FOOTBALL PERFORMANCE

how to raise your game

A SPECIAL REPORT FROM

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The research newsletter on stamina, strength and fitness

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From the editor

We're all football mad these days – not least the women! Indeed the 'beautiful game' is said to be growing in global popularity faster than any other sport. And this increased participation is matched by an explosion of scientific research into all aspects of play. So we make no apology for devoting an entire special report to the science and practice of football.

This report, prepared for you by the *Peak Performance* team of expert writers, covers all the areas of key interest to footballers, from 'prehabilitation' (three comprehensive off-season conditioning programmes) through nutrition (is it time for a return to post-match fish and chips?), hydration (your personalised strategy) and psychology (survival techniques for managers adrift in the cut-throat world of pro football) to tournament play (with some excellent advice for the England manager in the lead-up to the next World Cup).

On a more serious note, Sanjay Sharma focuses on the rare but devastating problem of sudden cardiac death in young players and how those at risk can be identified and protected; while John Shepherd examines footballers' post-retirement health prospects, with particular emphasis on osteoarthritis, back trouble and neuropsychological problems (particularly relating to heading).

Meanwhile an extended 'what the scientists say' section encompasses a wide range of additional research, including football benefits for children, good and bad news about stretching, the role of personal fitness in team success and the ever-present risk of hamstring strains.

Whether you are a devoted fan, a keen amateur, an up-and-coming pro or a member of the support team, we hope you enjoy this special report and find it useful.

Isabel Walker
Editor

Three off-season programmes to set you up for what lies ahead

This article demonstrates some specific exercise routines that can be incorporated into your off-season training, before pre-season starts, to help ensure your readiness for the season itself.

'Prehabilitation' is the new buzz word describing the use of exercises that work on the major muscles used during your sport, as well as preconditioning the prime mover (agonist) muscles in a sport specific fashion. All footballers need to be able to effect repeated sprints and changes of direction, while goalies in particular need to be able to throw the ball for long distances. These are all maximal effort activities and the body needs a sound base of strength in order to prevent resultant injury.

Does it work? Recent research has demonstrated the importance of the concentric action of the hip extensors and eccentric action of the knee flexors when running (1). Running economy was linked to the level of local muscular endurance in these muscles, and the authors recommended specific training actions to help increase this endurance.

Other research has shown that high school baseball pitchers tend to have an imbalance between internal and external shoulder rotators and should work on their external shoulder rotation to prevent injury (2). The ideal time to do this work is during the off-season, before pre-season workouts start.

Training must have a purpose though. In a recent study, no link was found between strength training and either injury prevention or level of performance in elite rodeo competitors (3). The authors of the study surmised that the rodeo riders did not train specifically for their sport – they just trained. So it is important to have a plan, and to link it to the requirements of your sport.

Conversely, a study on the effectiveness of a 20-minute programme of exercises designed to enhance dynamic stability around the knee, carried out twice a week for nine weeks, found it was successful in reducing impact forces (associated with ACL injuries) in female athletes [4].

This type of programme can easily be accommodated into most people's training, with little detriment to other aspects of training.

Three programmes are described in detail in this article:

1. for throwing actions;
2. for strengthening the knee;
3. to enhance local muscular endurance for running activities.

Before starting these programmes it is best to have a musculoskeletal examination carried out by a chartered physiotherapist to rule out any current injuries. If any are found, you should get treatment before embarking on any of these programmes.

Programme 1 – shoulder prehab

This programme, set out in table 1, opposite, is useful for goalkeepers and players taking throw-ins.

'It is important to have a plan and to link it to the requirements of your sport'

For all the shoulder rotation exercises you will need a bench and a dumbbell. Ideally you should have access to a cable column in a gym, in which case the exercises can be performed standing up. All descriptions are for the right arm; just switch sides for left arm exercises, and alternate between left and right arms as you do the programme.

Perform these exercises as a complete session 2-3 times a week in the off-season, progressing the load at about 5% per week and ensuring that all reps are performed in a controlled manner.

Internal rotation. Lie on your right side on the edge of the bench with your right elbow at your right hip, your arm bent outwards at an angle of 90°, palm facing upwards. Keeping the elbow at the hip and the arm bent, curl the weight upwards and towards your stomach, then lower under control.

Table 1: shoulder prehab programme

Exercise	Sets	Reps	Load
Internal rotation	2	10	60% 1RM*
External rotation	2	10	60% 1RM
Vertical rotation – forwards	2	10	60% 1RM
Vertical rotation – backwards	2	10	60% 1RM
Internal rotation (ball)	2	10	Tennis to cricket to medicine ball
External rotation (ball)	2	10	Tennis to cricket to medicine ball
Vertical rotation – forwards (ball)	2	10	Tennis to cricket to medicine ball
Vertical rotation – backwards (ball)	2	10	Tennis to cricket to medicine ball
Press-up hold	2	Hold for 20 secs	
Impact press-up	2	10	Wall to kneeling to standing

- 1RM stands for One Repetition Maximum – the maximum load that can be lifted in one attempt, using correct technique

External rotation. Lie on your left side on the edge of the bench with your right elbow at your right hip, your arm bent at 90°, palm facing down. Keeping the elbow at the hip and the arm bent, curl the weight upwards from the left hip and towards the ceiling as far as it can go, then lower under control.

Vertical rotation – forwards. Lie on your back, with right elbow by your right side, and right hand holding the weight by your right shoulder, palm facing up. Keeping your elbow by your side, bring the weight up towards the ceiling, and then lower under control.

Vertical rotation – backwards. Lie on your front, with right elbow by your side, and arm hanging down to the floor, palm facing backwards. Keep your elbow by your side and curl the weight until it is level with your shoulder, then lower under control.

Internal rotation (ball). Standing up, hold your right elbow by your right hip, arm bent outwards at 90°, right hand holding the ball out at your right side. Then bring your hand back across your body, keeping the elbow at your hip, and release the ball to your left.

External rotation (ball). Standing up, with the ball in your right hand, right elbow by your right hip, bend the arm at an angle of 90° across your body to hold the ball at your left side.

‘Work on a surface with some give, such as grass, a studio floor or thick mats, rather than on concrete, which generates considerable impact on landing’

Then bring your hand back across your body to the right, keeping the elbow at your hip, and release the ball to your right in a backhand motion.

Vertical rotation – forwards (ball). Standing up, with the ball in your right hand, hold your arm out front at shoulder level, then bend your forearm up at 90°, holding the ball up and slightly backwards as if waving. Then bring your hand forwards, keeping the elbow still and release the ball to your front, finishing with your forearm parallel to the floor.

Vertical rotation – backwards (ball). Standing up, with the ball in your right hand, hold your arm out to the side at shoulder level, then bend the arm forwards at a 90° angle, keeping the forearm parallel to the floor. Then bring your hand backwards quickly, keeping the elbow still, and release the ball behind you, finishing with your hand facing backwards. This is an awkward movement to perform, but try to rotate around the fixed elbow position to isolate the shoulder joint.

Press-up hold. Get into a normal press-up position, with elbows fully extended, then push shoulders slightly further to the ceiling, so your back is arched like a stretching cat. Hold this position for 20 seconds, progressing up to a minute.

Impact press-up. Stand about one metre away from a wall, with arms extended in front of you. Fall to the wall, absorbing the impact by bending your elbows, and finish with your nose nearly touching the wall. When this has become easy, progress to doing the same exercise from a kneeling position, and falling to the floor from there. Gradually progress first to a crouched then to a standing position. This latter movement has a high impact, so make sure you have no wrist, shoulder or elbow injuries before starting this exercise.

Programme 2 – knee prehab

The graduated exercises set out in the table opposite will help to prevent knee injuries caused by the sudden changes of direction that are an integral part of football and other intermittent field sports. They should be performed twice a week on non-consecutive days.

Table 2: knee prehab programme

Exercise	Sets	Reps
Weeks 1-2		
Reach jumps	3	10
Tuck jumps	3	10
Standing broad jump	1	10
Bound in place	2	20
Weeks 3-4		
Reach jumps	3	10
Tuck jumps	3	10
180° turns	2	5 (each way)
Double-leg hops x 2	2	5
Weeks 5-6		
Tuck jumps	3	10
Single-leg lateral hop	3	5 (each leg)
Single-leg forward hop	2	5 (each leg)
Double-leg hops x 3 with vertical jump	2	5
180° turns	3	5 (each way)
Single-leg 45° lateral hops	2	10 (each leg)
Weeks 7-8		
Reach jumps	3	10
Single-leg forward hop	3	3 (each leg)
Double-leg hops x 3 with vertical jump	2	5
180° turns	4	5 (each way)
Standing broad jump	2	10
Single-leg 45° lateral hops	2	10 (each leg)

Warm up for approximately five minutes before performing these exercises and allow for 30-60 seconds' rest between each set. Work on a surface with some 'give', such as grass, a studio floor or thick mats, rather than on concrete, which generates considerable impact on landing.

Reach jumps. Bounce up and down on your toes with both arms overhead, reaching for the sky.

Standing broad jump. Jump forwards as far as you can, landing with soft knees, maintaining balance.

Bound in place. Stand on one leg, jump into the air and land on the opposite leg. Use the unsupporting leg and your arms to generate as much drive as possible.

180° turns. Jump into the air, turning 180° to face the opposite direction, and land with soft knees. Then return the same way – *ie* if you turned to the right the first time, turn to the left on your return.

Double-leg hops x 2. Perform consecutive standing broad jumps *(described on previous page)* with minimal ground contact time between jumps.

Single-leg lateral hop. Stand on one leg and hop to the side.

Single-leg forward hop. Stand on one leg and hop forwards.

Double-leg hops x 3 with vertical jump. Perform three consecutive broad jumps with minimal contact time between jumps. Immediately on final landing, jump vertically as high as you can.

Single-leg 45° lateral hops. Hop on one leg to a point 45° to the side – *ie* diagonally.

Programme 3 – lower body muscular endurance

The programme set out in table 3, below, is useful for building lower body muscular endurance for running activities. Muscular endurance is needed to help delay the onset of fatigue during a match and also to facilitate a faster recovery from sprints. You will need a Swiss ball to perform these exercises.

In weeks 1-4, start with five reps or 15 seconds of each exercise, then add three reps or five seconds to each set every week, so that on week four you are doing 14 reps or 30 seconds. In weeks 5-8 perform the new exercises at the lower end of the

Table 3: lower body muscular endurance programme

Exercise	Sets	Reps\duration
Weeks 1-4		
Bridge	3	15-30 secs
Leg curl	3	5-14
Hip bridge	3	15-30 secs
Bicycle swing	3	5-14
Hamstring drops	3	5-14 to bench
Weeks 5-8		
Single-leg bridge	3	15-30 secs
Single-leg curl	3	5-14
Single-leg hip bridge	3	15-30 secs
Bicycle swing weighted	3	5-14
Hamstring drops	3	5-14 to floor

scale and then progress at the same pace as for weeks 1-4. Perform one set of each exercise continuously in a circuit, then rest for two minutes before doing the second set.

