eg* press thumb and middle finger together;
- Recall a memory or imagine a situation where you can experience that state – *eg* recall a situation where you were totally calm, relaxed, confident etc;
- When the experience is vivid and you are in the desired state at the peak of its intensity, squeeze your thumb and middle finger together;
- Release the anchors when the experience begins to fade;
- Now do something else – open your eyes, count down from 10 to break the state and distract yourself;
- Repeat the steps above several times, each time trying to make the memory more vivid (not required when the anchor is established at the high point of a real experience, but you can strengthen the anchor by establishing it at the high point of several such experiences);
- Apply the anchor and check that the required state occurs;
- Apply the required anchor during the half-time interval to generate the appropriate emotional state.

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Footballing injuries – are they really on the rise?

During the 2006 World Cup, the media was full of stories about the apparently increasing incidence of injuries among professional footballers. However the reality is far more complicated than the tabloid headlines would have you believe

Football is a highly athletic sport with rapid deceleration, acceleration, single-stance twists, single-stance ballistic movements and aerobatic manoeuvres. This may explain why the overall level of injury to a professional footballer has been shown to be around 1,000 times higher than in industrial occupations generally regarded as high risk[(1)].

During the run up to the World Cup, few can have been unaware of the increased reporting of injuries to high profile footballers. Just 10 days before the start of the tournament, the sporting headlines were full of footballing injury stories.

The Argentina and Barcelona forward Lionel Messi was still recovering from a thigh injury, while his fellow countryman and Villarreal centre back Gonzalo Rodríguez had effectively waved goodbye to his chances of going to the World Cup Finals after tearing a ligament in his left ankle.

Meanwhile, the Germany and Bayern Munich player, Michael Ballack, was also doubtful due to an ankle injury, as was the Dutchman Rafael van der Vaart of Hamburg, who limped out of training after hurting the same ankle he thought had healed.

And with the British media brimming with stories about the fitness or otherwise of Michael Owen and Wayne Rooney, it was hard to avoid the conclusion that the overall incidence of footballing injuries is increasing.

However, there's mixed evidence for this. Increased sport participation does increase the risk[2], but on an hour-for-hour participation basis, it is likely that the risk has remained the same[3]. The fact that certain injuries can keep high profile players away from the game for months or even years brings particular injuries into the public arena.

With this in mind, this article reviews the evidence for injury patterns to the lower limb and spine, the mechanisms of injury, and the trends and possible theories underlying the findings.

Lower limb injuries

With the advent of Wayne Rooney's injury in the run-up to the World Cup, metatarsal fractures have been topical. Rooney fractured the fourth metatarsal in his right foot. This type of injury has also afflicted other international players, such as Edwin van der Sar (Netherlands and Manchester United), Gaël Clichy (France and Arsenal), Ivan Campo (Spain and Bolton) and Paulo Ferreira (Portugal and Chelsea).

The high incidence of metatarsal fractures in football players has raised the question as to whether modern football boots offer enough protection to the foot and whether they are to blame for the high number of foot injuries. Indeed, Rooney was wearing a new Nike model, the Total 90 Supremacy, for the first time on the day that he was injured.

Although Nike denies that its boots are linked to a higher risk of injury, Tommy Docherty, the former manager of Manchester United, said that when he was a professional football player in the 1950s, it used to take six weeks to break a pair of boots in and players used to have to put them in a bucket of water[4]!

The English Football Association also states that, 'players are ill-advised to start a game having not previously worn the boots they are to play in as it may lead to unnecessary injury'. They also go on to advise how to break in the boots progressively during training sessions prior to wearing them in a match, and concur with the idea that soaking them in water may not be a bad idea[5]. The theory here is that the water softens the leather and allows the boot to be broken in faster.

Another reason why we are hearing more of these types of injury is the terminology now used and the increased reporting of the injury by the media. Tony Book, a former professional UK footballer, told the Manchester Evening News that he believes the name of the injury has changed. He believes the old 'broken toe' injury is now reported as 'fractured/broken metatarsal'[4]. This changing terminology, coupled with increased media reporting, may be giving rise to a perceived increase in the number of injuries. There may not be more metatarsal injuries now than there used to be, but we all certainly know more about them[6].

'There may not be more metatarsal injuries now than there used to be, but we all certainly know more about them'

Before MRI scans were widely available, 'ankle pain' was common, but now we have various degrees of 'bone bruises'. Likewise, in 1960, no one had heard of 'Gilmore's Groin', but by 1990 everyone had one! Again, this indicates that with changing times and advances in technology, the terminology changes but the underlying injury does not.

The foot and footwear

When considering the foot in the context of injury, we have to allow for the position of the foot on the ground, the forces applied to it and the type of grip available (in terms of studs or blades) and any additional support offered by the footwear.

Other forces may come into play with the other foot (the non-stance foot), and relate to the instantaneous forces applied to the toes, foot and ankle in kicking the ball, or accidentally kicking or being kicked by another player.

