What Every Coach Should Know About Energy Systems

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When we talk about training it can be simplified to stress, recovery and adaptation. As a coach, your job is to stress the physiology of the athlete through training, the athlete has a period of recovery (rest) and the athlete's physiology adapts. Through adaptation the athlete can gradually develop the capability to handle more training or training with more intensity. As the coach, you manipulate combinations of training frequency (how often you train) training intensity (how hard you train) and training duration (how long you train) and the type or mode of training.

Another key factor is how the training you do relate to your sport or specificity. If I run long distance, I have improved my endurance adaptation, but it does not transfer the adaptation to developing strength and power. Physiologists call this SAID – Specific Adaptations to Imposed Demands. The athlete by following your training plan will adapt to the type of load that you place upon them.

We have all heard of Non-oxidative (Anaerobic) and Oxidative (Aerobic), but what do these terms really mean. Non-oxidative (without oxygen) supplies rely on using stored resources (ATP, CP and production of lactic acid) and do not go into using oxygen to produce more energy. Oxidative (with oxygen) the body uses oxygen to aid in energy production through what is called the Krebs cycle. This whole process is called oxidation phosphorylation.
The standard energy of all human motion is the release of energy from ATP (Adenosine Triphosphate). Therefore, all of the components are related to the resynthesis or replenishment of ATP or the removal and/or dissipation of the waste products associated with maintaining our ATP supplies.

The trained athlete has the ability to utilise the system or systems necessary to replenish the ATP that is being utilised. The three major components: ATP/CP, LA and oxidative have the ability to support activities of varying intensities and durations. All athletes have the ability to produce power and work intensities that exceed their ability to resynthesize ATP. For example, even in a 100m sprint on the track the athlete slows down due to fatigue. Similarly, in a series of five jumps or explosive lifts, power output drops.

Energy Systems - Non-Oxidative

Physiologists have devised a method to look at the energy expenditures of different sports. They have broken energy systems into three categories based on the duration of all-out exercise and the intercellular response. However, it is important to note that while the different systems mentioned provide the resources for activities of varying intensities and power output requirements the systems function in an integrated fashion. Table 1 attempts to quantify the percentage contributed that could be expected from each of the major systems for varying sports or activities.

TABLE 1: Energy Systems

SPORTS	ATP-PC/ LA	LA/02	O2
Basketball	60	20	20
Fencing	90	10	
Field events	90	10	

Golf swing	95	5	
Gymnastics	80	15	5
Hockey	50	20	10
Distance running	10	20	70
Rowing	20	30	50
Skiing	33	33	33
Soccer	50	20	30
Sprints	90	10	
Swimming 1.5k	10	20	70
Tennis	70	20	10
Volleyball	80	5	15

The first phase is called the ATP- CP system. ATP (Adenosine Triphosphate) is stored in all cells, particularly muscles. In a sense, it is free energy because the body stores ATP to make it available for immediate use, however, you can only use it once and it needs recovery time to restore the storage. The ATP system is great for short and quick activities, because it only last for about 5 seconds. It would be used in activities like-- 10 metre sprints, diving, spiking and throwing the shot.

When ATP is used it breaks down into ADP. ADP then can combine with phosphocreatine (PC) to make more ATP, but only for a short period of time around 5-20 seconds. This system requires some recovery time as well. It takes about 25-30 seconds to regain about half of the phosphocreatine stores. These two systems combine for activities like 200m sprints and sports where short intermittent burst of activity are required— for example, basketball, hockey and rugby. A coach can train this system to adapt to some extent. A sample of training would be maximum efforts (5-10 seconds) with rest of about 1 minute.

The next major phase is called the Lactic (LA) system. After the 20 seconds of the ATP-PC system, the body requires another ingredient-- muscle glycogen (glucose) to be added to continue.

This system begins when phosphocreatine stores are depleted. Lactic acid (or lactate) comes from the breakdown of the glucose released from the muscles. One of the outcomes of this breakdown, is that positive Hydrogen ions are expelled which accumulated in the muscle and cause it to fatigue.

The lactic system is used in a number of sports that do repeat sprinting or high energy activities, such as ice hockey, sprint cycling, 100m swim, lacrosse, soccer, up to the 400 metres in track. Training can be designed to help the athlete improve their tolerance to the build up of the positive hydrogen ions. Bouts of intense training lasting from 25 to 45 seconds with rest ranging from 20 seconds to 3 minutes (determined by the amount of time of the work or the distance covered).

Energy Systems - Oxidative

The third system is the Oxidative phase. In this phase, as the term indicates you are using oxygen to fuel the breakdown of carbohydrates first, free fatty acids second and if the exercise continues long enough -protein. Whereas, the previous systems have related to higher intensity work (or power) the aerobic system is more for moderate or low intensity work, but of longer duration.

The oxidative system should be developed to aid in lactic system. The development of the aerobic system aids in lactate removal, so that the athlete can tolerate more lactate. Training to develop this system consists of the traditional long runs, but can also have repeats of shorter distances of low intensity with reduced rest (20 x 200m with 30 second rest). This example would not have the athlete perform with an all-out effort, but would be at race pace for a mile run.

References:

Frank W. Dick, Sports Training Principles (London: A & C Black, 2002).
Donald K. Mathews and Edward L. Fox, The Physiological Basis of Physical Education and Athletics (Philadelphia:W. B. Saunders Company, 1993).
Brent S. Rushall and Frank S. Pyke, Training for Sports and Fitness (South Melbourne: MacMillan, 1990).
William D. McArdle, Frank I. Katch and Victor L. Katch, Essentials of Exercise Physiology (Philadelphia: Lippincott Williams & Wilkins, 2006).