Bridge. Lie on your back on the floor, with both ankles resting on the Swiss ball. Raise your buttocks off the floor so that only your shoulders and head are in contact with the floor, keeping legs straight. To start, you can keep your arms outstretched for balance; but as you progress, start folding your arms across your chest. Single-leg bridge is the same, with only one foot on the ball at a time.

Leg curl. From the bridge position, bend your knees, using your ankles to curl the ball towards your buttocks. Then straighten your legs as you push the ball back to the start position. The single-leg version is the same, but with just one foot on the ball; perform with one leg and then the other without pause as one set.

Hip bridge. Similar to the bridge position, but this time put your feet flat on the ball, and raise your hips up, with your knees bent at 90°. Single-leg is the same, but just have one foot on the ball at a time.

Bicycle swing. Standing upright, with your left arm resting on a wall or chair for balance, raise your right leg to the front until parallel with the floor, then pull it back down to the floor, brushing your toes on the floor, and kicking up behind you so that your right heel touches your right buttock. Turn around and repeat on the other leg. The weighted version is the same, with a small weight on the ankle – about 1kg to start.

Hamstring drops. (This is best done with the help of a training partner, or with your feet hooked under a secure bar.) Kneel upright with your thighs at a 90° angle with the floor, in front of a bench. While your partner holds tightly to your ankles, lower your body down to the bench. Return to the start position and repeat. In the second phase, lower your body all the way down to the floor.

All of the above programmes should be conducted in the off-season, as a way of conditioning the body for the more sport specific football training that occurs during the pre-season. If you train with the prehab programme 2-3 times a week, while keeping up with your general conditioning training, you should enter the pre-season training phase better equipped to cope with its demands. During pre-season and (depending on your schedule) the competitive season itself, you can reduce the intensity of the load and simply conduct a maintenance session once a week.

James Marshall

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‘Your role is to make sure there are no fat b******s in my team’

That may not be the most scientifically precise instruction a person in my position can receive, but it is a familiar refrain in many football clubs and it has the value of letting you know where you stand! Frustrating? Perhaps: but, on a broader level, the role of the sports nutritionist in professional football is seen as one of manipulating carbohydrate, protein, fat, fibre, fluid and micronutrient intake to maintain health, promote adaptation to training and ultimately enhance or – in our particular sport – maintain performance over the course of a season.

The role of the nutritionist in football has evolved over the last five years. Compared to some practitioners, I am new in the sport (one dietician at a top Premier League club has been employed continuously for 13 years!), but I am sufficiently long-in-the-tooth to have detected significant change over this period. At the time of writing, 19 out of 20 Premier League teams employ someone specifically to take care of the nutritional requirements of their players. This role is not always performed by a nutritionist or a dietician: in many teams the responsibility for implementing a nutritional support strategy falls on the shoulders of the sports scientist, conditioning coach, or physiotherapist.

Nutrition in football – a brief history

Football was, for a long time, classed as an endurance sport due largely to the fact that a football match lasted at least 90 minutes. As a result, the nutritional requirements of football players were extrapolated from early scientific research carried out in relation to other ‘endurance sports’, such as running and cycling. Yes, it is true that the duration of a football match is normally 90 minutes; however, the training loads associated with these sports are vastly different. On closer inspection it becomes clear that the daily energy expenditure of professional football players may not be particularly high. Football players are generally inactive when not training and training load will vary, depending on factors such as the stage of the season, or whether tactical or fitness drills predominate in training.

Ron Maughan of Loughbrough University assessed the dietary intakes of two Scottish Premier League teams (he managed to get 51 players to perform seven-day weighed intakes) and found average daily energy intake to be approximately 2,620kcal and 3,050kcal respectively[1]. This is the only published data available on football players in this country and, notwithstanding a recent finding that Japanese football players under-reported dietary intakes[2], this work does highlight lower energy requirements than were perhaps originally recommended for professional football players.

'On closer inspection it becomes clear that the daily energy expenditure of professional football players may not be particularly high'

If football players were to consume 7-10g of carbohydrate per kg of body weight each day (a recommendation found in many a textbook) then a quick calculation that included reasonable amounts of protein and fat would generate a daily energy intake closer to 4,200kcal. In Scandinavia this may be closer to the truth *(see table 1, opposite)*. Once the playing season gets under way, the Scandinavian subjects typically train seven times per week compared with roughly four sessions in this country. So it is not surprising that energy intakes will exceed 4,000kcal in a country like Sweden.

Not only were early dietary recommendations for professional football players slightly misjudged, but a number of other problems existed in the delivery of nutritional support. Football was flooded with science and its analytical techniques, and experts employed by clubs exploited the 'measure everything' approach. Blood, saliva, urine, lactate and expired air were all being indiscriminately extracted from players, often with very little feedback offered in return. In the world of nutrition and football, science was calling the shots.

Table 1. Energy and macronutrient intakes of elite international football players[3]

Nationality	Sample size	Energy (kcal)	Carbohydrate (%)	Fat (%)	Protein (%)
Senior					
Swedish	15	4,929	47.0	29.2	13.6
Danish	7	3,738	46.3	38.0	15.7
Italian (1)	33	3,066	56.0	28.0	14.0
Italian (2)	20	3,650	55.8	28.3	15.9
Junior					
Canadian	5	3,619	48.0	39.0	13.0
Puerto Rican	8	3,952	53.2	32.4	14.4
Total	**88**	**3,682**	**52.9**	**30.1**	**14.5**

A new climate prevails

'An athlete's diet must be high in carbohydrate, moderate in protein, low in fat, include sufficient vitamins and minerals, and plenty of fluid.' This was the original model with which many football nutritionists used to work. Although very simple, much of it still holds true today. However, as our understanding of the game in this country has improved, nutritionists have been able to tease out strategies from each of the model's sub-sections that more closely match the requirements of our sport. What is different is that science no longer holds all the cards. Football has caught up with science and is now dictating where our efforts are directed.

For, example, the glycaemic index of foods, a ranking of foods based on their immediate effect on blood glucose, has become a particularly useful tool in football. Five years ago the approach in football was to advocate a high carbohydrate, low fat diet at all times. Any food that at all met these requirements would be recommended to players in a bid to maximise muscle glycogen storage for training and competition.

Now a more measured approach is employed with the glycaemic index and, to a lesser extent, the insulin index utilised in a bid to control body composition as well as carbohydrate provision. Emphasis is now placed more on achieving optimum carbohydrate intake prior to matches, and during the recovery period after matches, particularly when some clubs find themselves involved in up to three games per week in the busiest part of the season.

Good attitudes to reducing fat intake are now commonplace in the modern player. Emphasis is placed on increasing intake of certain fatty acids that are found to be lacking in players' diets. When performing dietary analyses of players, low intakes of essential fatty acids – eicosapentaenoic acid (EPA) and docosahexenoic acid (DHA) – are consistently reported. Despite the appearance of oily fish in the canteens of football clubs, there may be a case for blanket supplementation in this particular group of sportsmen.

There is growing evidence that protein supplementation after training can promote protein synthesis and adaptation of muscle. The type, timing and amount of protein can be manipulated to enhance the adaptive response. The work of researchers such as Bob Wolfe and Kevin Tipton in Texas, and Mike Rennie in Dundee (whose primary interest has been likened to 'preventing older people falling down') has enabled us to design strategies for protein intake that may promote better adaptation to training.

Interest in micronutrients has historically been associated with the free radical muscle damage hypothesis. In fact there is now some suspicion that the release of free radical species associated with exercise is necessary for adaptation of the cells to subsequent stressful events. It is entirely feasible, although not proven, that free radicals play an important part in the adaptation of the muscle to hard exercise, and that increased consumption of some antioxidant nutrients might interfere with these necessary adaptive responses. Practitioners now warn against the use of mega-dose antioxidants.

Urine indices to the fore

Many indices have been investigated to establish their potential as markers of hydration status. Body mass changes, blood indices, urine indices and bioelectrical impedance analysis have been the most widely investigated. Current evidence tends to favour urine indices, and in particular urine osmolality, as the most promising marker available. Five years ago urine colour charts were commonplace on the walls of clubs' changing room toilets. Nowadays osmometers can be found at Premier League clubs. Urine samples provided by players can be analysed in approximately 30 seconds and the machines quickly identify dehydrated subjects.

A recent preliminary report has suggested that American football players who repeatedly suffer muscle cramping in training and competition have greater sweat losses and a higher sweat sodium content than players matched for fitness and other factors but who do not suffer from muscle cramps [4]. Data on sweat electrolyte losses in football players in training are now being collected in a bid to identify those players at risk of potentially debilitating muscle cramp.

'Assessment of body composition plays an important role in nutritional evaluation, particularly in a sport obsessed with body image'

Assessment of body composition plays an important role in nutritional evaluation, particularly in a sport obsessed with body image. Along with body mass, an estimation of body fat percentage (or sum of skinfolds) has traditionally been the requisite regular test demanded by football managers. In addition to the usual body composition assessment methods, a number of other techniques are being utilised in the modern game. The evaluation of skeletal muscle mass, in particular appendicular skeletal muscle mass, can contribute important information to the assessment of nutritional status because it reflects the body protein mass.

A major impediment to determining muscle mass is the lack of suitable, easy and non-invasive methods for estimating muscle mass. Lee and others [5] have developed anthropometric prediction models validated against the 'gold standard' method of magnetic resonance imagery to estimate total body skeletal mass, using skinfold thickness and limb circumferences. These have proved useful in tracking changes in muscle mass associated with inactivity or resistance training protocols.

Although expensive, dual-energy X-ray absorptiometry (DEXA) is proving a valuable tool for body composition assessment, particularly with injured players recovering from a period of inactivity. If you are lucky enough to have access to DEXA at a university or hospital, this technology is able to identify accurately fat and lean tissue and can be used both for whole-body measurements of body composition and for providing estimates of the composition of specific sub-regions (eg trunk or legs). The DEXA instruments differentiate body weight into the components of lean soft tissue, fat soft tissue and bone based on the differential attenuation by tissues of two levels of X-rays.

Indirect calorimetry is used to estimate daily energy expenditure of individual players, particularly those who are undergoing a period of inactivity through injury. Measuring a player's oxygen consumption and time spent during different activities allows a picture of energy expenditure to be drawn. This information can then be used to prescribe eating and drinking plans that match more precisely players' energy requirements.

