COACHING AIDS

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1. SPEED

Acceleration Techniques and Speed Development

Phil Campbell explains the science and biomechanics behind the acceleration techniques that will increase your athlete's speed

There are certain numbers that will be remembered for a lifetime. Most sports enthusiasts, most will never forget their best 100-meter sprint time, and in the USA, no one forgets their personal best 40-yard sprint. Why do athletes remember their personal best speed time all their lives? It is probably because speed is highly correlated with performance in most sports and speed has been shown in 2004 to predict athletic performance in US college football. For years, there were opinions about which tests were most valuable because no one really knew, which, if any of the tests would actually predict success for college athletes. A new study now provides the answers.

The researchers summarised their findings

The purpose of this investigation was to examine the relationship among 6 physical characteristics and 3 functional measures in college (US) football players. Data was gathered on 46 NCAA Division I college football players. The 3 response variables were 36.6m sprint (40 yards), 18.3m shuttle run, and vertical jump. The 6 regression variables were height, weight, percentage of body fat, hamstring length, bench press, and hang clean. A stepwise multiple regression analysis was performed to screen for variables that predict physical performance. Regression analysis revealed clear prediction models for the 36.6m (40 yards) sprint and 18.3m shuttle run. (Davis 2004)[1]

During recent years in the US, a system of selecting athletes for college and professional sports teams has evolved into several major physical tests involving speed, agility and strength given to athletes on the same day. These tests are called the "combines" in the USA. Having a good day at the combines can produce on the spot scholarships from large universities, and it can mean literally millions of dollars in sign-on bonuses and salaries for athletes entering the professional ranks. With the results of this new study, future "combines" may focus on two acceleration tests. In the USA, the 40 yard sprint is king for many sports, except baseball, which uses the 60 yard distance required to run bases.

Big Ticket Items in Teaching Acceleration Techniques

There are several acceleration techniques that can be taught in a few training sessions that will increase the speed of many athletes. Techniques like Ankle Dorsiflexion, Pocket Chin Arm Swings, Acceleration Position, and the grand prize of speed training is the Valsalva Acceleration Technique.

Dorsiflexion

Most untrained athletes run with their toes pointed downward. While they may have fast leg turnover, but just like throwing a ball without using the wrist, the power is missing unless the foot is dorsiflexed (pointing up) and ready to fire off the ground. Dorsiflexion of the ankle simply means to raise the toes and, in essence, cock the foot before striking the ground. This action engages the ankle and the foot for additional power generation and this can mean additional stride length for the athlete. The Claw Drill and many of the skipping drills teach athletes to dorsiflex their feet.

Pocket-Chin Arm Swings

Without exception, teaching proper arm mechanics for maximizing running speed is the most difficult. Many athletes do not see themselves unless they are taped and they frequently gauge what they are doing with their arms based on their perception of how their arms feel during sprinting. In most cases, arms swings are incorrect and need repositioning. "Pocket / Chin" is a good way of teaching arm mechanics and the Butt Bumpers drill is the best drill I have seen for teaching correct arm swing mechanics. Have your athletes sit on the ground with both legs straight in front (side-by-side) with arms locked at 90 degrees. In slow motion, have athletes swing one arm backward until the hand reaches the pocket, and one arm forward until the hand reaches chin level (approximately twelve inches away from the chin).

This is the "pocket / chin level" position. Performing this drill in slow motion initially is a good idea until the coach sees that the athletes are getting the feeling of the arm positions. Move to half speed, then to full speed for three sets of 5 to 10 seconds. If performed correctly, it is easy to see why this drill is called butt bumpers. In 1970 I was taught to run with arm swings pointed in a straight line forward. Now we know that this instruction slightly restricts the hips during running and thus, makes the athlete run slower. The arm swings should be pointed slightly toward the centre of the body in order to maximize the hips, which can increase stride length. Too much side-to-side will over rotate the hips and cause problems. If an athlete points the arms past centre of the body, this can make the feet push off the surface in a duck-footed style rather than push the athlete straight toward the target. When you see a problem with the feet, look to the arms first for correction as there may be an easy fix here. Challenge them to perform Pocket/ Chin drills with "locked 90 degree arms" at home looking in the mirror, sideways and front ways.

Acceleration Position

Due to the work of Brian Mackenzie coaches are hearing about the importance of proprioception training for sports. This term becomes very important in teaching the acceleration position. The number one mistake made by athletes trying to run faster, is to stand up too soon in fly phase running without going through the "drive phase," which is marked by an aggressive forward lean (at the ankles). The description of an airplane taking off, low at first, but slowing raising upward with effort made to not jump up to quickly and bump the passengers heads, seems to be an understandable analogy for most athletes. When performing the standard calf stretch, with one leg back and one forward, while leaning on a fence is a good way to reinforce the acceleration position -- straight back, bent at the ankles.

Valsalva Acceleration Technique

A slower athlete can beat a faster athlete to the ball, to the hoop, to the tackle, to the touchdown, and to the finish line if the slower athlete is trained to hit the acceleration position (body straight, forward lean from the ankles) with arms pumping pocket-to-chin level and tactically using the Valsalva acceleration technique at precise points.

If you look up Valsalva manoeuvre on the internet, you will find that this describes briefly holding the breath. When applied properly for a brief burst of 2.5 seconds, this technique can be the greatest single producer of an instantaneous explosion in force, speed and strength known in science. Like many techniques, this one is so powerful that it can cause harm but it also delivers championship plays.

We all use the body's natural ability of increasing strength by unconsciously performing the Valsalva manoeuvre. My favourite analogy to explain this to athletes is to describe a situation where the athlete's mom hands the athlete a jar with a tight lid. Mom needs some extra strength to open the jar so she calls on the athlete for help. On first attempt, the lid is too tight for the athlete. On second attempt, the athlete increases the intensity and pushes hard with maximal effort.

If you will think about what the body does naturally in this situation, you will understand this valuable technique. The athlete tightens the abs, and holds the breath for 2 or 3 seconds as max effort is applied. This is the Valsalva manoeuvre. The body increases blood pressure by additional 100 points very quickly with this natural action. Clearly, this is dangerous to older adults with potential for stokes and it can be dangerous to some young athletes. But this technique will assist an athlete to open the jar, lift more weight maximally, and to beat a faster athlete to the ball, goal or finish line.

An athlete can not perform a maximum lift while inhaling. Nor can an athlete quickly accelerate with maximum force while inhaling. The body is designed for the Valsalva manoeuvre and needs to be trained how and when to deploy the technique.

Valsalva Acceleration Strategy

Holding the breath too long can cause harm by making an athlete actually pass out. One occurrence is reported in the literature where this technique was responsible for bursting a tiny blood vessel in the eye of an athlete during heavy maximal lifting.

It is easy to observe that the Valsalva manoeuvre is frequently used safely as a natural function of the body to increase strength, but it is only held for two to three seconds naturally. A 100 meter sprinter would have time to plan for four Valsalva acceleration techniques during the short ten second event, or a masters sprinter like me, may get in five before the finish. The miler may place the Valsalva acceleration technique in the race strategy 100 meters before the finish line to power that extra kick.

The 400 meter sprinter may want to deploy this technique during the four handoff zones during the single lap around the track. The baseball player may want to deploy this acceleration skill twice during the seven second trip to first base.

The football player may strategically use the Valsalva technique to break on the ball for a surprise steal. The applications for this acceleration technique are endless.

Conclusion

We have all seen the superstar athlete interviewed on television after making a game winning play.