Ideally any boot should:

1. provide good grip and traction to allow rapid acceleration/deceleration and change of direction;
2. provide adequate support and stability for the foot;
3. distribute the load and decrease the shock of impact;
4. protect the foot and toes against direct trauma (ball and another boot);
5. be comfortable and flexible[7].

The older style football boot with its hard toecap and high sides offered protection to the foot and ankle, but limited the range

of motion of both[8]. The design of modern football boots allows the foot and ankle total freedom of movement to provide maximum flexibility to the player.

But has the modern football boot succeeded in protecting the player while optimising performance? Also, have the changes led to injuries elsewhere, such as an increased tendency to rupture the anterior cruciate ligament, by virtue of increasing torsion on the extended knee?

The available research on these questions is far from conclusive, as the literature is full of anecdotal and conflicting evidence. Simply looking at the number of injuries to the foot is of little value since the forces on the foot cannot be accurately assessed and the level of play, position on pitch and technique would have to be taken into consideration.

It is very easy to blame football players' 'tools', but other factors also have to be taken into account and it is highly unlikely that any single factor is to blame for an injury pattern. It is also unlikely that any single factor could be isolated unless there was a large increase in a particular type of injury in association with a particular boot or playing surface.

What the research says

Research has identified three main factors that influence the increased likelihood of injuries in football players:

1. Intrinsic factors, such as age, previous injury history, fitness and skill level;
2. Extrinsic factors such as the amount and quality of training, playing field conditions, equipment (*eg* boots, shin guards) and subjective exercise overload during training and matches;
3. Violation of the rules (foul play)[9].

For example, artificial playing surfaces have been implicated in non-contact injuries of the lower limb, such as ruptures of the anterior cruciate ligament. Evidence from research in America has indicated that there may be an increased number of lower limb injuries when playing on artificial surfaces compared with grass[9, 10].

Again, however, we cannot simply blame artificial grass, as it

appears that variations in shoe-surface traction can also account for some injuries[11]. This includes ground hardness, dryness, grass cover, grass root density, length of studs on players' boots and relative speed of the game. It is possible that measures to reduce shoe-surface traction, such as ground watering and softening, and players using boots with shorter studs, may reduce the risk of football injuries[12].

Studies have indicated that up to 87% of injuries in football occur in the lower limb (thigh, knee and ankle), with only 38% of injuries involving player-to-player contact[13]. With this in mind, non-contact injury mechanisms are under increasing analysis in order to try to minimise and reduce further injuries.

Spinal pain and football

Modern football requires exceptional gymnastic abilities in the spine as well as the lower limbs. The spine, in conjunction with the 'grounded' foot, provides the stable platform for the mobile

Artificial turf

Artificial turf has been around for several decades now. It was originally developed to address the limitations of natural grass in the USA, but was not specifically developed for football, which meant that the style of football tended to change significantly when played on artificial turf. This became very apparent when, in 1981, Queens Park Rangers installed an artificial pitch; players and fans complained as the ball seemed to ping around as if it was made of rubber! As a result, artificial surfaces were never thoroughly embraced by football for high-level competition matches.

The breakthrough came about when manufacturers of artificial turf started to make sport-specific turf for football. The basic construction of the newest generation of artificial turf is a blend of grass-like fibres attached to a special backing with a mix of sand and/or rubber brushed in. This construction has proven to be the most favourable for football to date.

According to FIFA, the installation of this new generation of turf at the Borussia-Park in Monchengladbach is another major step in the quality and development of artificial turf surfaces. UEFA have since announced that approved artificial surfaces would be permitted in their competitions, with effect from the 2005-2006 season.

foot to kick the ball, or for the head to head the ball. The spine is a complicated system of segmented levers with 33 joints stacked one on top of each other, separated by small shock absorbers. It is therefore no wonder that it occasionally fails.

As people age, so do the intervertebral discs, and this process can start as early as the mid-20s. Players are therefore at increased risk of injury to their spine during the peak of their career but this is likely to be a feature of degeneration and heavy demand rather than one of increased rate of injury because of a single occupational aspect of sport.

Considering the number of lower limb injuries sustained by football players, it is surprising that more do not get spinal pain. One possible explanation could be that the selection process for footballers is such that those with back pain develop symptoms early in their career and never reach the status of an elite athlete.

Another explanation is that spinal flexibility, spinal muscle strength and highly developed motor pathways protect the players from the potential damage to the spine that might result in pain. Indeed, severe back pain is uncommon in footballers and injury patterns such a spondylolisthesis (as often seen in cricket players) is absent.

'Considering the number of lower limb injuries sustained by football players, it is surprising that more do not get spinal pain'

One noteworthy exception to this is David Beckham who suffers from back pain. He has been reported to have one leg (left) shorter than the other; this, together with his unique kicking style, may put unusual stress on certain areas of his spine and therefore cause his particular pain and dysfunction.