These are just a few examples of where science and football have worked together to develop player and sport specific nutritional support programmes. Science should be committed to meeting the demands of football, and not *vice versa*. It may sound obvious, but it wasn't always so.

The challenge ahead

Despite the progress that has been made in our understanding of the demands of football, there is a need for continued improvement. No other sub-discipline of sports medicine comes with so many contrasting views of what is right and wrong. The 'Zone' diet, the 'Atkins' diet, mass supplementation, the concept of the 'nutritional guru' – all are still prevalent in the modern game. Players are becoming more demanding because of what they learn in conversation with other players from other teams and even other sports.

Players from overseas bring with them their own ideas (nearly always related to vitamin intake), which are very often lacking in scientific support. In addition, at present there is a fundamental mismatch between what players and practitioners view as important. Players believe in supplements, extra vitamins and minerals: anything that involves increasing muscle mass, and reducing energy intake to achieve 'lean' body composition. Scientific research, on the other hand, demonstrates that players should concentrate more on appropriate energy consumption, and high carbohydrate and fluid intake.

Football is steeped in tradition, which many people wrongly write off as Luddite-type conservatism, or little better than old wives' tales passed around the old boys' network. It is true that many coaches and support staff are employed from within, but it is also true that these people know the sport and its peculiarities better than anyone. Furthermore, the practice of employment from within will eventually spawn a new breed of coaches who will have, one hopes, more positive and enlightened experiences of sports nutrition.

Back to the fish and chips?

Of course, providing a cutting-edge nutritional support programme has no value unless it is backed by a stimulating and imaginative education programme. It is important to pitch your educational material appropriately: 'healthy eating' on its own simply does not wash with Premier League football players. Science and technology, pitched correctly, most definitely do. For all the advances science has made, the most important lessons nutritionists have had to learn are 'respect the sport' and 'know your place'. It is sobering to note that Real Madrid, arguably the world's best football team, employ no fewer than nine masseurs but no one to take care of their players' nutritional requirements.

My personal working title for this article was: 'The role of fish and chips in modern football'. Five years ago I walked into a football club and one of the first changes I made was to remove the fish and chips from the post-match menu. This wasn't a popular move, and it would be dishonest to say that any menu offered to the players since has received anything like the same enthusiasm. Should I go back to fish and chips?

Well, potato is a high glycaemic index carbohydrate food, thought to be preferable for the recovery of muscle glycogen

'For all the rewards that science and nutrition has to offer, these can only be achieved if we respect the traditions of the sport and take the players with us'

stores, and fish is a complete protein source possessing essential amino acids ideal for stimulation of muscle protein synthesis. Most importantly, most players will definitely eat this dish. OK, the high fat content will probably interfere with the glycaemic response of the potato and, of course, there are other health promotion implications to wrestle with.

In actual fact, I probably won't return to post-match fish and chips for the players, however popular this would be, but this real-life example does highlight the fact that, for all the rewards that science and nutrition has to offer, these can only be achieved if we respect the traditions of the sport and take the players along with us.

Nick Broad

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It used to be oranges in the centre circle… now it's a personal hydration strategy

It has always seemed strange that football – in financial terms, the most professional of sports – is the least professional in terms of the approach of individual players to training and other aspects of preparation. Football clubs, as employers and investors in the players, have also been slow to take advantage of the opportunities to maximise the return on their expenditure. Nutrition has generally been low on the priority list, if it has featured at all. Every club expects the players to train, but it hardly seems worthwhile insisting on this if the opportunities offered by good nutrition are neglected.

One of the key areas where nutrition can have a direct impact on performance is in the area of hydration. There is good evidence that players who become dehydrated are more susceptible to the negative effects of fatigue, including loss of performance and increased risk of injury. There is also growing evidence that excessive sweat losses, especially high salt losses, can be a factor in some of the muscle cramps that affect players in training and competition.

Recently, however, a number of clubs have recognised that hydration is important and that no single strategy suits all players in all environments. This has led to an assessment of individual needs so that a personal drinking strategy can be put in place. This practice appears to have gained ground in American football, where pre-season training typically takes place in extreme heat and involves two sessions per day. In recent years, a number of high-profile fatalities, including that of Korey Stringer in the NFL, have raised the awareness of what can happen when things go seriously wrong. Several of the top English football clubs now have monitoring strategies in place.

Zero-cost analysis

At its simplest level, weighing players before and after training gives an indication of their level of dehydration and risk of heat illness. This takes account of both the amount of sweat lost and the amount of fluid drunk, and gives the net balance. There will be a small amount of weight loss due to the fuels used to produce energy (mostly carbohydrate, with a bit of fat), but this amount is relatively small. There will also be water loss from the lungs and through the skin. Broadly speaking, a weight loss of 1kg represents a net loss of 1L of body fluid.

A slightly better measure is obtained if the player is weighed before and after training or competition (nude and dry on both occasions) and his (or her) drinks bottle is also weighed before and after, assuming that all players drink from their own bottles and that anything that is taken from the bottle is swallowed and not spilled/poured over the head/spat out. If the decrease in weight of the drinks bottle is added to the decrease in weight of the player, we get the actual sweat loss. We also get a measure of the player's drinking behaviour.

All of this is easy to do, and all it requires is a set of kitchen scales to weigh the drinks bottles, a reliable set of scales to weigh the players, and a bit of organisation. The cost is effectively nil – just a bit of time and effort on the part of one of the backroom staff. There is one more measure that can be usefully added, but this needs rather more specialised apparatus and is thus likely to be the preserve of the top clubs only: the measurement of salt losses in sweat.

Identifying salty sweaters

There are many ways to measure salt losses in sweat. The one that is most convenient in practice is to use gauze swabs covered with an adhesive plastic film: typically, four are applied at different sites before exercise begins and left in place for an hour or so. After they are removed, the amount of sweat and the amount of salt in the patch can be measured, allowing the ‘salty sweaters’ to be identified.

We have made these measurements on the first team squads at a number of Europe’s top teams, typically testing about 20-30 players at each club. The results have been consistent between clubs when the training sessions have been similar, but the variability between individual players has been striking. Key findings in a typical 90-minute training session are as follows:

1. Average sweat loss is typically about 2L, but this can vary from about 1L to over 3L, even though all the players are doing the same training in the same conditions and are wearing the same amount of clothing.
2. Average fluid intake is typically about 800-1,000ml, but this can vary from about 250ml to over 2L.
3. There is no relationship between the amount of sweat a player loses and the amount he drinks.
4. The sweat salt content varies greatly: the better acclimatised players have lower sweat content, but again there are large individual differences. Sweat salt (sodium chloride) losses can reach almost 10g in a single training session in some players, and this during twice-a-day training. Others lose only small amounts – 2g or less in the same training session.
5. When training takes place in the cold, sweat losses may be almost as high as when training in the heat, but players drink far less and so end up just as dehydrated – or even more so.

‘The aim should be to drink enough to limit weight loss to no more than 1-2% of pre-exercise weight’

These findings may appear simplistic and predictable – apart from the last one, which is not intuitively obvious – but they give the training staff of a club that is serious about maximising its human assets a chance to prescribe fluid according to the player’s needs. The aim should be not to drink too much, as some players do, but to drink enough to limit weight loss to no more than 1-2% of the pre-exercise weight.

There is also a suspicion – and I should stress it is no more than a suspicion at present – that players with a very high sweat salt content are more prone to cramp, and that this risk can be reduced by salt supplements.

These simple steps can make a difference between being able to score that vital goal in the last minute and being a virtual spectator. It is only surprising that it has taken the world of professional football so long to realise this.

Ron Maughan

Who is there to support the managers? A psychologist reflects on survival techniques in a cut-throat world

You have only to read the sports pages or listen to the news to learn of yet another football manager who has got the sack, might get the sack or is in trouble. The world of the professional football manager is one in which danger and uncertainty about the future hover over every match the team plays. It is an often lonely and isolated position, which can leave managers vulnerable to psychological stress.

Here, I review the season I spent working with a professional football manager in my capacity as a sports psychologist. While the manager's name must remain confidential, I want to make it clear that I have his full permission to write what follows. The journey I embarked upon taught me many important lessons about the culture of football and its impact on the psychological wellbeing of managers. I also learned how a sports psychologist can support a football manager in what is often hostile territory.

Initially, I focused on developing an understanding of the manager's work environment. I needed to know what demands were being placed upon him and what their impact was. I discovered that football managers are subject to four main sources of pressure that impact on their psychological wellbeing:

- the players

- the club owners
- the fans
- the media

Each of these sources of pressure places different – often conflicting – demands on the manager, all which have to be satisfied. This creates an intensely pressurised working environment.

The overall effect is to create a climate of uncertainty and insecurity for the manager. The elements of this climate that impact most significantly on his psychological wellbeing are as follows:

- lack of personal security
- isolation
- fear of public humiliation
- lack of control over his own destiny (*ie* the players ultimately decide his fate)
- need to appear strong and in control
- need for quick fixes
- culture of non-sharing
- ego-oriented culture in which everyone is an expert

‘The culture within football expects the manager to be strong and in control at all times, with no place for uncertainty or need for reassurance’

These factors need to be fully understood by a sports psychologist if he/she is to work effectively with a football manager. The culture within football expects the manager to be strong and in control at all times, with no place for uncertainty or need for reassurance. Taken in isolation, the above-mentioned factors would be a challenge for anyone, but in combination their effect can be devastating and it is not surprising that managers are prone to stress-related illness.

What became apparent to me during the season was the lack of support available for the manager, who was often working in isolation to solve difficult problems. In theory, the assistant coach and the management were available to work with him, but in reality the manager was responsible for every decision. The fact that he then had to justify those decisions to everyone else was an additional source of stress.

A pendulum mindset?

Exploration of the manager's mindset revealed pendulum-like swings from very negative to very positive, which were completely dependent on the outcomes of matches. The following quotes illustrate some of the widely-held beliefs within football that were wholeheartedly embraced by the manager I was working with:

- 'When you don't win people don't believe in you'
- 'When you are winning you are never wrong'
- 'Players will lose you your job'
- 'You live and die by your decisions'
- 'I am too soft'
- 'Results make you God'

This mindset indicates a lack of stability and balance. When the team is winning, the sense that the manager can do no wrong creates a false sense of security and a 'feelgood' factor that is often short-lived. As soon as the team is losing – or even drawing – his whole coaching methodology is called into question, even though nothing has changed fundamentally from one game to the next.

The net effect of this is to leave the manager doubting himself and his approach to many aspects of the game. It is extremely difficult to persist with strategies that you believe to be correct when everyone around you is telling you, either overtly or covertly, that you are not doing a good job. And this growing self-doubt soon impacts on the manager's relationships with players, with other staff and with the club owners.