"How did you make that great play?" asks the reporter.

"I knew that the game depended on it. I gave it everything I had, and I made the play" seems to be the frequent answer. That is what we hear, but the athlete should have explained:

"I wanted to make the play so I made the extra effort to get into the acceleration position (with a straight body bent from the knees), pumped my arms pocket-to-chin level, and I positioned my shoulders lower to the ground than my competitor to drive my body forward toward the target, I took the extra energy necessary to apply the Valsalva technique to temporarily raise my blood pressure by an extra 100 points so I could get there faster then my competitor."

Some athletes make great plays without knowing the science of acceleration, but what if all your athletes trained with these techniques throughout the season. Perhaps this technique explains why some teams that do not match the physical attributes of stronger teams, still find ways to win championship. Perhaps the inferior team realised that they had to go deep inside, work hard, get into the acceleration position on every play, and use the Valsalva technique more to beat the superior team. "Who wants the victory the most, will win this game" is what we say to the team.

Perhaps we should train athletes to use this natural technique designed to assist the body to get into maximal effort so athletes will have the skills necessary to beat a faster athlete and not wait until it is the game winning play to deploy it. I rest my case. Speed is a skill and skills can be improved.

2. SKILL

Agility Training to meet the demands of field and court games

Vern Gambetta explores the components of agility training and how they may be developed

Agility training is speed training, it is not conditioning work. That simple statement speaks volumes and has incredibly complex implications. The principles of speed development are well known, but have not been systematically applied to the improvement of agility. The principles of motor learning are clearly defined, they must be observed for optimum development of agility. Agility in game situations takes place in a time span of 2 to 5 seconds. This is high neural demand work that must be consistently reproduced in a climate of fatigue. That is where most of the problems start. Do not begin by incorporating fatigue, start with teaching the skill, then master the skill, add reaction, master that, and then and only then incorporate fatigue.

The components of agility

The multi dimensional movement demands of field and court games dictate a revaluation of the traditional approach to the development of agility. This demands a systematic multi factored approach that results in significant improvement in game speed. Possibly we have put the cart before the horse by training agility in isolation without considering the underlying coordinative abilities and strength. Full development of coordinative abilities provides a repertoire of motor skills that can be adapted to deal with sport specific movement demands. According to Drabik (1996)[1] the coordinative abilities are:

- Balance - Maintenance of the centre gravity over the base of support. It has a static and a dynamic quality
- Kinaesthetic Differentiation - Ability to feel tension in movement to achieve the desired movement
- Spatial Orientation - The control of the body in space
- Reaction to Signals - The ability to respond quickly to auditory, visual and kinaesthetic cues
- Sense of Rhythm - The ability to match movement to time
- Synchronization of movements in time - Unrelated limb movements completed in a synchronized manner
- Movement Adequacy - Ability to choose movements appropriate to the task

The coordinative abilities never work in isolation, they are all closely related. They are the underlying foundation for agility and the prerequisite for technical skills.

Strength is fundamental

Agility, by the nature of its demands in terms of stopping and starting, requires good basic strength. Without adequate leg strength there is a limit to the quality of the movement which will significantly affect the ability to train. Leg strength must be developed in parallel with agility work. The forces involved in multiple planes also demand that we take a less traditional approach to the development of leg strength that will transfer to the movement skills. Begin with body awareness and control in conjunction with strength training. It is not an overnight affair, but part of a longer term systematic development program, based on fundamental movements and the subsequent refinement of those movements. Build progressively into sport skills. Carefully understand the movement patterns of the sport and their position within the sport. Each sport has certain movement commonalities with other sports. Look for those commonalities. Each sport will also have movements that are unique to that sport so understand those and prepare for them. Equipment will often dictate movement patterns and positions i.e. the glove in baseball, the stick in field hockey and ice hockey, the ball in rugby and football. Therefore train and test agility incorporating the game equipment to get a more accurate picture.

Is playing the sport enough to develop agility?

There is one school of thought that feels it is unnecessary to do any significant agility work outside the practice of the actual sport. The thought process is that practicing the movements outside the sport are non specific work that will not transfer and that it is impossible to duplicate the intensity of the actual practice or a game. I do not share that viewpoint. It is necessary to carefully design drills that tap into the repertoire of motor skills developed through the development of the coordinative abilities that make up the components of the movements required in the specific sport. The overload should be progressive and based on sound motor learning principles, sound biomechanics and adapted to each individual athlete.

Developing appropriate exercises

The approach is to design a hierarchy of exercises that lead seamlessly into the sport's skills. That hierarchy is:

- First Derivative - The actual movement done at game speed
- Second Derivative - The movements broken into component parts

- Third Derivative - Basic movements (coordinative abilities) that underlie the skill

Understanding the derivatives means understanding the breakdown of the movements in the respective sport.

Analyse the moments

Use game analysis to determine the movements and game speed. Game analysis will also determine the volume of work in the actual sport, which will in turn determine training volumes and intensities. Essentially what we are trying to do is take the guesswork and opinion out of the whole process so as to be as exact and precise as possible in the selection and prescription of exercise in order to produce an adaptive response that will transfer to the game. I personally have spent too much time drilling for drill sake. Agility drills with a million cones and sticks look good but what is the benefit? The player gets good at the drill, but the drills do not transfer to the game. The goal with agility drills should be efficient, effortless, flowing movement that transfers directly to the sport. Time the drills whenever possible to provide feedback to the player.

The components of agility training are:

- Body Control & Awareness - The ability to control the body parts and maintain a high level of awareness of those parts in relation to the goal of the movement.
- Recognition and Reaction - Recognition is the domain of the actual sport skills involved. Recognition of patterns and cues keys reaction. Reaction is the ability to respond quickly to the required stimulus.
- Starting - The ability to over come inertia. In multi-direction sports starts can be stationary or moving or a combination depending on the sport.
- Footwork - The hip to foot relationship. Conceptually agility is built from the ground up therefore footwork is the unifying thread in all agility work.
- Change of Direction - Initiated by getting the centre of gravity outside the base of support and then regaining control to maintain control and move in the intended direction. Change of direction involving stopping, which is the key to agility, also incorporates the ability to restart when necessary, regardless of the position of the body.

All these components can be significantly improved through systematic application of specific drills. The application of speed to sports that require multi-dimensional movements demands an understanding of the concept of game speed. Game speed is not linear track speed. It is the ability to apply all elements of speed to the demands of the game. In fact some of the technical aspects of speed that are rewarded in the sprint events in track and field can be counterproductive to game speed. Very little movement in multi-directional sports is straight ahead for any significant distance. Most movement involves angles, curves, starts, stops and direction changes. Agility and game speed are closely related. Agility is defined as the ability to recognize, react, start and move in the required direction, change direction if necessary and stop quickly. This typically occurs in a time frame of two to five seconds.

How to improve agility

Agility can be significantly improved if we understand and apply some basic principles/concepts:

- Skill - Open skill occurs when the movement goal is unknown. In a closed skill the movement is pre-programmed. The progression in agility training usually proceeds from closed to open skills.
- Reaction versus reflex - Reaction is the response to a stimulus to initiate movement. It is a conscious act that can be improved through training. Reflex, on the other hand, occurs at the sub cortical level and cannot be trained.
- Speed as a motor task - A motor task can be learned; therefore speed can be taught if the motor tasks involved are clearly defined.
- Practice
    - Massed - the skill is practiced until learnt without taking a break. These sessions are good for athletes with high level of fitness and experience and are most suited to fixed practice.
    - Distributed - practice is interspersed with breaks which can either be rest or another skill.