Seasonality and overuse injuries

Footballers generally only have four to six weeks off from training and playing. If they are not involved in cup games or representing their country, they may stop playing in mid-May and restart pre-season training in July. However, if they are playing for their country in tournaments (such as the World Cup) most players will be lucky if they have three to four weeks of not playing football. With this amount of time spent playing, overuse injuries are not uncommon.

Injury preventions strategies

The simple fact is that football players get injured. Prevention is very difficult due to the nature of football as a contact sport, and the forces generated during the game. However, there are some simple guidelines that can be followed to help minimise injury to players at all levels:

Warm up and down thoroughly to get the body and muscle temperatures up to sporting activity levels;

- Mobilise muscles and mobilise joints prior to any activity;
- Perform specific strengthening of the muscles used during football so that the high forces generated can be absorbed effectively;
- Include training activities that replicate the activities of football; eg sprints, twisting, turning, jumping, kicking;
- Control the amount of football the player plays (eg incorporate adequate rest/light training sessions);
- Try to use the best possible footwear and shin pad design.

Overuse injuries are unlikely to be a significant influence in overall injury trends. The risk of injury is related to the time spent playing (just as the risk of a driver crashing a car is related to the number of miles travelled). Below a certain minimum playing time, the risk is increased where there is a lack of skill or training or there is poor fitness, but above this level, increased play, on balance of probabilities, will result in increased injuries.

Although this makes sense, research has found that top level football players who also represented their country in a World Cup (and so played more games than players who did not play for their country) did not show any increased risk of injury during the season, and actually had a lower injury risk at training than non-World Cup players[14].

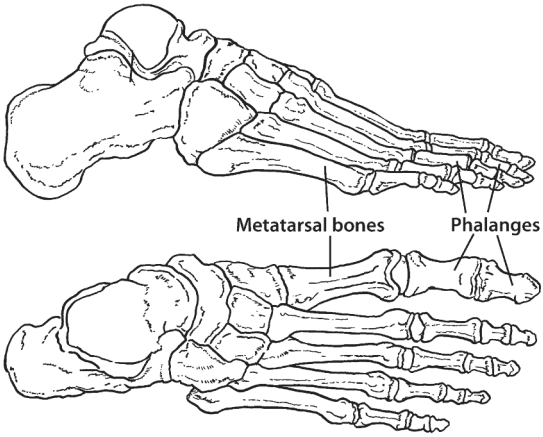
Pre-season injuries in football are inevitable, possibly due to a number of factors, such as a decrease in fitness, hard playing surfaces (after the summer), fatigue or inappropriate content or progression of pre-season training programmes. One study found that 17% of all injuries occurred during pre-season training, with the average time lost from these injuries being 22 days. It was also found that younger age groups (17-

Anatomy of the metatarsals

There are five metatarsal bones in each foot. They are the relatively long bones located between the heel and toes *(see figure 1 below)*. The ankle and foot have two principle functions: propulsion and support. The metatarsal bones play a major role in both of these functions. For propulsion they act like a rigid lever and for support they act like a flexible structure that aids balance, thus holding up the entire body.

Fractures to the metatarsal bones can be caused by direct trauma, excessive forces or overuse. During football, direct trauma is usually caused by a player accidentally kicking the sole of an opponent's boot, or by an opponent stepping on a player's foot. As there is very little soft tissue to protect the top of the foot, bony injuries are common. The second, third and fourth metatarsals are the most commonly fractured with this mechanism of injury. Stress fractures are also common in the metatarsals.

Figure 1: Bone structure of the foot



25 years old) sustained more pre-season injuries that senior players (26-35+ years old)[15]. Overall, however, injury in youth team (academy) football is approximately half that of professional players[16].

What can we learn?

In this modern era, with increased coverage of football on television, media demand and financial influence, we all want to know how and why our favourite football players are getting injured, and when they will be able to play again. For the fans, this is an important question; for the club and player it is a vital question. With the cost to professional clubs in England of injuries occurring during an average season estimated to be in excess of £75m and up to 10% of the professional squad unable to play due to injury, it is imperative that measures to prevent injuries, and not just to treat them, are in place.

Studies have shown that better shin pad design may help cut the rate of tibial fractures (sometimes known as 'footballers fracture')[17]. However, this particular study also showed that 85% of footballers wearing shin pads still sustained a tibial fracture, suggesting there's a long way to go.

Other simple measures may prevent some of these injuries. These include:

- a joint approach to training between the medical and coaching staff;
- a progressive training regime during the pre-season;
- wearing running trainers or shock absorbent orthotics when the ground is hard in pre-season;
- using other training methods to get players' cardiovascular fitness up prior to running, *eg* cycling.

Injuries also occur at the amateur level. There are essential differences between the amateur and professional footballer (apart from the salaries!) and this revolves around training and pre-game preparation. The lessons that have been learned in professional football should be used in the amateur game in an attempt to reduce injuries. Likewise, the lessons from other sports should be used to help professional footballers improve their game and prevent them from becoming injured.