While it has been widely accepted that low self-confidence impacts negatively on an athlete's performance, its effects on the performance of managers have been generally ignored. Furthermore, the consequences are particularly grave for managers: if the team's results are poor the owners will still own the club, the players will still play for it and the fans will still support it, but the manager will be sacked in an effort to improve the team's performance. This knife-edge existence leaves managers very vulnerable.

Off-pitch dynamics

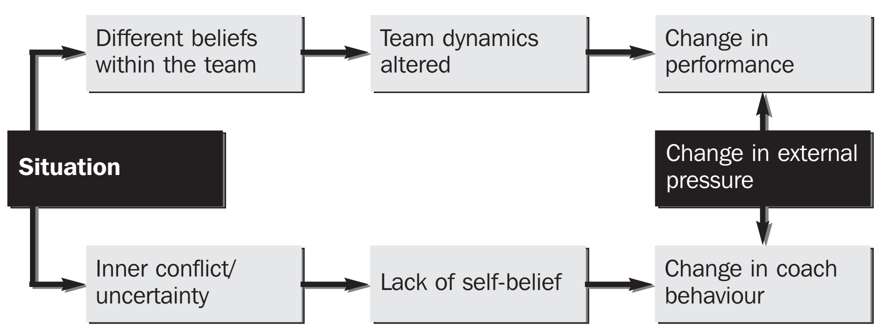
‘It became clear that the toughest issues the manager had to contend with occurred away from the pitch’

As my season progressed, it became clear that the toughest issues the manager had to contend with occurred away from the pitch. Examples included players trying to adjust to life in a foreign country, players facing retirement, players involved in gross misconduct, marital difficulties and older players intimidating younger ones.

While these issues might appear to have nothing directly to do with the players’ ability to play the game, it became clear that the manager’s ability to help his players resolve them did have a direct impact on performance. And it is in these situations that football expertise, knowledge and ability can’t help you, even though they might be the reasons why you were given the job.

It was also clear that these situations impacted in different ways on the team and the manager. Your perception of any situation will vary considerably, depending on your role within an organisation. The diagram *(below)* illustrates a situation in which there were differing beliefs within the team regarding a decision made by the manager. The consequence of this was a shift in the team dynamics, causing rifts and a negative impact on performance. For the coach, the situation generated inner conflict and uncertainty, which led to a lack of self-belief. The result of this was a change in coach behaviour to a more autocratic style.

Effect on the team



My role as a sports psychologist was to work with the manager to help him find solutions. However, in order for my work to be effective there were a number of fundamental principles that needed to define the working relationship:

1. The confidentiality of the manager had to be assured. The importance of this principle should not be underestimated, given the culture of football. If other people had known about the work it could have been compromised, as could the manager's position
2. It was important that I was not a stakeholder in the club and was there solely for the manager's benefit
3. It was important that I was non-judgmental about – indeed unconcerned with – the results. Our agenda was focused on the manager's response to any given situation, whether on or off the pitch

'In his world of constant insecurity and mistrust, if he had ever doubted me the work would have been over'

These principles were vital to the work we undertook. In his world of constant insecurity and mistrust, if he had ever doubted me the work would have been over. This trust was hard won, but once established it enabled real progress to be made.

What I learned from my experience was that it is vital to really understand the culture of the game, so that, in a very real sense, you can learn to speak the same language as those who inhabit the football world. Coming from an essentially non-football background, I had to work hard to appreciate the context within which the manager's job was being undertaken. Sometimes I got it wrong, but through questioning and acknowledging my own limitations I developed my understanding. Ultimately this made me more effective in my role. I discovered that it was good to challenge current practice, but that we had to work through realistic alternatives that would work in football. My role was to support the manager, not solve player problems.

My work with the manager had three key aims:

- To develop more effective inter-personal communication skills
- To enhance understanding of group dynamics and how to

affect them
- Personal stress reduction

As the season progressed, the manager was able to use our sessions to tackle difficult situations he was facing. He was able to discuss openly and freely any concerns or doubts that he was experiencing in relation to the players, the owners or even the fans. Consequently, he was being supported, and given the opportunity to develop strategies to help him manage more effectively.

In summary, it is clear to me is that the managers of the future need to develop skills in inter-personal communication and to have an understanding of group dynamics and effective group management. They also need to work to develop personal coping and stress-reduction mechanisms if they are to survive the cut-throat world of football management.

Misia Gervis

What happens when you hang up your football boots – for good?

You may be at the peak of your football powers right now, having conditioned your body to be the ultimate machine for your position, but what will happen to that machine as matches, not to mention knocks, take their toll? Will that highly conditioned physique break down later in life because of too much football-induced wear and tear? And is there anything that you can do now to prevent potential decline in physical function caused by your football participation?

Specifically, this article will consider the following issues:

- Soft tissue and joint damage – primarily to the knee and anterior cruciate ligament;
- Long term heading of the ball (seen by some as a cause of neuropsychological problems);
- The impact of playing position, playing surface and age at which injuries occur on post-retirement health.

Joint damage and osteoarthritis

A great deal of research has been carried out into the effect of participation in football (and other sports) on the incidence of osteoarthritis in later life.

Osteoarthritis is a degenerative condition of the joints, which can become swollen and painfully inflamed. The 'itis' bit implies pain, without which the condition is known as osteoarth*rosis*. The condition affects the joint cartilage – a smooth substance covering bone endings that allows bones to glide over each other with minimal friction and also cushions force as it is transmitted through the joints. In fact, cartilage serves a very similar function to the oil in your car engine, the big difference being that it cannot be topped up when lost.

Degeneration of cartilage occurs as a result of ageing and, more relevant to this article, injury and overuse. The condition is diagnosed by X-ray, where cartilage appears as a black space between bones and the joint space is significantly narrowed.

Osteoarthritis is very difficult to treat, and management therefore focuses on relieving pain and preventing deformation of the affected joint. In extreme cases there is no option but to fuse a joint together.

There has been considerable research into the link between contact sports, like football and rugby, and osteoarthritis around the knee, hip and ankle during and after playing careers. For example, Turner and associates investigated the long-term impact of football on the 'health related quality of life' of former professional footballers in the UK with a survey of 284 former players [1].

Respondents were asked to report on medical treatments, osteoarthritis diagnosis, other morbidity, disability status and work-related disability since ending their football careers. The researchers found that medical treatment for football-related injuries was a common feature, as was osteoarthritis, particularly of the knee. And players consistently reported a reduced health-related quality of life when suffering from this condition.

This exploratory study suggests that playing professional football can impact on the health of footballers in later life and that osteoarthritis is a key problem. Further research by Drawer *et al* came up with very similar findings in a study of English professional footballers [2].

Demands of the game

There is a high risk of knee damage at all levels of the game, given the need for constant turning and cutting and, of course, the ever-present risk of sustaining a 'bad' tackle, or even making one. In many cases damage is done to the anterior cruciate ligament (ACL).

The ACL is one of four ligaments that are critical to the stability of the knee joint. A ligament is made of tough fibrous material and functions to control excessive motion by limiting joint mobility. Without ligaments to control the knee, the joint would be unstable and prone to dislocation. The ACL prevents the tibia (shin bone) from sliding too far forward and contributes stability to other movements at the joint including angulation and rotation. When an ACL injury occurs the knee becomes less stable, and this instability can make sudden pivoting movements difficult and make the knee more prone to osteoarthritis and cartilage tears. Surgery is usually required.

ACL injuries in football

A particularly relevant study on ACL injuries in football was carried out by Bjordal and team [3], who carried out a retrospective study of all ACL injuries (972) verified by arthroscopic evaluation at hospitals in the Hordaland region of Norway from 1982 to 1991. The final study group comprised 176 patients who had participated in organised football. The researchers found an overall incidence of 0.063 injuries per 1,000 game hours. Men incurred 75.6% (133) of the injuries), although women had an incidence of 0.10 injuries per 1,000 hours, which was significantly higher than that of the men (0.057). The incidence of ACL injury was highest (0.41) for men in the top three divisions. Most injuries (124) occurred during games, with tackling and the ensuing contact causing injury in 46.0% of the cases.

'ACL injuries are common in football, with women more susceptible to them than men'

Reconstructive surgery was performed on 131 (74.4%) of the injured players and was found necessary for return to a high level of play. Men at high levels of play had the highest return rate (88.9%) while men over 34 had the lowest (22.9%). Unfortunately, nearly one third of the injured players retired from the game because of poor knee function or fear of new injury, which would obviously not augur well for future mobility.

So it seems that ACL injuries are common in football, with women more susceptible to them than men. This idea has

‘Extrinsic factors such as weather, playing surface, temperature or player position did not influence the injury rate’

received further support from a Swedish study of the incidence of injury in two female elite soccer teams over a year [4]. Of 41 players, 33 (80%) sustained 78 injuries, with an incidence of injury during games of 24 per 1,000 hours and a training incidence of 7 per 1,000 hours.

Most (88%) of injuries were localised to the legs, most commonly the knee or ankle (49%),with injuries spread relatively evenly between left and right legs. Traumatic injuries (72%) occurred mainly during games, and particularly at the beginning of the competitive season. Almost 80% of these injuries occurred during physical contact with an opponent. Extrinsic factors such as weather, playing surface, temperature or player position did not influence the injury rate.

Although most injuries were not serious, 17% of the players sustained a major knee injury during the year, suggesting a high risk of osteoarthritis after retirement.

A further Swedish study substantiated these findings and generated some interesting recommendations for female footballers looking to maximise their careers and avoid knee problems in later life [5]. The study focused on 398 female players who had sustained an ACL injury before age 19. Of this total, 38% were under 16 when injured, and 39% of these were injured when playing in senior teams.

At the time of this investigation (2-7 years after the ACL injury), 78% of the players reported that they had stopped playing football, in most cases because of persistent knee problems The researchers concluded that: ‘Female soccer players under the age of 16 years should be allowed to participate only in practice sessions but not games at a senior level’.

Back injury

Back injury is less prevalent than lower limb injury in football, but is far from rare. Turkish researchers investigated early degeneration of the spine in amateur and master football players – previous research having indicated that such degeneration begins 20 years earlier than in the non-playing population [6].

They found that range of motion in the spine of football players was reduced by comparison with the non-playing population, with degenerative changes paricularly prominent in the over-30s. 'A tendency toward early degenerative changes exists in soccer players,' they concluded, 'most probably due to high to low impact trauma to the upper spine caused by heading the ball.' Heading has also been implicated as a cause of neuropsychological damage in footballers – of which more later.