These sessions are good for athletes with lower levels of fitness and experience and are most suited to variable practice.

Strength qualities related to agility

Effective starting demands a high level of concentric strength to overcome inertia. It is extension of ankle/knee/hip pushing back against the ground to propel the body in the intended direction. Effective stopping demands a high level of eccentric strength demands. It is the proportionate bending of the ankle/knee/hip. Basic strength is a prerequisite for force production and reduction.

Eccentric strength, the primary requirement to stop effectively, is the ability to reduce force. It also requires tremendous joint stability and control. Force must be produced and reduced in extremely short time frames therefore the premium is on rate of force development. It is the ability to handle forces in an eccentric mode up to 12 times body weight and be able to change direction and overcome those forces. This all must be done in tenths of a second. It is developed through exercises that develop unilateral and reciprocal leg strength.

The following table shows the relationship of the strength qualities to the components of agility.

<table>
<tr><td>Basic Strength</td><td rowspan="4">F
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W
O
R
K</td><td>Balance, Body Control and Awareness</td></tr>
<tr><td>Speed Strength & Plyometrics</td><td>Starting and Acceleration Speed Angles & Vectors</td></tr>
<tr><td>Power Endurance</td><td>Complex Footwork</td></tr>
<tr><td>Maximum Strength</td><td>Change of Direction, Stopping</td></tr>
</table>

These qualities must be developed in parallel, not in isolation and then put back into the whole. There is overlap and interdependency. The traditional approach was to develop strength through repetition of the movement. Theoretically as the athlete got stronger the movement got better, but it did not. The bad habits and patterns that developed due to improper strength resulted in poor movement mechanics. So even though the athlete was doing the drill, the transfer was negative. Incorrect repetitions led to the acquisition of faulty movement patterns that impede the formation of correct skills. A more rational approach demands mastery of prerequisite fundamental movement skills that are within the strength capabilities of the athlete. As the athletes strength increases through a systematic strength development program the complexity of the movements can change in parallel. Given the large window of adaptation open to the developing athletes this can occur quite rapidly.

What is agility work?

Agility work is not conditioning, it is speed development work. That statement has many profound implications. Movements must be mastered before any element of fatigue is brought into the picture. Old myths die hard! Grass drills, matt drills, line drills, agilities until you are ill have no foundation in training theory. In fact this approach is counterproductive in terms of sound motor learning. Incorrect movement patterns are learned and grooved. Does fatigue or so called pressure training fit into the picture? There is no question that the plants, cuts, starts and stops must be able to be done in a fatigued state. But that is not where you start, add reaction, add game situations and then add fatigue when the movements are mastered.

Mix reaction speed and agility

Perhaps the biggest shortcoming in most agility work is the lack of a reaction component. Research out of Australia has shown significantly different patterns of activation on simple cutting tasks done with reaction than the same tasks done without reaction. In short reaction changes everything. Reaction can be incorporated early and often if it is placed as part of a logical progression. Reaction should be practiced to the dominant cue demanded by the game.

Reaction can be to one of the following stimuli:

- Visual - Tracking ability, Narrow versus wide focus
- Auditory - Different cadences and tones
- Kinaesthetic - Pressure, pushes, bumps and surfaces

Conclusion

Agility is the key to game speed. It not only has a performance enhancement component, but it can make a huge contribution to injury prevention. An athlete who is more agile will be able to safely get into and out of positions that would otherwise be impossible. This can only be developed through a systematic approach that has a foundation in sound motor learning principles.

3. ENERGY DEMANDS OF FOOTBALL

Just to remind you, there are three major systems available for the production of energy in the muscles: the ATP-PC system for high-intensity short bursts; the anaerobic glycolysis system for intermediate bursts of relatively high intensity (this system produces the by products of lactate ions and hydrogen ions, commonly known as lactic acid) and finally, there is the aerobic system for long efforts of low to moderate intensity.

With sporting events such as cycling, swimming and running, where the intensity is constant for the duration of the event, it is possible to estimate the relative contribution of each energy system. For example, the energy for the 100 metre sprint is split 50% from the ATP-PC system and 50% from the anaerobic glycolysis system, whereas the marathon relies entirely on the aerobic system (Newsholme et al, 1992)[4]. By contrast, games such as football are characterized by variations in intensity. Short sprints are interspersed with periods of jogging, walking, moderate-paced running and standing still. This kind of activity has been termed "maximal intermittent exercise".

It would seem reasonable to assume that during a football game all three energy systems would be required, as intensity varies from low to very high. However, because it is not obvious just how fast, how many and how long the sprints are, and just how easy and how long the intervening periods are, it is difficult to determine which of the energy systems are most important. Most of the football-related research has attempted to tackle this problem.

A 15m sprint every 90 seconds

English researchers Reilly and Thomas (1976)[7] investigated the patterns of football play in the old first division. They found that a player would change activity every 5 to 6 seconds, and on average he would sprint for 15 metres every 90 seconds. They found the total distance covered varied from 8 to 11km for an outfield player - 25% of the distance was covered walking, 37% jogging, 20% running below top speed, 11% sprinting and 7% running backwards. Ohashi et al. (1988)[5], researching football in Japan, confirmed these findings, showing 70% of the distance was covered at low to moderate pace below 4m/s, with the remaining 30% covered by running or sprinting at above 4m/s. Thus, for example, if a football player covers 10km in total, around 3km will be done at fast pace, of which probably around 1km will be done at top speed.

The pattern of football play has also been expressed in terms of time. Hungarian researcher Apor (1988)[1] and Ohashi et al. (1988)[5] both describe football as comprising sprints of 3 to 5 seconds interspersed with rest periods of jogging and walking of 30 to 90 seconds. Therefore, the high to low intensity activity ratio is between 1:10 to 1:20 with respect to time. The aerobic system will be contributing most when the players' activity is low to moderate, i.e. when they are walking, jogging and running below maximum. Conversely, the ATP-PC and anaerobic glycolysis systems will contribute during high-intensity periods. These two systems can create energy at a high rate and so are used when intensity is high. The above research has described the average patterns of play during football and from this we can reasonably deduce when each of the energy systems is contributing most. However, now we need to establish just how important each energy system is for success.

Recovering from high-intensity bursts

There is evidence that the aerobic system is extremely important for football. Along with the fact that players can cover over 10km in a match, Reilly (1990)[6] found heart rate to average 157 bpm. This is the equivalent of operating at 75% of your VO2max for 90 minutes, showing that aerobic contributions are significant.

This is confirmed by the fact that various studies have shown footballers to have VO2max scores of 55 to 65 ml/kg/min. These VO2max scores represent moderately high aerobic power. Reilly and Thomas (1976)[7] showed that there was a high correlation between a player's VO2max and the distance covered in a game. This was supported by Smaros (1980)[8] who also showed that VO2max correlated highly with the number of sprints attempted in a game. These two findings show that a high level of aerobic fitness is very beneficial to a footballer.

The greater the player's aerobic power the quicker he can recover from the high-intensity bursts. These short bursts will be fuelled by the ATP-PC and anaerobic glycolysis systems. Then, during rest periods, a large blood flow is required to replace the used-up phosphate and oxygen stores in the muscles and to help remove any lactate and hydrogen ion by-products. The quicker this is achieved, the sooner a player can repeat the high-intensity sprints, and thus cover more distance and be able to attempt more sprints. Therefore, the aerobic system is crucial for fuelling the low to moderate activities during the game, and as a means of recovery between high-intensity bursts.

