Introduction to Exercise Physiology & Sports Performance

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Lecture – 38

Performance testing in anaerobic sports

Good morning, ladies and gentlemen and welcome to lecture 3 of week 8 of this course on exercise physiology and sports training. Today, we will be discussing performance testing in anaerobic sports. In the last lecture we have gone over performance testing in aerobic sports and today we will be talking about anaerobic sports.

I will be covering this topic under the following headings, Introduction, ultra short-term anaerobic power tests, short-term anaerobic power tests, muscle strength evaluations and conclusion.

Events which last less than 10 seconds primarily use the ATP PC system to produce ATP. While events which last between 30 to 60 seconds utilize anaerobic glycolysis as the major bioenergetic pathway to synthesize ATP. We all know ATP is the primary energy supplier to the cell. This principle should be remembered when designing tests to evaluate an athlete's anaerobic power for a specific sport. We have to know about the bioenergetic pathways which the sports use so that we can pick and choose the appropriate test for these motor qualities.

The tests employed to assess anaerobic power should use the muscle groups and the energy pathways which are involved in the sport. And that is why tests to assess maximum anaerobic power are generally classified into ultra short-term tests designed to test the maximal capacity of the ATP PC system and short-term tests to evaluate the overall anaerobic capacity which measures the maximal capacity for ATP production by both the ATP PC system and anaerobic glycolysis.

Let us talk about ultra short-term anaerobic power tests. There are several practical field tests which have been developed to assess the maximal capacity of the ATP PC system to produce ATP over a very short time period that is between 1 to 10 seconds. Think sprinters in the 100-meter race. Race finishes within 10 seconds. These tests are generally referred to as power tests.

There are something called jumping power tests. These are the standing broad jump test and the vertical jump test which have been used as field tests to evaluate an individual's explosive anaerobic power. This photograph depicts the standing broad jump test being performed. It is valuable in the estimation of lower limb power of athletes and are widely used by coaches in professional football, soccer and basketball.

This may not be an appropriate test for American football and hence Stuart et al developed an anaerobic fitness test for football players designed to evaluate the athlete's ability to perform repeated short bursts of power. This is called the 40-yard dash test and it is a popular test to evaluate power output in football players. The athlete generally performs two or three timed

40-yard dashes with full recovery between efforts. The fastest time recorded is considered an indication of the individual's power output.

The test is conducted in the following manner. After a brief warm up, the athlete performs a series of 10 timed 40-yard dashes of maximal effort with a 25 second recovery between the dashes. The 25 second recovery period is designed to simulate the elapsed time between plays in a football game. Running speed is graphed on the y-axis and the trial number is graphed on the x-axis. Athletes who are highly conditioned will be able to maintain faster 40-yard dashes.

If you design a running test for American football, it may not be appropriate for soccer. As we know, soccer is what is called as football in the rest of the world and football is American football in America. So, soccer is a complex game requiring intermittent bursts of maximal running followed by periods of walking or slow running thereby utilizing both anaerobic and aerobic bioenergetic pathways. A popular field test to determine both performance and metabolic responses of soccer athletes is the Loughborough intermittent shuttle test developed at Loughborough University in England.

How is it performed? The Loughborough intermittent shuttle test is performed with the subjects completing the following runs. 3 x 20 meters at walking pace, one 20-meter shuttle at maximal running speed with a 4 second recovery, 3 x 20 meters shuttle at running speed at 55% of VO2 max and 3 x 20 meters at a running speed corresponding to 95% of individual VO2 max. This block of exercise is repeated continuously for 90 minutes so as to simulate a football game.

The sprint times are recorded by infrared photoelectric cells and represent one of the measured performance variables. Soccer players with the highest fitness levels will be able to maintain higher maximal sprint speed throughout the shuttle test. The total distance covered during the test is also measured as a performance variable.

Cycling power tests. The Quebec 10-second test was developed to assess ultra short anaerobic power in cyclists. After a brief warm up, the subject performs two all-out 10 second cycling trials separated by a rest period. The initial resistance on the cycle flywheel is determined by the subject's body weight and it is set at 0.09 kg per kg of body weight.

How do you do this test? When there is a verbal command by the investigator, the subject begins to pedal at 80 rotations per minute. The subject then pedals as fast as possible for 10 seconds. After a 10-minute rest period, a second test is performed and the results of the two tests are averaged out. This test is not only useful in cyclists but has also been used to test ultra short-term anaerobic power in non-athletes, in runners, in speed skaters, in bi athletes and also bodybuilders and weight lifters.

Short-term. Now, from ultra short-term we come to short-term. So, what are the short-term anaerobic power tests which are present or which are useful? Let's have a look at them. Anaerobic glycolysis becomes an important metabolic pathway for energy production in events which last longer than 15 seconds. To evaluate the maximum capacity of anaerobic glycolysis to produce ATP during exercise several short-term anaerobic power tests have been developed and like any other performance test, these power tests should involve the specific muscles used in the specific sport.

Let's talk about cycling anaerobic power tests. Researchers at the Wingate Institute in Israel have developed a maximal effort cycling test called Wingate test designed to determine both peak anaerobic power and mean power output over the 30 second period. This test has been shown to be highly reproducible and offers an excellent means of evaluating anaerobic power outputs in cyclists and others who are involved in jumping sports.