There are a number of ways to reduce the risk of football-induced joint health problems – although some rely more on luck than judgement:

1 *Injury avoidance.* Using American football as an example, Moretz focused on the incidence of knee osteoarthritis in 23 Grid-Iron participants, 20 years after high school competition, compared with 11 age-matched controls [7]. The good news was that no statistically significant increase in osteoarthritis was found in the players who had not been injured, although there was a significantly increased incidence in those who had sustained a knee injury.
2 *Supplementation.* It is not possible to go into great detail on this subject, but a growing body of research suggests that glucosamine sulphate and chondroitin sulphate can improve joint health and reduce further deterioration and the symptoms of osteoarthritis. Glucosamine is used in the manufacture of very large molecules found in joint cartilage, called proteoglycans. These molecules are able to hold on to water rather like a sponge, so providing cushioning for joints. *(For a more detailed consideration of the benefits of glucosamine sulphate and chondroitin sulphate, see PP 192, January 2004)*.
3 *Preconditioning and conditioning.* Again it is beyond the scope of this article to go into a detailed consideration of preconditioning (training to train) and conditioning (training) football methods, but suffice it to say that these will have a strong bearing on the 'control' of non-contact joint damage. There are numerous conditioning methods that can strengthen body parts, making them less prone to

injury. Female conditioning should take account of their particular physiological and biomechanical disadvantages – including their hamstring/quadriceps strength ratio as well as their increased risk of knee injury.

Neuropsychological problems

A great deal of research has examined the potential link between concussion (caused by head clashes, for example), sub-concussive blows (from heading) and brain damage in footballers.

Downs *et al* from Florida hypothesised that football players, particularly older ones, would demonstrate reduced neuropsychological performance by comparison with swimmers [8]. In their study, 32 football players (26 college and 6 professional) and 29 swimmers (22 college and 7 masters) completed four neuropsychological tests measuring motor speed, concentration, reaction time and conceptual thinking.

‘Players in certain positions, notably defence and attack, displayed poorer neuro-psychological results than mid-field players and goal keepers’

The footballers performed worse than the swimmers on measures of thinking, reaction time and concentration, and the researchers concluded that: ‘participation in soccer may be associated with poorer neuropsychological performance, although the observed pattern of findings does not specifically implicate heading as the cause’. Although these deficits were most apparent in the older players, the researchers recommended regular neuropsychological testing for early detection of impairment for younger players too.

Similar findings have emerged from other studies. And Dutch researchers found, additionally, that players in certain positions, notably defence and attack, displayed poorer neuropsychological results than mid-field players and goal keepers, possibly due to their greater involvement in heading [9].

Other researchers have been more equivocal on the role of heading as a cause of neuropsychological dysfunction. In a recent literature review, a British team concluded that: ‘there is no reliable and certainly no definitive evidence that impairment occurs as a result of general football play or football heading’

Playing football is and should be a fun activity at all levels. However, it does appear that it can leave players with a legacy of ill health in later life. Players needs to minimise injury risks as far as possible by being optimally conditioned and monitored where appropriate. They should also consider limiting the numbers of headers made in training and their level of involvement at an early age (particularly if female). Footballers will also have to ride their luck (and the tackles) when it comes to injuries.

John Shepherd

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Sudden cardiac death: how can clubs pick out those at risk ?

The cardiovascular benefits of regular exercise are well established: as well as improving stamina, regular exercise promotes weight reduction, controls blood pressure, regulates blood fats and enhances insulin sensitivity, thereby reducing the risk of coronary artery disease and sudden cardiac death. Young people (under-35s) who participate in regular physical training generally make up the healthiest segment of our society. However, a significant minority are at risk of sudden death, usually during or shortly after a bout of physical training [1,2].

Sudden cardiac death in young athletes is, fortunately, rare, although precise data on its incidence is lacking. Data compiled from long-standing endurance running events in the USA and the UK suggest an incidence range of 1 in 50,000-67,000 [3,4]. However, these are probably conservative estimates since the data is derived from highly scrutinised sporting events. With no systematic notification of sudden cardiac death in athletes, deaths associated with lower-profile events or recreational activities are not taken into consideration when compiling statistics.

While the commonest cause of sudden cardiac death in the over-35s is coronary artery disease [5], more than 80% of sudden deaths in young athletic individuals are due to inherited (congenital) defects of the heart, resulting in structural and/or functional abnormalities [1]. For affected individuals, the surges of adrenal hormones that accompany competitive vigorous physical activity predispose them to fatal cardiac arrhythmias (rhythm disturbances) and sudden death.

Most of these deaths occur in adolescent male athletes; according to one study from the US, the mean age of sudden cardiac death is 17.1 years[1].

Some athletic individuals harbouring these potentially lethal cardiac abnormalities are capable of incredibly high levels of performance. Sudden death has been reported in many sporting disciplines including rowing, running and cycling. But most reported deaths in the UK have been in footballers. In 1992 Daniel Yorath, the son of Terry Yorath (former Leeds United player and manager of the Welsh national team) died while playing football with his father in the garden. Daniel himself was a football player of great potential, who had just been signed, aged 15, by Leeds United.

This tragedy was followed by the deaths of Ian Bell, 16, who had just signed for Hartlepool, John Marshall, also 16, a junior international who died the day after he signed for Everton, and Jason Erics, 17, a member of the Tottenham Hotspur youth team. The more recent death of Manchester City star and Cameroon international Marc-Vivien Foe, aged 24, during a live televised international match in June 2003, was the most disturbing of all. All of these young men harboured a cardiac condition that proved fatal; and in all except one, that condition was hypertrophic cardiomyopathy (HCM) – pathological enlargement of the heart muscle.

Cardiac death: the commonest cause

In fact, HCM is the commonest cause of sudden cardiac death in athletes, accounting for almost one third of all sudden death in highly trained sportsmen. It is a familial heart muscle disorder, caused by gene mutations affecting contractile proteins of the heart[6]. The condition has a prevalence of 1 in 500[7] and is characterised by unexplained left ventricular hypertrophy (LVH) of variable magnitude, coupled with a relatively small left ventricular cavity.

Affected individuals usually have impaired relaxation of the heart muscle, with a propensity to myocardial ischaemia (poor blood flow to the heart) and fatal arrhythmias during intensive physical activity. The disorder is variable in degree, with some people having only minimal ventricular hypertrophy. It is also variable in presentation, with some patients displaying severe symptoms and others being entirely asymptomatic.

The commonest manifestations of the disorder are central chest pain during exertion (angina), breathlessness that is disproportionate to the amount of exercise being performed, palpitation, and syncope (fainting). However, with entirely asymptomatic individuals sudden death may be the first presentation of the problem.

'Although there is no cure for HCM, the risk of sudden death may be reduced by giving up vigorous physical activity'

The puzzle of Marc-Vivien Foe

Most people with HCM cannot boost their stroke volume (the amount of blood put out with each beat of the heart) during exercise at high work rates because of their small left ventricular cavity and impaired left ventricular filling (with blood). For this reason, most do not reach high levels in competitive sport. However, some are capable of high levels of athletic performance, particularly in sporting disciplines like football that are characterised by a 'start-stop' pattern of activity. Marc-Vivien Foe, for example, was regarded by the managers of West Ham and Manchester City as fitter than most of his fellow squad members, and he never complained of any cardiac symptoms before his death.

Hypertrophic cardiomyopathy is diagnosed by means of echocardiography (cardiac ultrasound) – a simple, non-invasive test that can be carried out in 15-20 minutes by a skilled technician or cardiologist. Although there is no cure for the condition, the risk of sudden death may be reduced by giving up vigorous physical activity. In patients at high risk of sudden death, the implantation of an internal cardiovertor defibrillator (which restores normal cardiac rhythm) has been shown to prevent sudden death[8].

There is a case for saying that if HCM can be diagnosed with relative ease in athletes, they should be screened for the condition. In the cases of sudden death referred to above, a diagnosis of HCM would have led to disqualification from football[9], which might have proved costly in psychological as well as financial terms but might also have saved lives.

In Italy, all young athletes are required to produce an annual certificate of fitness based on a normal physical examination, ECG and a limited exercise test. And the systematic evaluation of sudden cardiac death victims in northern Italy reveals that HCM is a very rare cause of death in young athletes[10]. This evidence contrasts with published reports from other countries, where HCM is by far the commonest cause of sudden cardiac death. One interpretation of this discrepancy is that Italian athletes with HCM are being identified early and excluded from sporting activities.

The argument against screening for HCM is that the condition has a very low prevalence of just 1-in-500 in the general population and probably even lower among athletes, since most people with HCM would find themselves unable to compete in sporting disciplines requiring vigorous physical activity at regional or national level. In order to identify the very small proportion of athletes with HCM, it would be necessary to screen many thousands of healthy individuals. Admittedly, such activity would not be cost-effective, but there is also an argument for saying that most Premier League clubs are sufficiently well-endowed to carry this cost if it has the potential to save young lives.

‘The steady trickle of sudden deaths in football has led the Premier League to invest substantial sums into screening all junior recruits’

The death of Daniel Yorath in 1992 led Leeds United to organise pre-participation cardiovascular evaluation – comprising physical examination, ECG and echocardiography – for all junior recruits before accepting them onto the team. Everton adopted the same policy after the death of John Marshall. The steady trickle of sudden deaths in football has led the Premier League to invest substantial sums into screening all junior recruits with ECG and echocardiography over the past five years, although their results, in terms of detecting cases of HCM, have yet to be published.

Football is the most popular sport in the UK and, of course, Premier League players are merely the tip of a very large iceberg. However, large-scale screening for the general population participating in football and other sports is not currently considered a viable option. Since cost is a major issue, raising public awareness of the risk of sudden cardiac death in athletes and the warning signs and symptoms may be a more practical way forward.

Athletes suffering from exertional chest pain, disproportionate breathlessness, dizziness or fainting should be evaluated in specialist cardiology centres to exclude the possibility of underlying cardiovascular disease. Given that HCM is a familial disorder, athletes with a family history of the condition, or of unexplained sudden death under 40, should also be evaluated

Regular physical training is usually associated with modest increases in left ventricular wall thickness and cavity size [11]. In the vast majority of athletes, the maximal left ventricular wall thickness is well within values for the normal population (less than 12 mm). A very small proportion of athletes, including football players, may develop relatively greater LVH, which is similar to that seen in mild HCM [12,13]. However, a left ventricular wall thickness of more than 14 mm is most unusual in football players with non-pathological LVH. Furthermore, unlike people with HCM, athletes with this kind of benign LVH also tend to have large left ventricular cavities [14].