Which system fuels the sprints?

As already mentioned the ATP-PC and anaerobic glycolysis systems fuel the high-intensity periods. However, if we are to optimize training programs, we need to know whether in performing the high-intensity bursts both systems contribute evenly or whether one is more important. As the sprints a player makes are mostly 10 to 25 metres in length, or 3 to 5 seconds in duration, some researchers have assumed that the ATP-PC system will be the most important. However, since football has an intermittent intensity pattern, just because the sprints are brief does not mean that anaerobic glycolysis does not occur; research has shown that anaerobic glycolysis will begin within 3 seconds. To determine whether anaerobic glycolysis is significant during football, researchers have analysed blood lactates during match play. However, results from these studies have varied. Tumilty et al. (1988)[9] from Australia cite research varying from 2 mmol/l, which is a low lactate score indicating little anaerobic glycolysis, to 12 mmol/I, which is quite a high score. Most studies seem to find values in the 4-8 mmol/I range, which suggests that anaerobic glycolysis has a role.

The contrast in results is probably due to the varying levels of football in the different studies. Some use college-level players, others professionals. Some studies test training games, others competitive matches. This is likely to confound results. Ekblom (1986)[2], a researcher from Sweden, clearly showed that the level of play was crucial to the lactate levels found. Division One players showed lactate levels of 8-10 mmol/1 progressively down to Division Four players showing only 4 mmol/1. Tumilty et al. (1988)[9] conclude that the contribution of anaerobic glycolysis remains unclear, but is probably significant. They suggest that the tempo of the game may be crucial to whether anaerobic glycolysis is significant or not. As Ekblom (1986)[2] noted: "It seems that the main difference between players of different quality is not the distance covered during the game but the percentage of overall fast-speed distance during the game and the absolute values of maximal speed play during the game".

The conclusion from these lactate studies is that, as the playing standard increases, so may the contribution of anaerobic glycolysis. However, I think more precise research is needed to determine exactly how fast and how frequent the high-intensity efforts during play are. Maximum-intensity bursts with long recoveries will emphasis the ATP-PC system, whereas high-intensity but not maximal bursts occurring more frequently will emphasise the anaerobic glycolysis system more. Thus, along with the standard, the style of play and football culture may also influence the physiological demands. This means that the country in which the researchers are based may affect the conclusions they draw when studying the relative contributions of the two systems.

What action to take

From the research completed so far, it would probably be fair to conclude that for the high-intensity bursts during play both the anaerobic glycolysis and the ATP-PC systems contribute, but that the ATP-PC system is more important. This is because the ratio of high-intensity to low-intensity activity is between 1:10 and 1:20 by time. The high-intensity periods are very short and the rest periods relatively long. Therefore, the ATP-PC system will probably be more useful and also has sufficient time to recover. Research has also shown that lactate values become moderately high but not so high as to indicate that the anaerobic glycolysis system is working extremely hard. Indirectly, this is confirmed by Smaros (1980)[8] who showed that glycogen depletion was mostly in the slow-twitch muscle fibres, which suggests that glycogen is being used for the aerobic system but not the anaerobic system. However, the possibility exists that for professional-standard football, or football played at a high tempo, anaerobic glycolysis will be at least as significant as ATP-PC.

If coaches of professional teams want to know better which system is more important, then more research taking place in their own country and using top players as subjects is needed, accurately analysing intensity patterns in match play and measuring lactate levels. Until then, training regimes must cater for all three systems, with particular attention to the aerobic and ATP-PC systems. Nagahama et al. (1988)[3] performed a Maximal Intermittent Exercise (MIE) test on footballers that consisted of 20 x 5 seconds maximum efforts with 30 seconds active rest. This was meant to mimic a high-intensity section of the game. They correlated the performance on this test with fitness tests representing the three energy systems, VO2max for the aerobic system, lactic power for the anaerobic glycolysis system, and maximum power for the ATP-PC system. All three components of fitness were significant to the performance on the MIE test. Apor (1988)[1] agrees with this in making fitness recommendations for footballers, saying that a good aerobic fitness needs to be linked to a moderate anaerobic glycolysis power and a high ATP-PC power.

A specific type of interval training for footballers would be to mimic the demands of an actual game with the correct work-to-rest ratios and distances covered. If players sprint for over 1 km during a game with high to low ratios of 3 to 5 seconds to 30 to 90 seconds, then a session such as two sets of 20 x 25m maximal sprints with 30 seconds rest (2 minutes between sets), would represent the demands of a tough match, namely, frequently repeatable high power. To focus solely on the ATP-PC system, short maximal sprints of 20 to 60 metres with 1 to 2 minutes recovery are best. To train the anaerobic glycolysis system, longer sprints of 15 to 30 seconds, with 45 to 90 seconds recovery, are recommended. Aerobic training involves running continuously, fartlek, long repetitions (e.g., 6 x 800 metres, 1 minute rest) or extensive intervals at moderate speeds (e.g. 30 x 200 metres, 30 seconds rest). Trainers should be aware that running sessions, intervals and shuttle runs (or doggies) should be carefully planned so that they target the correct energy system. Running speeds, distances and rest periods should be calculated so that the session will target the specific energy system the coach wants to develop.

4. FLUID REPLACEMENT

It has always seemed strange that football in financial terms, the most professional of sports is perhaps 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.

Nutrition

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 of 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 loss 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. They 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 is a large individual difference. Sweat salt (sodium chloride) losses can reach almost l0g 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.

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.

5. NUTRITION ADVICE

While the average distance covered by a top-class outfield player during a 90-minute match is over 10,000m, at an average speed of over 7km per hour, these figures do not accurately represent the full demands placed on a player. In addition to running, a player must jump, change direction, tackle, accelerate and decelerate, etc., and each of these individual tasks requires an energy input over and above that required simply to cover a similar distance at a constant speed. Scientific investigation has shown that the true demands on a player can be approximated at roughly 70%VO2max. This is based on evidence of heart rate, sweat loss, increase in body temperature, and depletion of carbohydrate stores within the muscles (intramuscular glycogen).

The Keeper

The specific demands of the different positions within a team are not as clearly defined as in some other team sports, such as rugby union. The obvious exception to this is, of course, the goalkeeper. A keeper relies little on the aerobic system for energy production since all the important phases of play for him last a relatively short time. The key performance quality of the keeper is probably agility, and this can be broken down further to include speed, power, strength and flexibility. If he happens to be tall, it's clearly an added bonus!

Popular training programs for keepers include repetitions of short sprints performed at maximal speed, with many changes of direction involved. Obviously, an element of skill can be built into this training by having to save a bombardment of shots at goal. This way, another important constituent of training is then automatically introduced, namely, the ability to regain one's feet in order to save a follow-up shot at goal.

However, to gain the edge in physical development, the keeper should also train away from the pitch so that upper and lower body strength and power can be improved in the weights room. In addition, plyometric training lends itself perfectly to improving the qualities necessary for agility around the goalmouth. Plyometric training does need to be conducted correctly, which includes the provision of generous rest periods between sets of exercises, but if done so can produce some significant improvements in the ability to move one's own body weight at speed.

Outfield Players

As far as the rest of a soccer team goes, the differing demands are less obvious. However, a systematic analysis of soccer matches on video has shown that midfield players tend to cover the most distance, and other studies have - not surprisingly - shown these players to have the highest VO2max scores, and to show the least fatigue when performing many repeated sprints in succession. Compared to forwards and defenders, midfield players tend to have a more continuous involvement in the game. However, while forwards and defenders usually have more time to recover between sprints, they also need to perform those sprints at a faster speed to be successful in their crucial phases of play.