TJ Salih

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Knockout blow – what should athletes do when concussion strikes?

In the 2006/2007 season Chelsea were affected by a series of head injuries. Firstly goalkeepers Peter Cech and Carlo Cudicini were both stretchered off in October during a league game against Reading. First choice keeper Cech was out until January when he returned wearing a scrum cap more associated with rugby. Cudicini had to be provided with an oxygen mask when he left the field, although he returned to action sooner than Cech. In the Carling Cup final captain John Terry was left unconscious after an accidental boot to the head. Chelsea won the game and somehow Terry was able to discharge himself from hospital that evening. Concussion therefore does play a part in football, and as we have heard is tricky to prevent, diagnose and treat due to its variability. This article should help to explain.

What is concussion?

In 2004, the Second International Symposium on Concussion in Sport (the most recent meeting of international experts in the field) defined concussion as 'a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces'[1]. Put more simply, concussion is the way the brain responds to a 'bump'. A 'bump' is really any significant force that passes through the brain *eg* a clash of heads in football.

Less obvious are indirect blows where the force is transmitted up to the head from another part of the body; for example a player might shoulder into a jumping player's back, flicking back his neck and some of the force of the tackle passing through his brain. He may end up concussed without ever taking a direct blow to the head.

Both direct and indirect bumps cause the brain (an organ with the consistency of jelly that is effectively suspended by a set of strings) to be shaken about inside the skull (a tight-fitting, hard box). There is an obvious potential for injury if you consider the brain in this way.

Concussion is the brain's response to a significant bump and manifests itself as a range of symptoms and signs such as headache, confusion, amnesia, drowsiness, dizziness, balance problems, slurred speech and feeling sick *(see box 1 for more)*.

There are two subtypes of concussion[1]:

1. *Simple concussion* – characterised by an uneventful progressive recovery within seven to 10 days with rest being the most important component of management. Most concussions fall into this category.
2. *Complex concussion* – where recovery takes longer than seven to 10 days and/or is complicated by problems such as fits, recurrence of symptoms associated with exercise or prolonged unconsciousness.

Box 1: Symptoms and signs of concussion

Symptoms

- Nausea (feeling sick)
- Headache
- Memory loss (amnesia) – not remembering what you were doing around the time you were injured
- Confusion – not being aware of where you are, what time it is, who you're playing, etc
- Dizziness/feeling clumsy
- Feeling dazed or stunned
- Ringing noise in the ears (tinnitus)
- Visual problems *eg* double vision
- Feeling sleepy

Signs *(things a doctor might find when he examines a concussed athlete)*

- Reduced conscious level
- Slurred speech
- Impaired balance and coordination
- Personality changes *eg* aggression, over-emotional
- Reduced concentration
- Slow thought processes

Box 2: The structure and function of the human brain

The brain is our control centre, an incredibly complex collection of over 100 billion nerve cells (neurones). These neurones are arranged in a particular way, giving the human brain its structure where specific areas of the brain are responsible for specific thoughts and actions. This is important for us to understand because damage to specific areas of the brain will result in specific problems, for example damage to the occipital lobe (at the back of the brain) will cause problems with vision but will leave other functions not controlled by that area unaffected.

The brain's function depends upon the initiation and conduction of electrochemical signals along neurones – any significant disruption to this process in a large enough number of neurones will affect what we think and do and could be termed a 'functional' problem.

Unlike many other cells in the body, neurones cannot repair themselves, they rely on neighbouring neurones to take over their function when they die, but this is a slow process where the level of function is rarely as good. Therefore one would expect damage to the structure of neurones to cause problems that are slow to recover or permanent.

By definition, the brain is not functioning normally in a concussed athlete. However, the experts are divided as to why the brain is not functioning properly – is structural damage to the brain the cause of concussion or is concussion a purely 'functional' problem? To understand these arguments, it's necessary to have a basic understanding of the structure and function of the human brain *(see box 2)*.

Concussion controversy

Advocates of the structural damage theory of concussion often talk about a cumulative effect of one concussion after another. If concussion were due to structural damage, we would certainly expect a cumulative effect given what we know about neurones being unable to repair themselves.

The British Medical Association (BMA) seems pretty convinced of a cumulative effect, having made the case for a boxing ban on this basis since the early 1980s. 'Punch-drunk' syndrome is a recognised phenomenon in older and retired

professional boxers that has been attributed to repeated punches to the head. However, the BMA admit in their August 2006 position statement on the subject that relevant research studies have significant weaknesses and a recent article in the British Journal of Sports Medicine failed to show any cumulative effect for people with one or two previous concussions (although the authors admit that damage could have been missed by their assessment methods)[2]. More research is needed in this area before any firm conclusions can be drawn.