To summarise, sudden cardiac death in young football players is rare, but is most commonly due to HCM. The condition can be identified, and sudden death prevented, by discontinuing vigorous exercise. The steady trickle of deaths in football has led to mandatory screening for all junior recruits at Premier League clubs. However, most clubs cannot afford screening (which is not available on the NHS), and so efforts should be made to raise awareness of the symptoms of HCM amongst athletes, coaches and doctors in the hope that symptomatic athletes can be screened and premature deaths on the football pitch prevented.

Sanjay Sharma

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What Sven Goran Erickson can learn from research in the lead-up to the 2006 World Cup

'In tournament football, fitness and conditioning are absolutely vital. They are among the most important things. You also need a little bit of luck with injuries and penalties and things like that.' So says Sven Goran Eriksson [1]. Wise words indeed from the England manager, but can PP make him any the wiser? This article takes an in-depth look at some of the key factors that impinge on creating a winning World Cup team.

Next year's playing season is designed to give the England squad more time to prepare for the 2006 World Cup in Germany. But will the rigours of a Premiership and European season for the majority of the English-based players have taken its toll on their readiness for the biggest tournament on earth?

Research by Ekstrand and his colleagues from Linkoping University in Sweden looked specifically at the domestic season's toll on top-flight footballers from across Europe in the lead-up to the 2002 World Cup, focusing on the impact of number of matches played on injury rates [2]. Team doctors at 11 of the best football clubs in Europe monitored their players continuously over the 2001/02 season, when 65 of the players participated in the Korea/Japan World Cup. During the tournament the clubs reported the injuries sustained by these players, while three international experts analysed how well they played.

Domestic games played by Europe's elite varied between 40 and 76. Not surprisingly, top players (or at least those in the more successful sides) played more matches, especially during the final period of the season, when there were more cup commitments. In all, World Cup players played 46 matches, compared with 33 for non-tournament players.

Perhaps surprisingly, given that they played more games, the World Cup players did not experience a greater injury rate than non-World Cup players during the season, However, 29% of them sustained injuries in Korea and Japan. And, ominously, 23 (60%) of the 38 players who had played more than one match in the week before the World Cup incurred injuries and/or underperformed during the tournament. This led the Swedish researchers to conclude that the number of games played in the last 10 weeks before the tournament was particularly crucial in terms of potential injury risk and/or underperformance.

'Should Sven forego friendlies in the lead-up to Germany?'

What of the demands of international football? Are those who play regularly at this level any more prone to injury than others? And should Sven forgo friendlies in the lead-up to Germany in consequence? This question was the subject of further research by Ekstrand, who carried out a longitudinal study of the Swedish team between 1991 and 1997[3].

During this six-year period the team played 73 official matches and attended three training camps. Fifty-seven of these matches and the three training camps were included in the study, amounting to a total of 6,235 training and 1,010 match hours. Exposure to football was recorded individually for each player, and the team doctor examined all injuries.

In all there were 71 injuries (40 incurred during training and 31 during match play). Five (16%) of the match injuries were major and resulted in more than four weeks out of the game. The incidence of injury during training was 6.5 per 1,000 player hours, while the incidence during matches was 30.3/1,000 hours.

Interestingly, a significantly higher injury incidence was found in matches lost than those won or drawn (52.5 compared with 22.7/1,000 hours), although no significant difference in injury rates was found between competitive and friendly matches and between matches played on home, away and neutral ground.

How to follow in Brazil's footsteps

Luis Filipe Scolari, manager of the victorious Brazil side in the 2002 Football World Cup, summarised the reasons for his team's victory in the following terms [4]:

- The staff and team created a 'winning spirit';
- The staff focused their energies on convincing the younger players that they could win if they wanted to. The veteran players already believed in their ability;
- Scolari interviewed all of the players' individual club coaches, allowing him to gather additional information on his team;
- The staff constantly gathered statistical data on all of the team's games and shared the information with the players, focusing on where goals were scored for and against;
- They put considerable effort into exciting the passions of the players as they felt that volatile Latinos were more likely to be led by their hearts than their minds!
- Physical fitness tests were carried out for all players at the very beginning of training so that there was a clear baseline from which improvements could be measured;
- The coaching staff focused on giving the players organisation and discipline as a team;
- They focused a lot of energy on winning the first game, as this was seen to be vital for mental preparation.

These findings led Ekstrand to conclude that the risk of injury when playing for a national team was comparable to that previously reported for professional football at a high level. However, given his previous findings [2], it would seem prudent for the English Football Association (FA) to limit their team to essential games only in the lead-up to the World Cup, to minimise the risk of injury and impaired performance in the tournament itself. England should also be careful to win all its games!

The quote from Eriksson in my introductory paragraph mentions the importance of luck, and there is certainly a huge element of luck involved in injury risk, as FIFA, the international governing body of football, discovered when analysing the incidence and type of player injuries that occurred during the 2002 World Cup [5].

The team doctors of all the participating teams reported all injuries after each match on a standardised injury report form, and a total of 171 injuries were reported from the 64 matches, equating to an injury rate of 2.7 per match. Of all the injuries, 73% were contact injuries and the remainder incurred without contact with another player. Half of the contact injuries (37% of total injuries) were caused by foul play as defined by the team physician and the injured player.

So, statistically speaking, luck will play a prominent part in determining Eriksson's players' injury risk, as there is not much than can be done to avoid contact injuries, especially if these are instigated deliberately by players on the opposing side. (Note: FIFA will be pushing the importance of 'fair play' in Germany in an attempt to reduce the incidence of deliberate fouls).

'If hamstring strains are to be reduced among elite players, club coaches need to be better educated on the merits of active warm-ups'

Hamstrings and hydration

It is beyond the scope of this article to go into detail about football conditioning and pre-conditioning methods. However, I do want to focus on hamstring protection and player hydration since these are among the most important determinants of player endurance (in all senses of the word) in tournament football. A strained hamstring will almost inevitably mean the end of the line for a player – at least as far as this particular tournament is concerned – while inadequate hydration can significantly impair performance and even increase injury risk.

UK researchers Dadebo and a team from Manchester Metropolitan University investigated the relationship between current flexibility training protocols and hamstring strain rates (HSRs) in English professional football clubs (6). Data on flexibility training was collected from 30 clubs in the four divisions during the 1998/99 season.

Although there was considerable variation in the way the different clubs trained for flexibility, the researcher discovered (surprisingly, given its limited relevance to match and training conditions) that static (passive) stretching was the most popular method.

In terms of injuries, hamstring strains accounted for 11% of the total and one third of all muscle strains, while about 14% of hamstring strains were re-injuries. HSRs were most prevalent in the Premiership (13.3 for every 1,000 playing hours) and least prevalent in Division 2 (7.8 per 1,000 hours), with forwards mostly likely to be injured. Most (97%) hamstring strains were grade I and II and two thirds of them occurred late during training/matches.

Just to explain this terminology, a grade I strain might consist of small micro-tears in the muscle; a grade II strain would be a partial muscle tear and a grade III would be a severe or complete rupture of the muscle.

When analysing injury rates in relation to flexibility protocols, the researchers concluded that about 80% of hamstring strain rate variability was accounted for by stretching holding time. In other words, the longer the muscle was stretched, the more likely a player was to suffer a hamstring strain.

The implication of this research is that if hamstring strains are to be reduced among elite players, club coaches need to be better educated on the merits of active warm-ups, including specific stretches (of which more later).

Fluid loss can inhibit performance and increase injury risk. We must hope that the England team will not assume that because the games are to be played in European conditions, albeit summer ones, there will be less need to pay attention to player hydration, as a large body of research suggests that such a lax attitude could lead to the team flying home early.

Maughan and colleagues from Loughborough University measured fluid balance during a 90-minute pre-season training session in the first team squad of an English Premier League football team(7). Sweat loss during the session was measured by changes in body mass after taking account of fluids ingested in drink and excreted in urine. Sweat composition was analysed by patches attached to the skin at four sites.

On the day of testing, the weather was warm: 24-29°C, with moderate humidity (46-64%) – similar conditions to those expected next summer in Germany. Over the course of the training session, the mean body mass loss was 1.10kg, equivalent to 1.37% of pre-training body mass. Mean fluid intake was 971ml and estimated mean sweat loss was 2,033ml, with a total sweat sodium loss of 99mmol, corresponding to a salt (sodium chloride) loss of 5.8g.

Maughan concluded that sweat losses of water and solute (liquid containing electrolytes) in footballers in training can be substantial.

However, there was considerable variation in losses between players, even in the same exercise and environmental conditions. There was also considerable variation in voluntary drinking, which was generally insufficient to compensate for fluid losses.

So it seems that Sven and his backroom team need to design and implement individual fluid replacement programmes for each player. To help them, Maughan recommends that players should drink enough to limit weight loss to 1-2% of their pre-training session/match weight. Since salt loss can make players more prone to cramping, he also advises that those with a tendency to cramp should consider taking salt supplements.

Warm-ups for big games

Finally, we need to consider how to warm up for the big games. And here Professor Angel Spassov has some key pointers for the England side. A football conditioning expert from Bulgaria, now based in the US, Spassov has worked with no fewer than six World Cup squads, most recently Portugal during Euro

Spassov's active warm-up

1. ***Non-specific warm-up***

- 6-8 minutes of jogging, followed by neck, shoulder, lower back and abdominal stretches;
- Use 2-3 different routines with 10-12 repetitions of each;
- Next target legs (hamstrings, hip flexors, abductors, adductors, quads and calf muscle) with passive and dynamic stretches. Perform 2-3 standard routines with 10-12 repetitions;
- Be sure to increase speed of performance for every set of the dynamic stretches;
- Next perform varying-intensity sprints in different directions;
- By the end of this part of the warm-up, players' pulse rates should have risen to 160-170 beats per minute.

2. ***Specific warm-up***

- Begin with various kicks of the ball with both legs and various technical moves with the ball, such as dribbling and stopping the ball;
- These should progress to medium intensity with one other player and then to high intensity, with more players combining into groups to practise all technical skills at the highest possible intensity and speed.

2002. Although his warm-up is far from revolutionary (from a general sports conditioning perspective) it is nevertheless very thorough and specific *(see panel below left)* [8].

Spassov advocates a passive and active warm-up, the latter incorporating a specific warm-up. For the former he recommends that players loosen their muscles 30-60 minutes before the game by rubbing ankles, knees, all the muscles of the legs, lower back, neck and shoulders with heating ointment – preferably one that is odourless and not too hot on the skin.

The warm-up that follows is divided into two parts, as described in the panel.

Spassov's suggested warm-up makes great sense and should control players' progression to match readiness. With the first part of the warm-up performed alone, players should be able to focus on their own movements and progression rather than being tempted to lash out at the ball before their hamstrings are fully prepared, with potentially dire consequences.

Neither I nor *PP* is being presumptuous in presenting these findings to Sven. Indeed we would be delighted if the Swede and his team already knew it all and only needed to worry about the luck factor out in Germany – and those penalties of course!