Implications for training should become apparent. Clearly, the midfield players need more of an all-round fitness profile, with an emphasis on both aerobic and anaerobic capacity. Aerobic capacity relates to sustained performance (20-40 minutes), or performance during lengthy repetitions, each of 2-3 minutes in duration. Anaerobic capacity can be related to performance of a repeated nature, but with work/rest intervals of equal length, and not over 30 seconds.

The players regularly involved in attacking/ defending situations will need more training emphasis on speed. Speed training can itself be broken down into at least two phases - an acceleration component and a maximal speed component. For improvements in acceleration, repeated sprints of not less than six seconds in duration, performed from a standing or walking start, will be useful in training. This will help develop the neuromuscular function of the athletes. For development of maximal speed, a gentle increase in speed to about 85 per cent followed by a sustained burst at maximum speed for about six seconds will produce improvements that are more specific. This will help develop both the metabolic and neuromuscular qualities of the muscles involved. Put simply, to improve acceleration, accelerate as fast as possible in training. To improve maximal speed, the length of time spent running at current maximal speed during training should be increased. A relatively gentle acceleration phase before a sustained burst can best achieve this.

If the coach can accomplish these sorts of training goals by using drills that involve ball skills, then the players will become used to performing the skills under conditions of fatigue. As many will appreciate, it is under conditions of fatigue and mental pressure such as a competitive match that skills often become lost - unless they are both well-drilled for their own sake and practiced under simulated conditions of fatigue.

Match-play

Moving away from training methods for a moment but continuing the analysis of the physical demands of the game, there is an interesting form of player behaviour that playing experience seems to encourage. Many players will recognise a phenomenon as common without perhaps understanding why. The behaviour in question is the avoidance of prolonged high-intensity activity that would require a corresponding long period of recovery - which can rarely be afforded in a competitive situation.

For instance, if a defender is involved in high-intensity activity as he assists in an attacking phase of play, he often will not attempt to return to his defending position in time for the immediate counter-attack. While this might be perceived as laziness, it may benefit both the individual player and the team in the longer term, providing the rest of the team has sufficient cover to deal with the counter-attack.

Sound physiological reasoning provides the basis for this. It has been shown that short periods of intense exercise (e.g. less than 15 seconds), when interspersed with rest periods of similar duration, produce a fairly low build-up of lactic acid in the muscles (a strong indicator of fatigue) even when this activity pattern is continued for some time. However, periods of intense exercise of about 30 seconds or more, even when accompanied by equal rest periods of 30 seconds (such that the work:rest ratio is till 1:1 as in the previous example), produce a far higher concentration of lactic acid in the muscles and also greater fatigue.

This situation is exactly what the experienced player is trying to avoid when he decides to return more slowly to his main position on the pitch. However, this obviously requires a large degree of teamwork, with team-mates prepared to cover for the defender concerned. If a team can achieve this sort of cooperation, it helps reduce player fatigue and increases performance capacity throughout the match as a whole. Clearly the role of the coach is paramount in organising this sort of team approach in spreading the workload, especially with inexperienced players. Indeed, some younger players may be almost too enthusiastic for the good of their own and the team's subsequent performance.

Nutrition

As already mentioned, the physical demands of the game are sufficiently high to require a high rate of energy production. Whatever the sport, this can only be done by the breakdown of carbohydrates, and soccer is no exception. This means that players should pay particular attention to this aspect of their diet - more especially when considering the notorious practices of soccer players when they are given no guidance about what to eat. The heavy training/match schedule that the British game involves only serves to increase the need for carbohydrate intake.

When discussing this subject, it is usual to express the form of the energy consumed as percentages (proportions) eaten as carbohydrate, fat and protein. While the typical diet for the general British population is about 40% carbohydrate, 45% fat and 15% protein, the recommended dietary proportions for a soccer player would be roughly 65% carbohydrate, 20% fat and 15% protein. However, the typical diet of the soccer player is actually very similar to that of the general population - too little carbohydrate and too much fat.

The work carried out some years ago by Jacobs and colleagues ("Muscle glycogen and diet in elite soccer players", European Journal of Applied Physiology, 1982, vol. 48, pp297-302) illustrates the potential pitfalls of a low-carbohydrate diet. These researchers studied players in the Malmo soccer team in Sweden -the side had finished as runners-up in the European Cup the previous season. The players consumed just 47 per cent of dietary energy as carbohydrates - well below the recommended values. Muscle glycogen stores were assessed immediately after a national league match (Day 1), and again 24 hours later after no training (Day 2), and 48 hours after the match after a very light training session (Day 3).

Muscle glycogen stores of the general population are approximately 70-90 mmol.kg-1 wet weight. The average values for the Malmo team were 46,69 and 73 mmol.kg-1 wet weight on the three days.

There is no reason why the players could not have refilled their muscle glycogen stores to pre-match levels within 24 hours if they had consumed a high-carbohydrate diet. Experiments have shown that, for highly trained athletes, a muscle glycogen level of well over 100 mmol.kg-1 wet weight is quite possible to achieve following two or three days of light training. The reason the soccer players didn't reach this sort of level was undoubtedly due to the lack of carbohydrate in their diet.

The importance of high muscle glycogen stores for performance in events lasting longer than 60 minutes has been demonstrated by numerous researchers. Specifically in relation to soccer, the diets (and hence the muscle glycogen stores) of players involved in an exhibition match have been manipulated, with those players having higher muscle glycogen stores before the match also covering a greater distance at a faster pace during the match. This effect was particularly noticeable towards the end of the match when glycogen always becomes lowered - and many goals are often scored as the game tends to open up. Therefore, a high-carbohydrate diet leads to increased muscle glycogen stores, which in turn leads to a greater distance covered during the final stages of the match, which in turn leads to your team scoring the winning goal in injury time! Well, not always, maybe, but you can increase the chances of it happening by taking a close look at players' diets

6. PLANNING THE TRAINING

Participation at amateur level remains high, with thousands of matches taking place on Saturday afternoons and Sunday mornings all over the country. The lack of success of our national squads may, in part, be due to the curious reluctance of many professional clubs to take on board the abundant expertise in the field of sports science that is now readily available. Many clubs still neglect what are considered as basic principles in training, preparation and nutrition, ideas that have been used to great effect in other sports for some time.

Demands of the sport

As with all team sports, playing position clearly affects the physical requirements. It is generally accepted that a goalkeeper does not need the same level of aerobic conditioning as a central midfielder. The distance covered by outfield players has been well researched. In a match, they each cover about six miles, though this obviously depends on whether you are a utility midfield player or a sweeper. There does not appear to be much difference between the distance covered by the top professionals and non-elite players.

This means that all outfield players need a reasonable level of aerobic conditioning. When aerobic power has been measured in soccer players, typical V02max values tend to be in the 50 to 60 ml/kg/min. This is a little below the value one would expect for 10K runners, who cover the same sort of distance in their competition. The reason is that a 10K runner keeps up a sustained pace at a high percentage of V02max, while a soccer player may cover the ground in a variety of ways: sprinting short distances, jogging, walking, shuffling and moving sideways and backwards. With this in mind, the training program should consist of more than steady state running, or basic interval training around a track, in an attempt to mimic the movement patterns of an actual game.

