Energy Utilisation during Exercise and Sport

In order to understand the importance of fuel before, during and after exercise it is important to have a general overview of how energy is used during the different types of exercise. In simple terms the extent to which and the manner in which the body restores used fuel will vary depending on whether the exercise is intense and brief in duration or moderate in intensity and prolonged in duration. Understanding the energy demands of your sport will therefore help you make more informed decisions as to what type and amount of fuel you require to help you perform to your maximum.

ATP – The Energy Currency

The energy for all muscular activity be it sprinting, sidestepping, fielding a ball or running a marathon is adenosine triphosphate (ATP). This energy unit in conjunction with the backup fuel store of phosphocreatine (PCr) provides the fuel for high-intensity efforts.

The body has one immediate store of ATP-PCr and it is located just where it is needed – at the site of muscle contraction. However, the supply is very limited. Notice in Table 1 that it supplies energy very fast yet it is limited in storage capacity.

Table 1: Breakdown of storage capacity and speed of supply of energy from the three energy systems of the body.

Energy system	Storage Capacity	Speed of supply
1. ATP-PCr	Small*	Very fast
2. Glycogen	Good **	Fair
3. Aerobic	Huge***	Slow

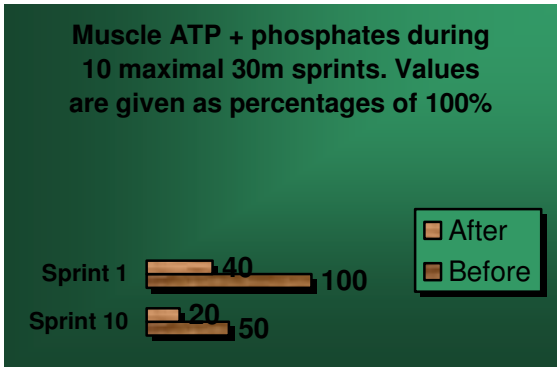
* runs out after 10 seconds
** depleted after 90 mins of repeated intense intermittent activity
*** enough for week(s) supply!

Fuel for Repeated Efforts

When the player has to repeat several explosive bursts on the field such as several repetitions of a short sprint as often occurs during team games then the

fuel stores located in the muscle will be depleted very quickly. Notice in Figure 1 that the ATP-PCr stores are reduced to about 20% of their original level after 10 maximal sprints.

Figure 1. Muscle ATP and phosphate stores during the performance of 10 maximal sprints with 30 seconds recovery between sprints (adapted from Bogdanis et al 1996 and Dawson et al 1997).



The second energy system – the Glycogen system – is a carbohydrate energy storage system and it too is located in the muscle. It plays a major role in supplying fuel for ATP production during field games. It starts to contribute to the pool of ATP almost immediately when high intensity exercise starts and is heavily involved when repeated efforts are required or when the effort is longer than a few seconds. As stated the primary energy system (ATP-PCr) cannot supply all the ATP fuel that is demanded for several explosive efforts back to back. A significant contribution for each consecutive repetition comes from the player's Glycogen or carbohydrate stores located in the muscle. The more intense your training or play the greater the reliance on these two energy systems.

We know from data recorded as far back as 1979 that the energy cost during a typical soccer game for outfield players was calculated at 17.4 kcalories per minute (42). If we assume that a value of about 1.2 kcal of energy per minute is used just to sit still then the energy used per minute in a relatively active state during a soccer game is over 14 times greater than at rest. It is likely that the intensity of the game has increased over recent decades. However, there is no information available on energy expenditure during Gaelic games but we can estimate that the rate of energy expenditure may be even higher than that reported for soccer player of the 1970's. In fact the higher the level of play the more energy demanding the game is in general. Also note that the energy cost of running sideways and backwards is greater than running forwards during play (43). This all means that Gaelic games may place great demands on the anaerobic energy system.

Lactic Acid build up

When very high exercise intensities are repeated, such as during several fast acceleration efforts over 30 metres the player will notice a heaviness in his limbs which will slow him down. This occurs as a result of two mechanisms:

1. a reduction in fuel at the site of muscle contraction and
2. a build up of acid as a result of the high rate of fuel use (this is really a build up of a by-product of blood lactate – hydrogen - ultimately leading to fatigue).

When a recovery occurs between these intense acceleration efforts, the body uses lactic acid to restore the ATP within the muscles. Also buffering systems may contribute to lowering lactic. In addition, the aerobic system contributes to recovery and thus all three energy systems are used during training and playing.

All the field based games such as Hurling, Football, Rugby and Soccer require short periods of high-intensity exercise interspersed with either complete rest or light exercise. When scientists study the demands of the game they often rely on blood lactic acid levels to assess the involvement of the anaerobic energy system. Resting blood lactic acid levels are typically about 1-2 mMol per litre. As the anaerobic energy system is taxed these levels rise. Studies reporting Lactic acid levels in Gaelic players have not been reported however we have examined player values which varied depending on the position of the player (22). Values as high as 9 mMol per litre were recorded for mid-field players with goalies having values as low as 2.4 mMol per litre. Players in between these positions had values ranging from 3.4 mMol to 6.8 mMol per litre. The values for the mid-field players reflect the high anaerobic energy demands placed on them. This is due to the intermittent nature of the game where mid-field players may have to cover more ground during a game and repeatedly accelerate over varying distances in addition to moving sideways and backwards at varying speeds.