John Shepherd

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WHAT THE SCIENTISTS SAY

Reports on recent football-related studies by Isabel Walker

Why football is good for children

There is good reason to believe that the more bone mass you accumulate during childhood, the higher your eventual peak bone mass and the lower your chances of suffering osteoporotic fractures in later life. Youngsters practising gymnastics and other highly demanding sports have been shown to accumulate more bone than their less active peers. But could the same be true for less intense recreational sports – such as football?

That is the question a group of researchers from the Canary Islands set out to answer with a study following 17 prepubertal football players and 11 matched controls over a three-year period. The football group, mostly recruited from sports clubs, had been playing football for at least a year and at least three times a week, while the activities of the controls, recruited from schools, were limited to those included in the compulsory PE curriculum (two weekly 45-minute sessions).

Bone mineral content and density were measured by dual-energy X-ray absorptiometry at the beginning and end of the study, as were body composition and various fitness variables. Key findings after 3.3 years, when all the participants were still under 13, were as follows:

- The football players exhibited greater bone mineral content (BMC) in the legs and greater bone mineral density (BMD) in all bone-loaded regions at the end of the study. More specifically, they gained twice as much femoral neck and intertrochanteric BMC in the legs as the controls, and increased their femoral neck BMD by 10% more and their mean hip BMD by a third more than the control group;
- Although the footballers' percentage body fat remained unchanged, it increased by 11 units in the control group;
- Total lean body mass increased by 6% more in the footballers than in the controls;
- The footballers attained better results than the controls in a 300m run test and 20m shuttle run test.

'Our study shows,' comment the researchers, 'that just [three hours] of soccer participation a week elicits a marked osteogenic effect on clinically relevant zones. This is why we think soccer may be considered as a low-cost and effective option to improve bone acquisition in growing children.

'Soccer participation entails benefits in cardiovascular physical fitness and soft tissue body composition as it counteracts the sociocultural tendency to accumulate body fat and improves lean mass.

'But the most important finding is that it has … osteogenic effects … which may facilitate the acquisition of a higher bone mineral peak, which can translate into a reduction in the risk of bone factures throughout life.'

Med Sci Sports Exerc, vol 36, no 10, pp1789-1795

Stretching may prevent hamstring strains…

The role of stretching in enhancing flexibility and reducing injury risk remains contentious, with some studies finding no relation between flexibility training and injury and others pointing to a positively harmful effect. Now, however, a carefully conducted survey of flexibility training protocols in English professional football clubs has suggested that stretching helps to prevent hamstring strains – the commonest and most problematic muscle strains associated with competitive sport.

Questionnaire-based data on flexibility training methods and hamstring strain rates were collected from 30 football clubs in the four divisions during the 1998/99 season and analysed for evidence of any relationship between the two.

Key findings were as follows:

- Hamstring strains represented 11% of all injuries and one third of all muscle strains;
- About 14% of hamstring strains were reinjuries;
- Hamstring strain rates were highest in the Premiership and lowest in Division 2;
- The vast majority of hamstring strains were minor or moderate, with two thirds occurring in the late stages of training sessions or matches;

- Forwards were injured most often;
- Use of the standard stretching protocol (a warm-up session followed by either a static or PNF stretching technique, holding the static stretch for 15-30 seconds) was the only factor significantly related to hamstring strain rates, suggesting a protective effect.

'Our findings clearly suggest,' conclude the researchers, 'that the current stretching practices of professional footballers are not detrimental, and an improvement in the quality and consistency of use of more appropriate stretching may possibly further reduce [hamstring strain rates].

'Stretching is probably involved in a complex, interactive and multifactorial relation with hamstring strain. However, stretching may be beneficial only if the technique employed and the stretch holding times are adequate; the number of repetitions of a stretch may not be important.

'The flexibility training protocols currently used by the professional football clubs need to be reviewed to ensure consistency in the use of static stretching/PNF with a stretch holding time of 15-30 seconds.'
Br J Sports Med 2004;38:388-394

...but doesn't help kicking

Research carried out on Australian Rules footballers showed no significant improvement in either flexibility or kicking variables following a stretching warm-up.

When planning their study, the researchers reasoned that, although static stretching might be unhelpful prior to strength and power activities, it has been found to be effective for increasing range of motion (ROM) at various joints, such as the hip, which might prove useful for kicking in football.

'Generally,' they explain, 'the greater the distance over which the swinging leg can move, the greater the potential to achieve a high foot speed at the instant of impact with the ball. Therefore, if stretching during warm-up can produce a short-term increase in flexibility, it could potentially enhance the ROM achieved in kicking and, in turn, increase foot speed at impact.'

Their study was set up to determine the effect of static stretching during warm-up on hip and knee joint flexibility, ROM at the hip and knee joints and foot speed during kicking for distance.

Sixteen AR footballers performed six maximum effort kicks following two different warm-ups on two different days, 1-3 days apart.

The control warm-up consisted of submaximal running and seven kicks of the football at 50-100% of maximum effort, while the experimental warm-up included static stretching of the hip flexors and quadriceps between the submaximal running and kicking. Immediately before and after each warm-up, the players were assessed for hip flexor and quadriceps flexibility by means of a test using joint angle calculations in a knee-to-chest position.

After this test, each subject performed six lab-based maximum-effort drop punt kicks with the right foot into a net about 10m away, while being videotaped to determine the range of motion of the kicking leg and foot speed at impact with the ball.

Key results were as follows:

- There were no significant changes in flexibility as a result of either warm-up;
- There were no significant differences between the warm-ups for any of the kicking variables.

The findings on flexibility were considered 'somewhat surprising', given that static stretching has been reported to produce significant short-term gains in flexibility in the plantar flexors and hamstrings.

It is possible, the researchers speculate, that a stretching routine is more effective for those with 'tight' muscles; or that a longer stretching period is needed to produce results; or that the flexibility test was not sensitive enough to detect changes resulting from the stretching warm-up.

However, as they point out: 'the question of interest is whether or not the warm-ups differed in their influence on ROM and final foot speed in kicking. The results indicated no significant differences between the warm-up conditions on any of these variables, suggesting that stretching had no influence on kicking kinematics.'

They explain that foot speed at impact with the ball is a function of complex neuromuscular patterns from many other muscles. And they

conclude that even if static stretching does produce short-term changes in flexibility, these 'may not be reflected in the kinematics of kicking because of the complexity and multi-factorial nature of this skill'.
J Sci Med Sport 2004; 7:1, pp23-31

Dehydration problems for the men in black

Given the enormous importance of football referees – reflected in the almost universal tendency for die-hard fans to displace frustrations with the team onto their hapless shoulders – it is surprising that sports scientists have paid so little attention to their physical and psychological status and performance.

Now a pair of Brazilian researchers have attempted to redress the balance somewhat with a study of hydration status in six male refs and six assistants (linesmen) during matches of the 2000 Paraná football championship, held in Brazil in their autumn months of March, April and May.

Why study hydration status, you might ask? The answer is that negative effects on performance have been shown with modest degrees of dehydration (2% of body weight). And it is generally accepted that cognitive performance is also impaired when dehydration and hyperthermia are present, which could be particularly relevant to the decision-making aspects of refereeing.

The subjects were weighed without clothes and had blood samples taken before and after each match, after emptying their bladders. The difference in readings before and after a match, plus *ad lib* water intake at half-time and urinary volume, were used to estimate total body water loss during the match, with the assumption that a body mass loss of 1kg was equivalent to loss of one litre of fluid. The blood tests were analysed for changes in plasma volume – the fluid portion of the blood.

The key results were as follows:

- Referees lost 1.22kg of body weight during matches, equivalent to 1.55% of their pre-match weight. Total body water loss averaged 1.60L, equivalent to 2.05% of their pre-match body weight. The difference between the two measurements reflects their half-time fluid intake;

- Linesmen, by contrast, lost only 0.48kg (0.63%) of their body weight and body water loss averaged 0.79L, equivalent to 1.05% of their pre-match body weight;
- The referees showed a reduction in their plasma volume, while the linesmen showed no significant changes in haematological status.

The researchers conclude that referees are moderately dehydrated after a football match, whereas their assistants exhibit only a mild, non-significant degree of dehydration.

'The physical activity performed by referees is a combination of various types of exercise (walking, jogging, sprinting and reverse running) covering an average distance of 9.3 miles in a match,' they point out. 'Our results show that this amount of activity caused significant dehydration which was not redressed by the spontaneous intake of water during the interval.

'Additional studies are required to find the best form of fluid replacement for football referees (during, before and after a match) to prevent a decrease in their physical and mental performance.'
Br J Sports Med 2003;37:502-506

The role of personal fitness in team success

What is the relationship between physical fitness and team success in football? Not as close as you might imagine. That is the conclusion reached by Scandinavian researchers following a study of 306 male players from 17 teams in the two highest divisions in Iceland – elite and first division – just before the start of the 1999 season.

Their aim was to study the relationship between physical fitness and team performance by comparing various indices of physical fitness between and within divisions with final league standing. The researchers also wanted to study differences in physical fitness between players in different positions.

Each coach selected the 18 best players from his team to participate and players were tested for the following variables:

- peak oxygen uptake;
- body composition;

- leg extensor power;
- jumping ability;
- flexibility.

Only 153 players (50% of the total) participated in all of the tests, but the 301 players who took part in at least one of the tests were included in the analyses.

The researchers were also interested in the relationship between player injuries incurred during the season and team success, so team physical therapists were asked to record injuries on a special form during the season.

When comparing team averages between the elite league and the first division, the only difference observed was that the elite teams were taller. However, when individual player values were compared between divisions, significant differences were also observed for peak oxygen uptake (2.4% higher among the elite players) and body composition (10% fat among the elite players compared with 11.2% among first division players).

A significant relationship was observed between the team average for jump height (countermovement jump and standing jump) and team success, defined as final league standing. But non-significant trends were observed when examining the relationship between team success and team averages for leg extensor power and body composition.

Finally, there was also a trend towards a better final league standing at the end of the season for teams that incurred fewer injuries during the season.

When making comparisons between players in different positions, goalkeepers were found to be significantly taller and heavier than outfield players, with greater range of movement in hip extension and knee flexion, but their peak oxygen uptake was lower than outfield players. Goalkeepers also displayed greater leg extensor power than midfielders and defenders, and lost less time due to injury.

Midfielders were older than strikers, defenders taller than midfielders and strikers more powerful than midfielders.

The researchers comment: 'The main finding…was that surprisingly few differences were observed in the team average test values between or within the two highest male soccer divisions in Iceland. Moreover, the relationship between team average performance on the various tests and team success expressed as final league standing was generally weak. Finally, goalkeepers appeared to have a different fitness profile from the other player positions, whereas the three groups of outfield players were similar in their performance on the tests.'