Development of speed is essential in soccer, where ability to reach the ball first, or outrun opponents, is paramount. Good soccer players will turn out 30 metre sprint times of well under 4 seconds, yet this alone is not enough. Speed endurance is vital as well, to maintain that pace throughout a match, especially during intense bursts. Agility is another important factor, since quick lateral movements may help you to feign and evade opponents. When it comes to set pieces, the tall and strong players are usually the target men. Leg strength and power are a crucial part of jumping ability. All round muscular strength is important in such a physical game, thus the musculature associated with sound posture should also be well toned to reduce the risk of injury.

Phases of Training

With a season that lasts from the end of August to May, it is difficult to be in peak condition for every match, the dream of any manager! Much conditioning training takes place in the summer months, preparing for the winter campaign. Most of the running training is done then and strengthening work carried out. In some European countries the season is split into two halves, with a break over the Christmas period. This double periodised year gives a physiological benefit and is likely to reduce the number of injuries. One current Premier League team follows this philosophy even though there is no break in our playing season; it simply goes back to endurance work midway through the winter. The problem here is that players run the risk of being over tired in matches during this period and lose speed and sharpness.

The training week

The training week is likely to be focused around the matches that are scheduled. Many professional teams have an easy day before a match, with just light skills work and travel, while the day after is usually a rest day. This does not leave much chance for physical training, especially when a manager wants to work on skills. Such work will include multiple sprints, perhaps within the penalty area, with short recovery periods before the next burst. Shuttle sprints are very popular with team managers because the sessions are easy to structure and monitor. However, an astute manager should avoid the "no pain, no gain" philosophy prevalent in the sport and choose a more appropriate workout.

Recovery runs the morning after a match can prepare players for the next batch of training and will help maintain an endurance base. These runs can last for up to an hour, provided the players are fit enough and intensity is kept at a low level. Workouts to develop speed, such as running drill sessions or **resistance training** exercises, need not be exhausting and are most effective when players are not heavily fatigued.

It is important to remember that small sided games, commonly used for practice, are themselves a form of physical conditioning training more specific to the demands of the sport than any strength or running workout, so they do not necessarily have to be followed by an "eyeballs-out" interval session.

7. HOW TO DEVELOP A TRAINING PROGRAMME

The process of creating a training program to help develop an individual's level of fitness comprises of 6 stages:

- Stage 1 - gather details about the individual
- Stage 2 - identify the fitness components to develop
- Stage 3 - identify appropriate tests to monitor fitness status
- Stage 4 - conduct a gap analysis
- Stage 5 - compile the program
- Stage 6 - monitor progress and adjust program

Stage 1

The first stage is to gather details about the individual:

- Age
- Reasons for wanting to get fit
- Current or recent injuries
- Health problems
- The sports they play and how often
- Their dislikes and likes with regards training
- What sports facilities they have access to - gym, sports centre etc.

Prior to starting any training, it is recommended you have a medical examination to ensure it is safe for you to do so.

Stage 2

The second stage is to determine what components of fitness they need to improve. This will depend upon what the individual wants to get fit for - to improve general fitness, get fit enough to play in the Saturday hockey league, run a local 5 km fun run or compete in next year's London Marathon.

Exercise scientists have identified nine elements that comprise the definition of fitness. The following lists each of the nine elements and an example of how they are used:

- Strength - the extent to which muscles can exert force by contracting against resistance (holding or restraining an object or person)
- Power - the ability to exert maximum muscular contraction instantly in an explosive burst of movements (Jumping or sprint starting)
- Agility - the ability to perform a series of explosive power movements in rapid succession in opposing directions (ZigZag running or cutting movements)
- Balance - the ability to control the body's position, either stationary (e.g. a handstand) or while moving (e.g. a gymnastics stunt)
- Flexibility - the ability to achieve an extended range of motion without being impeded by excess tissue, i.e. fat or muscle (Executing a leg split)
- Local Muscle Endurance - a single muscle's ability to perform sustained work (Rowing or cycling)
- Cardiovascular Endurance - the heart's ability to deliver blood to working muscles and their ability to use it (Running long distances)
- Strength Endurance - a muscle's ability to perform a maximum contracture time after time (Continuous explosive rebounding through an entire basketball game)
- Coordination - the ability to integrate the above listed components so that effective movements are achieved

Of all the nine elements of fitness cardiac respiratory qualities are the most important to develop as they enhance all the other components of the conditioning equation. You will need to consider which of these elements are applicable to the individuals training program based on what it is they want to get fit for.

Stage 3

The next stage is to identify appropriate tests that can be used to initially determine the individual's level of fitness and then to monitor progress during the training. The Evaluation Test page identifies suitable tests for each of the fitness elements.

Identified test should be conducted and the results recorded.

Stage 4

We now know the individual's background, objectives and current level of fitness. We now need to conduct a gap analysis of the current fitness levels (from test results at stage 3) and target fitness levels (identified at stage 2). The results of this process will assist in the design of the training program so that each component of fitness is improved to the desired level.

The following is an example of a gap analysis:

Test	Fitness Component	Current	Target
Multistage Fitness Test	Aerobic	Level 12 Shuttle 2	Level 12 Shuttle 5
30 metre acceleration Test	Speed	4.3 seconds	3.9 seconds
Illinois agility run Test	Agility	20 seconds	<16 seconds
Standing Long Jump Test	Leg power	2.4 metres	2.8 metres
Over head medicine ball throw	Arm power	16.1 metres	16 metres

Gap analysis - Aerobic fitness and arm power are good and just need to be maintained - sprint, agility and leg power tests are below target - leg power needs to be improved.

Stage 5

The next stage is to prepare a training program using the results of the gap analysis and FITT principles.

- F - frequency - how often should the individual exercise?
- I - intensity - how hard should the individual exercise?
- T - time - how long should each session last?
- T - training activity - what exercise or training activity will help achieve the individual's fitness goals?

For frequency, intensity and time you should start at an easy level and increase gradually e.g. 10% increments. Aerobic training should last for 20 to 40 minutes. Strength work should last 15 to 30 minutes and comprise of 3 sessions a week with 48 hours recovery between sessions.

Plan the program in four week cycles where the workload in the first three weeks increase each week (easy, medium, hard) and the fourth week comprises of active recovery and tests to monitor training progress. The aim of the four week cycles is to:

- ☐ Build you up to a level of fitness (3 weeks)
- ☐ Test, recovery and adjustment of the training program (1 week)
- ☐ Build you up to higher level of fitness (3 weeks)
- ☐ Test, recovery and adjustment of the training program (1 week)
- ☐ Build you up to an even higher level of fitness (3 weeks)
- ☐ and so on

The tests used to assess the individual's initial level of fitness should be planned into week 4 of the program in order to monitor progress and effectiveness of the program. The test results can be used to adjust the program accordingly.

The program needs to last 12 to 16 weeks in order to see any real benefits and the planning (initial & subsequent adjustments) should be conducted with the individual so that they feel they own the program. This will ensure the program is enjoyable and convenient to do.

8. INTERVAL TRAINING

Splitting some of his training sessions into sets and repetitions is familiar territory for the serious track athlete who wants to run faster or boost endurance. Yet it can usefully be adapted for conditioning athletes in any sport. Once you understand the principles, you can tailor your workouts to give yourself the optimum benefit. Even though interval training is far from a new concept, coaches still lack the courage to be imaginative and tend to stick to simpler traditional sessions to boost fitness. These may often be sound in nature but there is a danger of the athletes becoming bored and stale when the same workouts at the same venues are repeated time after time.