More scientific evidence that structural damage does occur in even very minor impacts (below those required to cause concussion) comes from a study which looked at blood levels of SB-100 (a protein that exists in a certain type of neurone) and NSE (an enzyme found in neurones) in female football players before and after a match[3]. When neurones are damaged, they spill SB-100 and NSE into the blood; this study showed that blood levels of both chemicals increased the more players headed the ball, suggesting that an impact as small as heading a football damages the structure of neurones.

Those who consider concussion to be a predominantly functional disturbance with little or no underlying structural damage cite a set of clinical symptoms and signs that are usually short-lived, recover spontaneously and fully, and that don't fit with what would be expected from structural damage to a specific area of the brain. They also point to a set of symptoms, which in the short-term are more severe than would be expected from the minimal structural damage for which we actually have reasonable scientific evidence. This suggests that there must be a large functional component to concussion.

Head scans using magnetic resonance imaging (MRI) and computer topographic (CT) usually demonstrate normal structure in patients with concussion. Functional MRI (fMRI) scans have been shown to be abnormal in concussed sportspeople[4]. However, it should be emphasised that MRI, CT and fMRI scans do not rule out structural damage; it may be that microscopic structural damage, too small for a CT or MRI scan to detect, is responsible for the functional impairment.

Assessing and managing concussion

Distinguishing concussion from a more serious, possibly life-threatening, brain injury as well as ruling out the presence of damage to the spine that could have happened at the same time as the head injury are the predominent priorities of management. These tasks are often far from straightforward and it is prudent to assume the worst – you should avoid moving the casualty and request emergency medical attention if you are at all uncertain. Concussed sportspeople should not be allowed to continue competing or training until they've been medically cleared.

Once serious brain and spinal injury have been excluded and the athlete has been removed from the field of play, a suitably qualified person such as a doctor or sports physiotherapist should assess the severity of concussion. Problems such as fits, significant drowsiness or deterioration may warrant admission to hospital for observation.

Even if you have been medically cleared, you should not be left alone for the first 48 hours and should go to hospital immediately should any of the following occur:

- Worsening headache
- Vomiting more than once
- Problems recognising objects, people and places
- Numbness or weakness in your arms or legs
- Feeling unsteady on your feet
- Slurring your speech

You will need a companion to look after you for 48 hours in case any of the following problems (which you won't be able to notice yourself) occur:

- You have a fit
- You start behaving differently or irrationally
- You cannot be woken up.

Neuropsychological tests

Concussion can result in subtle but important changes in mental function. A number of assessment tools (collectively referred to as neuropsychological tests) have been designed to help

athletes, coaches and medics to identify, grade and monitor recovery from concussion. These tests take a variety of forms, from simple pen and paper questionnaires to complex software programmes. Two of the simpler and more widely used tests are shown in boxes 3 and 4. It should be noted however that neuropsychological tests are only an aid to assessment and that they should not replace or preclude proper medical care.

Neuropsychological testing is an important part of a concussed athlete's medical assessment. Athletes are generally eager to return to sport and have a tendency to under report and underestimate symptoms caused by concussion, possibly endangering their prompt recovery and health *(see page 94)*. Neuropsychological tests offer an objective method of assessing recovery from concussion and have been recommended as the 'cornerstone' of understanding the injury and managing the individual particularly in cases of complex concussion[1]. An athlete's neuropsychological tests should return to a baseline level (taken at the start of the season) and the athlete should be symptom free at rest and on exertion before returning to the field of play.

Box 3: The digit symbol substitution test (DSST)

The aim is to complete as many boxes as possible in 90 seconds. A baseline measure should be taken at the start of the season and used as a comparison should concussion occur[5].

Digit:	1	2	3	4	5	6	7	8	9
Symbol:	–	T	C	L	⊓	O	^	X	=

Samples:																							
9	4	2	3	6	5	7	4	1	2	4	5	8	9	6	5	3	2	6	2	2	5	9	8
=	L	T	C	O	⊓																		

1	2	5	8	7	4	6	9	5	8	9	4	2	3	5	8	4	1	3	9	6	4	7	8

4	5	6	8	2	1	9	8	7	6	5	4	2	3	7	5	6	9	8	4	5	6	8	1

4	1	9	8	5	6	4	1	7	2	3	8	6	5	4	9	6	2	1	4	7	5	8	2

Box 4: The athlete self-assessment section of the SCAT (sport concussion assessment tool) card[1]

How do you feel? You should score yourself on the following symptoms, based on how you feel now.

	None			Moderate			Severe
Headache	0	1	2	3	4	5	6
Pressure in head	0	1	2	3	4	5	6
Neck pain	0	1	2	3	4	5	6
Balance problems or dizziness	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Vision problems	0	1	2	3	4	5	6
Hearing problems or ringing	0	1	2	3	4	5	6
Don't feel right	0	1	2	3	4	5	6
Feeling 'dinged' or 'dazed'	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like 'in a fog'	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
More emotional then usual	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Follow-up symptoms only:							
Sadness	0	1	2	3	4	5	6
Nervous or anxious	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
Sleeping more than usual	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Other	0	1	2	3	4	5	6

Recovery from concussion and return to sport

The golden rule of sport concussion is that the player should not be allowed to return to sport until they have completely recovered. Why not? To prevent the following problems:

- Another injury to the head or body being caused by the

incompletely recovered athlete being clumsy or slow;
- Injury to another player for the same reason;
- Post-concussion syndrome;
- Second-impact syndrome.