The researchers conclude that their limited ability to predict team performance from physical fitness tests suggests that other factors may be more important, such as player technique, team tactics, psychological factors or injuries.

'This does not mean,' they hasten to add, 'that a team with superior fitness would not have a definite advantage when playing an opponent with less physically fit players… Nevertheless, the ability to transform this fitness advantage to a real performance advantage would depend on a number of other factors, such as motivation, and technical and tactical skills.'

Med Sci Sports Exerc, vol 36, no 2, pp278-285, 2004

Hamstring strains the most common injuries

A two-season study of English football league clubs has confirmed that hamstring strains are the most common injuries in football, accounting for an average of 90 days and 15 matches missed per club per season and with a significant recurrence rate of 12%.

Player injuries were prospectively reported by club medical staff from July 1997 through to the end of May 1999, including any problem sustained during training or competition that prevented the injured player from participating in normal training or competition for more than 48 hours (not including the day of injury).

Of the 91 clubs that started the study, completed injury records for the entirety of both seasons were obtained from 87% in the first year and 76% in the second. The major findings were as follows:

- A total of 796 hamstring injuries were documented during the study period, more than for any other muscle group;
- 94% of these hamstring injuries were strains, with hamstring strains accounting for 12% of total injuries over the two seasons. More than half of these strains involved the biceps femoris muscle;

- The incidence of hamstring strains was higher among Premier League players (28%) than the other divisions (22-26%), perhaps reflecting the increased physical demands of faster-paced games;
- A rate of five hamstring injuries per club per season was observed, with an average of 18 days and three matches missed per strain, resulting in 15 matches and 90 days missed per club per season;
- Nine out of 10 hamstring strains were caused by non-contact mechanisms (running, jumping, turning *etc*), with 57% of the total sustained during running alone;
- A third of strains were sustained during training and nearly two-thirds during matches. Nearly half of match injuries occurred during the last third of the first and second halves of the match, suggesting fatigue as a factor;
- As expected, goalkeepers sustained significantly fewer hamstring strains than outfield players. Players of black origin sustained significantly more strains than white players and younger players were less prone to strains than their older counterparts;
- The reinjury rate for hamstring strains was 12%, compared with an average reinjury rate for all injuries of 7%.

The researchers, from the Football Association's Medical Research Programme, believe that the high incidence of hamstring injuries may be partly due to the fact that this muscle group functions over two joints and is therefore subject to stretch at more than one point. Also, the greater proportion of fast-twitch fibres in the hamstring muscles compared with others in the legs and thighs means that they are capable of higher force production.

The hamstrings may be particularly vulnerable to injury during running, the researchers explain, because they have to make a rapid switch from eccentric to concentric functioning during the swing phase, when they are placed under extremely high loads in an elongated position.

Players of black origin may be especially at risk of hamstring strains for anatomical reasons to do with the tilt of their pelvises.

Given the high recurrence rate of hamstring strains, the researchers emphasise the importance of prevention of initial injuries, accurate diagnosis, appropriate management and thorough rehabilitation.

Br J Sports Med 2004;38:36-41

Why the research void on injury prevention?

A growing interest in football – particularly over the last decade – has made it the most popular sport in the world, with about 200 million participants of both sexes and all ages. Given that the incidence of football injuries is likely to have risen in line with this increased popularity, one would expect to find a huge body of research on injury prevention.

But in fact there is a serious lack of research in this area, according to Canadian researchers, who set out to review evidence on the effectiveness of current injury prevention strategies in football and determine their applicability to children and young players.

Extensive searches through the worldwide literature resulted in just four studies that met the researchers' strict relevance criteria, as follows:

- A Swedish study assessing the effectiveness of a seven-part intervention programme in 17-36-year-old male players in a community soccer league noted 75% fewer injuries in the intervention teams than the controls. But the Canadian reviewers found problems with the quality of this study and point out that it is not possible to assess the relative contributions of the different components of the programme, which included warm-ups, cool-downs, protective equipment, ankle taping and controlled rehabilitation;
- A study of the effects of proprioceptive training on the incidence of anterior cruciate ligament (ACL) injuries in semi-professional and amateur male soccer players in Italy found a sevenfold reduction in injuries in the trained group. However, the reviewers point out that since this evidence comes from only one study, further research is needed before this kind of training can be recommended;
- A four-year US study looked at the effectiveness of strength training on the incidence of injuries in male college football players and noted a halving of the subsequent injury rate. But the researchers themselves acknowledged problems with their study design, which made it difficult to attribute the results with certainty to strength training;
- A multi-component approach to reducing heat stroke during a six-day youth football tournament involving 4,000 players led to a decrease in the rate of heat exhaustion from 21 cases per

thousand players in the first two days to 13 per thousand in the last four days – numbers which were considered too small for reliable statistical analysis.

The reviewers recommend further research into all these apparently promising interventions. They also call for further research on heading, protective eyewear and mouth guards and such environmental/facilities factors as goal post padding, playing surfaces and aggressive play.

'Effective injury prevention strategies based on sound surveillance data and high-quality research are essential for fostering safety…,' they conclude. 'This review set out to identify research that evaluated injury prevention interventions aimed at young soccer players and found a serious lack of research in this area (that is) surprising considering the enormous and increasing popularity of youth soccer around the world.

'The lack also raises concerns about injury prevention strategies that are currently in use. Without adequate research we cannot know which practices are effective at reducing the risk of soccer injuries.'
Br J Sports Med 2004;38:89-94

New measure of kicking accuracy

How should a football coach measure the kicking accuracy of his forwards and strikers?

Number of shots on goal? Okay, but that favours players in positions who shoot more frequently.

Number of goals per game? That can be influenced by all sorts of other factors, including the skill of the opposing goalie and the defence in general, conditions of the pitch and (of course) the weather.

Ability to strike a specified target? Better, but still relatively insensitive as a measure because it doesn't factor in the magnitude of error when the target is missed, or even which area of the target is struck.

Frustrated by the limitations of existing methods for assessing kicking accuracy – clearly a vital component of football performance – a research team from Minnesota in the US set out to develop and test a sensitive, reliable and valid means of measuring kicking accuracy that was relatively inexpensive, simple to make and easy to use.

The result of their endeavours was a plywood target 243.5cm wide and 122cm high, held in an upright position from behind by a wood plank frame. The surface of the plywood was covered with a textured white paint, while a black mark measuring 5cm squared (the bull's-eye) was placed at the midpoint of the base of the board.

A screw was placed in the middle of the bull's-eye in such a way that a hook at the end of a tape measure could fit over the head of the screw with a view to precisely measuring the distance from the bull's-eye to the centre of the mark left where the ball struck the target.

Sheets of white paper covered by carbon paper were placed over the board, such that when the soccer ball struck it left a mark on the underlying white paper. For each new kick, a new sheet of paper-plus-carbon was used.

To test the accuracy of the system, 10 ball marks were created on the target by having a subject kick a football at it 10 times from a distance of 6.1m. Two 'raters' then independently measured the distance from the bull's-eye to the centre of each ball mark, each taking the marks in a different random order. They then repeated their measurement on the same day, taking the marks in a different random order.

Analysis of the results showed a high degree of inter- and intra-rater reliability in measurement, with distances from the bull's-eye to the ball mark (ranging from 25.7cm to 150.75cm) accurate to within 0.15cm.

'These results suggest that our method for assessing kicking accuracy is a useful, valid and reliable tool for analysing performance in soccer players,' state the researchers. 'To our knowledge, no other tool has demonstrated reliability… Measurements were made to within 0.15cm, suggesting that the target is sensitive to change in kicking accuracy. Such targets may also be useful in sports other than soccer, such as lacrosse, ice hockey, field hockey and… handball.'

This particular device was tested indoors in a gym. But the researchers point out that game situations could be simulated more accurately by using defenders or a goalie against the player kicking at the target, placing it on a playing field – although not in rain or extreme wind – and/or making it larger to replicate the size of an actual goal (244x732.5cm).

Training and research are the two main applications of the target, they conclude. The bull's-eye could be moved to different places on the target, allowing players to practise kicking to specific spots. Each player's accuracy could be determined for each spot, and regions to

which the player does not kick accurately could become a primary focus of training. The target could then be used to measure improvements in accuracy over time.
Journal of Science and Medicine in Sport 5(4):348-353

Young footballers show no signs of brain damage…

…That's the encouraging conclusion of a major US study comparing 'neurocognitive' function in three groups of students at the University of North Carolina, comprising:

- 91 male and female footballers, with an average of 15 seasons of prior participation in the sport;
- 96 athletes other than footballers including players of women's field hockey, women's lacrosse and men's baseball;
- 53 non-athlete 'controls'.

The football players were further divided into two groups: those with and without a history of concussion.

The researchers were testing the theory that extended exposure to football may be associated with chronic impairment of brain function, as put forward by some recent European studies. 'A unique aspect of the game,' they point out, 'is the purposeful use of the unprotected head for controlling and advancing the ball. Reports of studies of high-level amateur and professional European footballers suggest that extended exposure to the game may be associated with chronic cognitive impairment.

'It is further postulated', they add, 'that multiple subconcussive impacts to the head, such as those involved in repeated heading of the ball, may be responsible for degenerative impairment of normal brain function. Some authors have even suggested that repeated heading of the ball in game or practice situations may be comparable in effect to receiving multiple blows to the head in a boxing match or while sparring.'

Such reports have apparently sent 'shock waves' through US youth football communities, with mandatory use of protective headgear proposed as a possible solution.

Happily, though, these fears seem unfounded – at least as far as college-age athletes are concerned. For a battery of 'neuropsychological' tests, measuring such capacities as orientation, concentration, problem-solving, verbal association, attention and memory failed to reveal any significant differences between the groups.

Even a history of concussion did not appear to predispose to mental impairment, since subjects with a history of two or more concussions were no more likely to have depressed neurocognitive performance that those with no such history. When analysis was performed by sex, the only significant difference found on any of the tests was for the verbal learning test of immediate memory recall. But this was as significant for the controls as for the footballers.

The researchers conclude: 'Our results indicate that participation in football is safe, at least up to the collegiate level, when considering its effect on neurocognitive function. Neither participation in football nor concussion history was associated with impaired performance of neurocognitive function in high-level collegiate football players with a mean age of 19 years. Although our findings need to be replicated in other settings, these results should provide reassurance that exposure to football during youth and adolescence does not appear to be associated with measurable deficits.'

However, it is clear that football players are at particular risk of concussion, and the researchers suggest that the focus should now be placed on ways to reduce the risk, most especially through 'quality instruction'.

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