VO2 max

If you are a soccer player, you may already perform high-intensity shuttles separated by short recoveries to improve your speed endurance. This may also have the added benefit of boosting your aerobic system, because volumes of research have shown that the best way to lift your VO2max (an index of aerobic fitness) is to train at an intensity close to, or above, VO2max. Realistically, this work has to be done in an interval format if the session is going to last any serious length of time-otherwise, after one hard burst for a few minutes you may end up collapsed in a heap of fatigue. This is where the true benefits of interval training become clear: by separating your efforts with short bouts of recovery, you can keep the intensity high, yet extend the volume.

Plan the session first

Our soccer player, however, may be guilty of the cardinal sin of all training: not thinking about and planning the session sensibly beforehand. The very nature of the session working at high intensity leads to the belief that the athlete should be thoroughly exhausted at the end. Yet it is the route to that exhaustion that is often ill-considered how to make the session more than simply running flat out for as long as possible and then going again on command. The coach should have a clear idea of the physical demands of the sport concerned, particularly the metabolic demands with regard to which energy systems are utilised during the performance. Video analysis of a match can determine typical activity patterns for games players, or heart rates and lactates can be monitored in a race. Armed with such information, you can make sure that the session you are considering is geared to the demands of your sport. Most coaches can gather this information from books and articles about their sport, but measurements on individuals can also help to build up the picture.

Getting the recovery time right

With the demands of the sport in mind, the coach should carefully consider each of three key aspects of the session: intensity, duration and recovery. Each of these can combine to govern which energy system is utilised to provide the bulk of energy in the muscles used during the mechanical work. If, for example, our soccer player wishes to improve his speed off the mark, he should choose a session with short but explosive activity such as 30m sprints at maximal speed. Here intensity is the key factor, so High Energy Phosphates (HEP) will be the immediate major source of the ATP (Adenosine Triphosphate) needed to fuel such activity. In such short intensive work, the recovery should be long enough to allow repletion of the HEPs, because if the recovery is too short an alternative energy system will have to be recruited and the quality of the session will be impaired.

Judging the exact recovery time to perfection is not always easy. Research has shown that the repletion of HEPs, after a sprint, starts very quickly and then slows. It takes about 20 seconds for the HEP stores to get back to half of their resting level, but a further 170 seconds to be topped up to normal. Therefore, if our player wants to keep the quality high, the recovery period should be about three minutes. In winter this may mean putting on and taking off clothing in between the short reps.

Sprinting quickly is only one aspect of soccer, and there may need to be a session dedicated to the ability to repeat high-quality sprints in rapid succession. This will require a different type of interval session because the player is working on the recovery aspect. Here he should cut the recovery between bursts so that the work is repeated before the HEPs are fully back to resting levels. Such activity requires a greater contribution from glycolysis, a different energy pathway that breaks carbohydrate down, producing ATP very quickly. A series of such sessions may well improve not only lactate tolerance but also the time required to replenish the HEP stores, both of which should enhance soccer fitness.

The type of recovery between efforts is also of paramount importance. Simply standing around with hands on hips, or bent double, is far less effective than walking or, better still, jogging. This active recovery actually helps to remove and disperse lactate that accumulates in the working muscles during intensive exercise. Indeed, active recovery can almost halve the time that is taken for muscle and blood lactate to return to resting levels after an intensive burst, and is likely to be even more effective in the aerobically training athlete.

Fartlek for games players

Another type of session can work on both of these aspects as well as on the oxidative system. Although not a structured interval session split into reps and sets like those already described, "fartlek", mixing fast with slow work, can be of immense benefit to those who play field sports. Fartlek comes from the Swedish for "speed play" and has been used by distance runners for years. But for games players, the session should not just use running, but also jogging and walking to fit in with the demands of the sport. After all, no soccer player actually runs for the whole 90 minutes of a match-the pace is varied. Similarly, the direction of work should not always be straight ahead. This may be important for the track runner who has to cover the ground as quickly as possible in one direction, but the games player has to go forwards, backwards and from side to side.

This must all be taken into account if the training session is going to mimic accurately the pattern experienced in a match. Remember, if you are a games player, you are not training to be a better sprinter, you are training to be better at your game. Therefore, sprinting should not just take the form of back and forth shuttles but should make you change direction or even imitate a slalom. This is where the imaginative element comes into play.

Progression is another aspect you need to consider. If you are to improve your condition, there should always be some element of progression in your schedule. With interval training, you have plenty of options to work with. For instance, you can lengthen the distance of your efforts. This is fine if you are a runner, a rower or a cyclist because you can build up the distance closer to your actual race distance. For the games player, or sprinter, however, this may not be so appropriate. In field sports, it is rare to have to sprint more than 30m in one go, so it is questionable whether long sprints are a suitable focus in training.

You can improve the intensity, which usually involves performing your reps a little faster. Here you must be careful to keep things specific, because if you are, say, a 10K runner it may not be appropriate to be running reps too fast in training. For example, you may be performing aerobic intervals, where the idea of the session is to give optimal stimulus to the aerobic system. The session might be 5 x 1 mile, where the intention is to be working at your maximum aerobic steady state. You can use heart rate in such sessions to control the intensity and make sure that you are not going too fast

However, if you are performing quicker, shorter repetitions on the track, heart rate may not be the best guide. In such super-maximal intensities, the heart rate does not quite reflect the high intensity encountered, partly because the reps are too short and the heart rate needs time to reach a steady state. Here it may be more appropriate to use split times to set your goals, with a gradual reduction from session to session to ensure an element of progression.

To improve your endurance, you can cut the recovery time allowed between reps. You can do this systematically - for example, by cutting the recovery time by five seconds each week. If you use a set recovery period, your heart rate before each rep will rise throughout the session. Alternatively, you can use your heart rate to determine your recovery. If you want to maintain quality in a session of 3 x 800m, rather than use a specific time for recovery, you can try waiting for the heart rate to drop to a specific level such as 120 or 100. As individuals vary so enormously in both their resting and maximum heart rates, it is impossible to give a general figure for everyone to aim for, but trial and error should produce a rate that works best for you.

Another way to build endurance is to add to the volume of your session. You can increase the number of reps performed in various sets during the session or even build on the number of sets performed. As long as this is part a structured plan and conforms to the demands of your sport, it should work well, being a tried and tested method for improving fitness in most sports.

Finally, if you intend to start interval training or rethink your schedule, remember:

1. Think about the aims of the session first, before you go to exhaustion
2. Make sure the session is specific to the demands of your sport in terms of intensity, duration and volume
3. Consider carefully the mode and length of recovery
4. Keep the movement patterns similar to those used in your sport-you don't always have to run
5. Make sure there is progression from session to session, but avoid improving more than one aspect at a time
6. Be imaginative in building your sessions - you don't always have to use sets of 10

9. SPEED TRAINING

For a number of sports acceleration and speed over a short distance is very important e.g. American Football, Basket Ball, Baseball, Cricket, Field Hockey, Rugby, Soccer, Futsal (5 a side football) etc.

Before You Start

Prior to starting any training, it is recommended you have a medical examination to ensure it is safe for you to do so. Any application of this training program is at the athlete's own discretion and risk.

Preparation work

What time do I have available for training?

- how long before I have to put my improved acceleration & speed to the test
- how many days each week can I train
- how many times a day can I train

What facilities do I need?

- Somewhere to run - an Athletics Track or sports field
- Somewhere to do exercises - gymnasium
- Somewhere to do strength training - weight training room

What equipment do I need or have access to?