'Post-concussion syndrome' is the term used to describe symptoms such as dizziness, fatigue and problems with concentration and memory, which can persist for weeks, months or even years after concussion. Post-concussion syndrome requires thorough investigation by a suitably qualified healthcare professional, although treatment is limited to rest and reassurance. Sport and exercise may prolong the condition and are therefore inadvisable.

'Second-impact syndrome' is a catastrophic condition where a person who hasn't fully recovered from a concussion sustains another minor head injury, leading to massive and often fatal swelling of the brain. However, there's doubt that this condition actually exists[6]. If it does, it's certainly rare – one study counted just 35 unconfirmed cases in 13 years of American football[7].

The length of recovery from concussion is very variable – from minutes to months – and there is little that can be done to speed recovery. It is recommended that concussed athletes refrain from sport for at least the rest of the day of the injury as an absolute minimum, even if they're apparently fully recovered. The exception to this is the professional athlete who may have immediate access to appropriately qualified people with ample resources to properly assess them. Any athlete who has suffered a concussion should ideally make a gradual, graded return to exercise before returning to competitive sport under close observation to ensure that their recovery is indeed complete. Some sports such as boxing apply a minimum period of exclusion for those who are concussed but there is no good evidence for such rules – some people may need more time than the obligatory exclusion period for recovery, some less.

Concussion in children

There are currently no guidelines for the assessment and management of concussion in children. Children differ from

adults in a number of important ways when it comes to concussion. Surprisingly, it is estimated that children require an impact force two to three times greater than that in adults to cause a concussion with the same symptoms[8]. This may be because a child's head is more resilient to force, having a different structure to that of an adult, or it could be that a child's response to a bump is different to an adult's. The different structure of a child's brain and skull also makes them prone to the rare but potentially life-threatening complication of brain swelling. On the plus side, children with concussion appear to recover faster than adults.

So should you assess children in the same way as adults? Many do because of the absence of alternatives, but you should exercise caution. Neuropsychological testing in children is not as accurate as it is for adults because children are developing and their test results should be improving as they age, especially between the age of nine and 15 years. A child whose neuropsychological test result after a concussion is the same as it was before could actually have suffered significant damage if the baseline was done pre-season and the concussion sustained at the end of it. Children involved in contact sports might benefit therefore from regular baseline tests every six months rather than yearly.

Finally, children with concussion do not normally require any investigations such as skull x-ray, CT or MRI scan. As with adults, the ideal management is careful observation, rest and a graded return to exercise once symptoms have resolved.

Summary

Concussion in football does happen; the golden rule of its management is that players should not return to sport until they have made a full recovery. Distinguishing between concussion and more serious injuries can be difficult. In the case of suspected concussion, players and their coaches would be well advised to seek medical attention sooner rather than later.

John Bye

Jargon buster

Enzyme – A protein molecule synthesised by the body that enables important biochemical reactions to occur that would otherwise either not occur, or occur too slowly

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I – The risks of being female

More women are playing football than ever before, but up until now there have been no studies of injury risk factors in elite female footballers. Now, German researchers have completed the first such study, involving 143 players from the German national league (Risk factors for injuries in elite female soccer players, *British Journal of Sports Medicine 2006: 40 785-790*).

Here's what they found:

- **Height:** the taller you are (taller than 1m 75cm), the more likely you are to get injured.
- **Weight:** if you have played a lot of matches during the previous season and are carrying a few extra pounds, watch out, you are heading for a non-contact injury.
- **Exposure:** players who pick up injuries during the season tend to have reduced training time and total exposure time. Players with the most match exposure (more than 45 hours per season) had a reduced injury risk.
- **Previous ligament injuries:** not surprisingly, if you have previously ruptured your ACL, the chances of a repeat injury are significantly increased. If you have previously sprained your ankle or knee, you are still at a higher (but not significant) risk of re-injury.
- **Playing positions:** defenders and strikers show a considerably higher incidence of injury than goalkeepers and midfielders. Injuries are more likely to occur in the areas of the pitch where ball possession is most fiercely contested (attacking and defending).
- **Limb dominance:** significantly more injuries (ankle or ligament ruptures) occur on the dominant leg; this is particularly true for overuse and contact injuries.