The impact of all this is of course a drain on the muscle glycogen content of the player. Over 20 years ago scientists showed how muscle glycogen reduction can be depleted in the working muscles at the end of a field game (1, 25). Thus by the end of a high-intensity, fast paced game of Gaelic football or hurling an outfield player's muscle glycogen stores are likely to be significantly reduced (29). In fact if a player is of the fast twitch muscle fibre type he is more likely to experience muscle glycogen depletion in these fast twitch fibres more rapidly (14).

Restoring lost fuel

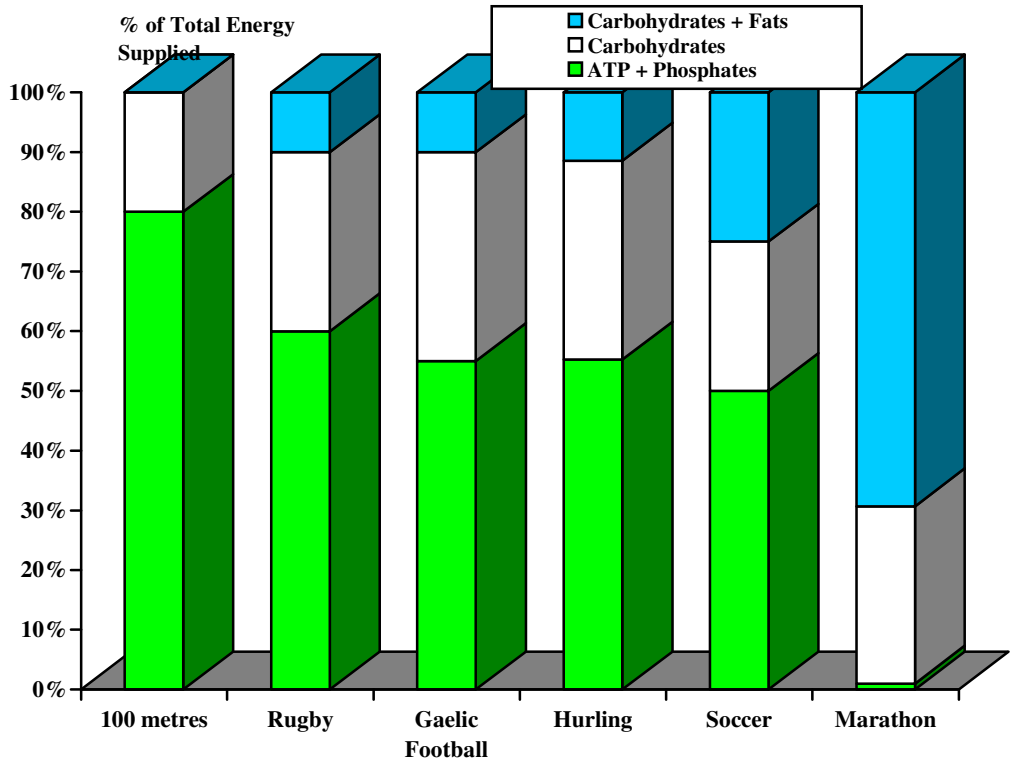
During the period immediately after exercise the muscle's ability to restore lost fuel is greatest (23). The muscle's capability to restore fuel is much higher immediately after training or playing compared to 2 hours later. Unfortunately

the dietary habits of Gaelic players have not been and are not yet that impressive when it comes to balancing their energy requirements (22, 45). Gaelic players tend to consume a lower than recommended energy intake especially during the playing season (22). Carbohydrate intake is also lower than recommended in GAA players and this may compromise their muscle fuel recovery. It has been shown that it takes up to 48 hours to replenish depleted muscle glycogen stores following intense training on a normal diet (40). Thus a diet rich in carbohydrates should be planned with eating and drinking strategies carefully timed about training and playing.

The message is clear – Gaelic games are likely to result in significantly reduced or depleted muscle stores of glycogen. Demanding training sessions will no doubt have the same effect. Previous and current GAA players habits of energy intake are still not at the recommended levels. It is likely that players in general require more energy to ensure that they are well fuelled prior to playing and especially after training or playing. Thus the player has to ensure that he then has strategies in place so that he restores used fuel as quickly as possible after training or playing.

Figure 2 illustrates the different relative contributions of fuel to performance in different sports. These are estimates as a precise energy contribution from the three energy stores is not possible to calculate given the variation that exists in playing or performance intensity and between individual athletes and players.

Figure 2. Energy systems used during selected sports. Contributions are estimated. References (2, 7, 22)



To summarise, the energy for fast explosive efforts – typically seen during Gaelic games, Rugby and Soccer comes from the first and second energy systems. The capacity to repeat these efforts is primarily influenced by the availability of fuel from the second energy system and from the type of training that the player completes. The third energy system is used mainly during continuous sub-maximal exercise such as during a long slow run. Thus Games players should ensure that their muscle carbohydrate stores are well stocked before and during exercise so that they can continue to reproduce brief high-intensity efforts over the duration of the game. In addition, evidence suggests that Gaelic players dietary habits are less than satisfactory in ensuring energy replacement. It is therefore critical to ensure that these fuel stores are restored as soon as possible following exercise so that a speedy recovery can take place in time for the next training or competitive unit.

Key Point 2
The primary and secondary energy systems are the chief suppliers of energy for the team game player.