- Appropriate clothing for training in
- Exercises mat
- Free weights for weight training

The preparation of any training program is explained in more detail on the Planning page.

Training Plan Phases

Split the available training time into two equal periods (phases). If there are 16 weeks available for training then we have 8 weeks for Phase One and 8 weeks for Phase Two. This would allow for two four week cycles in each phase.

Phase One

The objectives of phase one are to develop general strength and general endurance. The workload in the first three weeks of the example plan below increase each week (easy, medium and hard) and the 4th week comprises of active recovery and tests to monitor training progress. The aim of the 4 week cycle is to build you up to a level of fitness (3 weeks), allow a recovery (1 week), build you up to higher level of fitness, allow a recovery, and so on.

Remember **a training program is athlete specific** and the results of the tests in the 4th week can be used to adjust the training in the next four week cycle to address any limitations.

The pace for each of the running endurance sessions should be between 15 and 20 seconds per 100 metres.

Each session should include an appropriate warm up and cool down program.

Week One

Mon	(am) Strength Training General - (pm) 5 km steady run
Tue	Endurance - 2 X 4 X 150 metres (23 to 30 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Wed	Strength Training General
Thu	Endurance - 2 X 3 X 200 metres (30 to 40 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Fri	(am) Strength Training General - (pm) 5 km steady run
Sat	Endurance - 2 X 3 X 250 metres (38 to 50 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Sun	Rest

Week 2

Mon	(am) Strength Training General - (pm) 5 km steady run
Tue	Endurance - 2 X 4 X 200 metres (30 to 40 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Wed	Strength Training General
Thu	Endurance - 2 X 3 X 250 metres (38 to 50 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Fri	(am) Strength Training General - (pm) 5 km steady run
Sat	Endurance - 2 X 3 X 300 metres (45 to 60 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Sun	Rest

Week 3

Mon	(am) Strength Training General - (pm) 5 km steady run
Tue	Endurance - 2 X 4 X 250 metres (38 to 50 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Wed	Strength Training General
Thu	Endurance - 2 X 3 X 300 metres (45 to 60 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Fri	(am) Strength Training General - (pm) 5 km steady run
Sat	Endurance - 2 X 3 X 400 metres (60 to 80 seconds) Recovery of 2 minutes/repetition and 5 minutes/set
Sun	Rest

Week 4

Mon	Strength Training General
Tue	Cooper Test or Multistage Fitness test
Wed	Strength Training General
Thu	400m drop off test
Fri	Strength Training General
Sat	Quadrathlon
Sun	Rest

Strength Training

Examples of general strength training are:

- Weight Training program - dumbbells
- Weight Training program - free weights and machines
- Weight Training program - sprinters

For young athletes, <17 years of age, I would recommend circuit training in place of the weight training.

Phase 2

The objectives of phase two are to develop specific strength, specific endurance and speed. The workload in the first three weeks of the example plan below increase each week (easy, medium and hard) and the 4th week comprises of active recovery and tests to monitor training progress. The aim of the 4 week cycle is to build you up to a level of fitness (3 weeks), allow a recovery (1 week), build you up to higher level of fitness, allow a recovery, and so on.

Remember **a training program is athlete specific** and the results of the tests in the 4th week can be used to adjust the training in the next four week cycle to address any limitations.

The pace for each of the running sessions can be determined from the calculator provided after the four week program.

Each session should include an appropriate warm up and cool down program.

Week 1

Mon	Strength Training Specific
Tue	Endurance Specific - 3 X 3 X 40 metres @ 90% effort Recovery of 90 seconds/repetition and 5 minutes/set
Wed	Strength Training Specific
Thu	Speed - 3 X 3 X 30 metres @ 100% effort Recovery of 5 minutes/repetition and 10 minutes/set
Fri	Strength Training Specific
Sat	Speed - 3 X 3 X 60 metres (20m @ 100% + 20m @ 90% + 20m @ 100%) Recovery of 5 minutes/repetition and 10 minutes/set
Sun	Rest

Week 2

Mon	Strength Training Specific
Tue	Endurance Specific - 3 X 3 X 50 metres @ 90% effort - Recovery of 90 seconds/repetition and 5 minutes/set
Wed	Strength Training Specific
Thu	Speed - 3 X 3 X 40 metres @ 100% effort Recovery of 5 minutes/repetition and 10 minutes/set
Fri	Strength Training Specific
Sat	Speed - 3 X 3 X 90 metres (30m @ 100% + 30m @ 90% + 30m @ 100%) Recovery of 5 minutes/repetition and 10 minutes/set
Sun	Rest

Week 3

Mon	Strength Training Specific
Tue	Endurance Specific - 3 X 3 X 60 metres @ 90% effort Recovery of 90 seconds/repetition and 5 minutes/set
Wed	Strength Training Specific
Thu	Speed - 3 X 3 X 50 metres @ 100% effort Recovery of 5 minutes/repetition and 10 minutes/set
Fri	Strength Training Specific
Sat	Speed - 3 X 3 X 120 metres (40m @ 100% + 40m @ 90% + 40m @ 100%) Recovery of 5 minutes/repetition and 10 minutes/set
Sun	Rest

Week 4

Mon	Strength Training Specific
Tue	Lateral change of direction test and Leg elastic strength test
Wed	Strength Training Specific
Thu	Flying 30m Test
Fri	Strength Training Specific
Sat	Running-based Anaerobic Sprint Test (RAST)
Sun	Rest

Strength Training

Examples of specific strength training are:

- Complex training (mix of plyometrics and weights).
- Plyometrics
- Plyometric Exercises - Arms
- Plyometric Exercises - Legs
- Plyometrics High Intensity Exercises - Legs

- Weight Training program - sprinters

For young athletes, <17 years of age, I would recommend circuit training in place of the weight training. The exercises need to be specific to the demands of your sport or event.

Plyometrics

Plyometric drills can be incorporated into the warm up. Conduct 2 or 3 sets over a distance of 20 to 30 metres. Focus on quality and not quantity. Example of plyometric drills are:

- Single leg hops over cones
- Double leg hops over cones
- Zig Zag hops (one legged lateral bounds)
- Alternate Leg running bounds (up stairs)

Sprint Technique

Development of your sprint technique is just as important as the development of your strength and endurance. Guidance on the correct technique for each phase of the sprint is detailed on the sprint technique page and the sprint start page. To assist in the development of your technique see the information contained on the technique training page.

Technique Runs

As part of each track session, include at the start of the session 6 X 50 metres:

- 1st run only concentrate on running Tall
- 2nd run only concentrate on a running Relaxed
- 3rd run only concentrate on running Smoothly
- 4th run only concentrate on the Drive action
- 5th & 6th runs concentrate on them all

Explanation of Tall, Relaxed, Smooth and Drive is detailed on the sprint technique page.

Evaluation Tests

Evaluation tests are used to monitor progress and identify limitations. The following are examples of tests that could be conducted every four weeks during Phase One and Phase Two to monitor progress.

Phase 1

- 400m drop off test
- Cooper Test
- Illinois agility run test
- Muscle balance and strength tests
- Multistage Fitness test
- Quadrathlon

Phase 2

- Flying 30m Test
- Illinois agility run test
- Lateral change of direction test
- Leg elastic strength tests

- Muscle balance and strength tests
- Running-based Anaerobic Sprint Test (RAST)
- T - Drill test

Stage 6

The program has now been agreed and the individual can undertake the program. Every 4 weeks meet and discuss with the individual:

- How the training has gone
- The test results
- Progress towards target fitness levels
- Adjustments to the training program