Coaches should use these findings to develop an appropriate

conditioning programme to help cut individual players' injury risk. Here are some tips:

- **Body measurements:** Make sure you have an appropriate body composition. Depending on your body type, you may benefit from increasing or decreasing your mass.
- **Exposure:** Maximise your training time. Pre-season is the time to put in extra effort. Data suggests that fitness improvements from increased training time will help prevent injuries during the rest of the season.
- **Previous ligament injuries:** Implement an appropriate remedial conditioning programme that will ensure the ankles and knees remain fit and healthy.
- **Playing position:** If you are going to be regularly involved in contests for the ball, make sure you are up to the job. Football is a contact sport: your conditioning programme needs to make you as strong and powerful as possible, so you can shrug off any challenges from your opponents.
- **Limb dominance:** Make sure you adopt a balanced approach to your strength and conditioning work.

II – Are you in a position to get injured?

During the 2003-4 football season, researchers in the UK collected movement data on 55 football players (18 defenders, 18 midfielders, 19 strikers) from 12 Football Association English Premiership clubs. The researchers made some very interesting findings (Physical demands of different positions in FA premier league soccer, *Journal of Sports Science and Medicine 2007; 6:63-70*):

- **Defenders** perform the most jogging, skipping and shuffling movements, but spend significantly less time sprinting and running than the rest of their team-mates;
- **Midfielders** (known as the 'engines' of a team) do indeed

spend most of their time running and sprinting. Most of their runs are forwards;

- **Midfielders and strikers** spend a significant amount of time jumping, landing, diving, sliding, decelerating, falling and getting up. Strikers spend most of their time doing all of the above, and also perform the most physical contact at high intensity and decelerate and change direction more rapidly than other team-mates;
- **Defenders** perform significantly more backward jumping and also do the most backward and lateral movement.

The findings of this study should give football players and coaches a better understanding of the physical demands of the game, so you can develop appropriate player- and position-specific conditioning and rehab programmes that will help to reduce the incidence of injuries.

Here are some tips for the kinds of training you could do:

- **Strikers:** Develop strength and power to withstand high-intensity contacts. This may include increasing lean muscle mass to help you to be 'strong' in contact situations. Learn proper jumping and landing techniques.
- **Defenders:** Develop the ability to run and jump backwards. Plyometric and speed agility drills are almost always forward facing. Yet if defenders are to remain injury-free, they need to jump, land and run travelling backwards – qualities that are rarely coached.
- **Midfielders:** If you only ever run laps in training, you are setting yourself up for injury. You are the team's all-rounders and you must combine the qualities of a defender and striker with the heart and lungs of an athlete.

Nick Grantham

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Reports on recent rowing-related studies

Comparison of bone mineral density in runners and football players

Many athletes are aware that one of the beneficial effects of training is an increase in bone mineral density (BMD). An increased BMD is associated with a reduced likelihood of fracture, especially in later life when bone density begins to decline; athletes who have built up BMD therefore have a greater safety margin in later life when BMD losses are inevitable. What is less well known, however, is that BMD is 'region-specific' – *ie* the increase in BMD is not uniform in the body, but dependent on the type of training you perform.

To investigate this relationship, US researchers compared the BMD of 15 elite male footballers with those of 15 elite male runners using a very accurate technique technique known as dual-energy x-ray absorptiometry (DEXA). They also compared the DEXA results from these two groups with those of a control group, who performed no exercise. The results were as follows:

- After adjusting for age, weight, and per cent body fat, the football players had significantly higher whole-body, spine, right hip, right leg and calcaneal (the large bone at the back of the heel) BMD values compared with the sedentary controls;
- The footballers also had significantly higher right hip and spine BMD values compared with the runners;
- Runners had higher calcaneal BMD values compared with the controls.

Although running is often regarded as an excellent 'high-impact' form of bone-building exercise, these results show that compared to the sedentary controls, only calcaneal bone density was significantly increased whereas the footballers had higher BMD at all the sites

measured. The researchers concluded that running is associated with higher BMD only at directly loaded sites (ie the calcaneus) but not at relatively unloaded sites such as the spine. This is in contrast to the footballers, whose patterns of training and skeletal loading produced increased BMD in the spine and hip also and suggests that runners who want to increase skeletal BMD should consider incorporating additional forms of training into their routine.
Br J Sports Med 2007 May 1; [Epub ahead of print]

Proprioception training reduces ankle injury risk in footballers

Contrary to popular belief, it's not hamstring tears but ankle injuries that are the most common injury in footballers. And when footballers do sustain ankle injuries, there are three common treatment strategies employed to help prevent reoccurrence; strength training (to strengthen muscles and ligaments that stabilise the ankle), orthotic inserts (placed in the shoe to try and place the foot in a more 'biomechanically neutral' position and so prevent injury) and proprioception training (which mainly involves balance training and enhancing the ability of the ankle/foot structures to respond to and control external forces).

But which of these three single interventions is most effective at reducing the incidence of further ankle injury? That's the question that Iranian researchers have been trying to address in a study on 80 male footballers in the first division of a men's league who had all experienced previous ankle inversion sprains. The players were randomly assigned to one of four groups, each of which contained 20 subjects:

- Strength training;
- Orthotic use;
- Proprioception training;
- Control group (no intervention).

The players were then monitored for the rest of the season, during which data on the frequency of ankle sprain re-injury data were

collected. There were no significant differences among the groups in the number of exposures (*ie* all the groups were exposed to the same degree of injury risk in terms of time, matches played etc), but the incidence of ankle sprains in players in the proprioception training group was significantly lower than in the control group. However, while the risk was also reduced in the strength and orthotic groups, the reduction was not large enough to be considered statistically significant and the researchers concluded that only the proprioception training group showed a significant reduction in rates of re-injury. Of course this is not to say that strength training and orthotics don't have benefits; many rehab programmes use a combination of strength and proprioception training – something not assessed in this study. It does suggest however, that proprioception training is a crucial element in the prevention of ankle re-injury.

Am J Sports Med 2007; 22 [Epub ahead of print]

Comparison of standing balance in dancers and football players

The possible benefits of dancing for developing athletic balance and agility were discussed in a recent issue of PP *(issue 232)*. Now a new US study on dancers and footballers appears to provide further confirmation of these benefits.

Thirty two female collegiate soccer players were compared with 32 dancers for a number of measures of standing balance using 'centre of pressure' measurements, which involved balancing on a special pressure sensitive mat while the following were recorded:

- The degree of sway from vertical (*ie* how stable they remained when standing upright);
- The centre acquisition time (the time required to achieve vertical balance after performing a movement);
- The sway path length and velocity.

The results showed that while the scores from 15 of the 20 balance tests were not significantly different between the two

groups, the dancers achieved superior scores in the other five tests. The Harvard Medical School researchers went on to conclude that: 'Dancers have certain standing balance abilities that are better than those of soccer players,' and also that 'the COP measurements in this study can be used as a tool in future studies investigating standing balance in different groups of athletes.'
Gait Posture 2006; 29 [Epub ahead of print]

Attaining maximum distance in football 'throw-ins'

Being able to throw the ball large distances from the touchline confers an obvious advantage in football, especially if the ball can be propelled into the region of the opponents' goal area. But while some players are renowned for having long throw-ins, what does the science say about maximising thrown-in distance generally? A team of British scientists has been trying to answer exactly this question by studying maximum-effort throws using videography.

In the study, a male football player performed maximum-effort throws using release angles of between 10 and 60 degrees (the initial inclination of the path of the ball as it is released from the hands). These throws were then analysed using two-dimensional videography and the player's optimum release angle was calculated by substituting mathematical expressions for the measured relationships between release speed, release height and release angle into the equations for the flight of a spherical projectile.

The result indicated that the musculoskeletal structure of the thrower's body has a strong influence on the optimum release angle. In the study, using low release angles helped the player to release the ball with a greater release speed; because the range of a projectile is strongly dependent on the release speed, this bias toward low release angles reduced the optimum release angle from 45 degrees (the mathematical theoretically optimum angle for projectiles generally) to about 30 degrees. Calculations showed that the distance of a throw may be increased a few metres further by launching the ball with a fast backspin, but when backspin is

applied, the ball must be launched at a slightly lower release angle than 30 degrees!
Sports Biomech 2006 Jul; 5(2):243-60

New findings on ACL injuries in soccer

Rupture of the anterior cruciate ligament (ACL) in the knee is the injury that causes the longest lasting disability to footballers. Now a new study from Denmark has shed unexpected light on the causes of this injury that should help to prevent it in future.

The researchers, from a hospital sports clinic, surveyed 113 patients, consecutively admitted to their clinic with an ACL rupture sustained while playing football, to analyse the mechanism behind their injury.

Their key findings – some of them surprising – were as follows:

- Goalies sustained as many ACL injuries as other players;
- 62 ACL injuries occurred on the opponent's half of the field – 18 of them inside the penalty box;
- There was no statistical difference between the numbers of players in defensive and offensive roles at the time of injury;
- 30 of the injured players were in contact neither with other players nor the ball at the time of injury and 58 were in contact with the ball alone;
- Only 17 sustained an ACL rupture while being touched or pushed;
- 56 had intended to change their direction towards the side of the injured knee at the time the ACL was torn, while only ten had intended to turn towards the uninjured side;
- 26 sustained their injury when landing after heading the ball, of whom 20 were being tackled by an opponent in the air, so jeopardising their landing;
- 19 had a previous injury other than an ACL injury in the now ACL-injured knee, compared with five in the other knee.

The researchers draw two main conclusions from their findings:

First, that 'the mechanism behind ACL rupture differs from that of other soccer-related injuries because only a small fraction of the injured players had contact with another player at the time of the accident. We therefore conclude that tackling and kicking do not contribute significantly to ACL ruptures in soccer'.

Secondly, two distinctive actions – change of direction and landing after heading – are responsible for the vast majority of ruptures. If players could be trained to perform these particular moves more safely, the risk of injury could be substantially reduced. *Int J Sports Med 2006; 27:75-79*