How is the test done? The subject performs a 5-minute warm up at a low speed. After the warm up, if you can see this photograph, there is a basket here where you put weights. So how much weight is put? You put weight at 0.095 kg per kg of body weight that means it depends on the body weight of the athlete. So, the subject or the athlete begins to pedal with no load in the basket in the weight basket as fast as possible. Initially when he is at the peak pedalling speed the investigator puts load in the basket at 0.095 kg per kg of body weight. As soon as the load is dropped in the basket the subject continues to pedal as fast as possible at this load for 30 seconds. Lot of verbal encouragement is given and peak power output and average power output are recorded.

This is the test report which is generated and we can see that peak power output in watts and watts per kg and average power in watts and watts per kg is recorded. What is the difference? If you look at this graph when the subject starts pedalling and when the weight is dropped there is a peak and gradually the graph begins to drop down over the 30 second period. Now this is the peak power and this is the average power and that is the difference. This is how the peak power and the average power outputs are measured using a Wingate test.

There are some sport specific tests which have been developed because people say Wingate test and the other tests may not be relevant in their particular sport. So, in team sports such as basketball, handball and soccer the maximal anaerobic shuttle running test M.A.S.R.T was developed and this involves an intermittent shuttle run between two parallel lines and it is very easy to be administered by a single assessor. It is sensitive enough to identify even small changes in the anaerobic performance in team sport players and this test has been shown to be both valid and reliable.

There are certain sport specific tests and they have been developed that means ultra short-term and short-term sport specific anaerobic tests have been developed and can be developed to meet the needs of team sports or individual athletic events. These tests can be designed to measure peak power output or mean power output depending upon the energy demands of the sport. This provides the coach and the athlete with direct feedback about the athlete's present level of fitness and the effect of training programs.

From power let us come to muscular strength. Muscular strength is defined as the maximum force which can be generated by a muscle or a muscle group. Measurement of muscular strength is a common practice in the evaluation of training programs for American football players, shot putters, weightlifters and other power athletes. Strength testing can monitor both training progress and the rehabilitation of injuries. That is why this is a very important component of the injury rehab process which will give you an idea about how the athlete is progressing through his rehab. Muscular strength can be assessed by one of the four methods isometric testing, free weight testing, isokinetic testing and variable resistance testing.

The criteria for selecting a method of strength testing includes the following factors. Specificity, ease of data acquisition and analysis, cost of the test and the equipment and safety.

Let us talk about isometric measurement of strength. Measurement of isometric strength uses a device that permits testing of the sport specific muscle groups. As the subject generates maximal isometric force, the computerized tensiometer measures the force produced. Because isometric force does not involve joint movements and if you want to perform this test and make it relevant for sports, the measurement of isometric strength is typically performed at several joint angles. Isometric strength at each joint angles usually consists of two or more trials of maximal contractions and the best of these trials is considered to be the measurement of strength. To put it simply, to measure isometric force, you need a computerized machine which measures the force produced and this measurement is typically done at two or three different joint angles and testing at each joint angles, you do two or three trials and you take the best of these trials.

Advantages of isometric testing are these tests are generally simple and safe to administer. They can be used in physical therapy to evaluate training progress in the injured limbs to evaluate strength training gains. If you can do these tests in an injured athlete and you can safely do them in an injured athlete because the test is isometric, there is no joint movement involved, you can very well pick up how the injured muscle is progressing as far as strength gains are concerned. Disadvantages include the high cost, less relevance for many sporting activities involving dynamic movements and more time required for testing.

Now, let us come to something called free weight testing for strength and the method used is called one RM or one repetition maximum. This method involves using a weight machine. You may use a weight machine, you may use bench press, you may use free weights. The one RM method of evaluating muscular strength is the maximal amount of weight that can be lifted during one complete dynamic repetition of a particular movement. The movement may be a bench press, movement may be a curl, movement may be a hamstring curl, whatever. To test the one RM of any given muscle group, the subject selects a beginning weight that is close to the anticipated one RM weight. If one repetition is completed, the weight is increased by a small increment and the trial is repeated. This process is continued unless the maximal drifting capacity is obtained. The highest weight moved during one repetition is considered the one RM. The one RM test can be performed using free weights or an adjustable resistance exercise machine. There are safety concerns with one RM and because of these safety concerns, some physical therapists and exercise scientists have recommended that a dynamic test consisting of three or six repetitions be substituted for one RM. That means they say a six RM or a three RM test be substituted for the one RM and the results be extrapolated.

From isometric, let us come to isokinetic. The term isokinetic means moving at a constant rate of speed and the picture depicts a variable resistance isokinetic dynamometer which is an electronic mechanical instrument that maintains a constant speed of movement while varying the resistance during a particular movement. When you do an isokinetic assessment of test, you are measuring the resistance offered by the instrument which is an accommodating resistance which is designed to match the force generated by the muscle. A force transducer inside the instrument constantly monitors the muscular force which is generated by the athlete at a constant speed and relays it to a computer which calculates the average force generated over each time period and each joint angle during the movement. Because of this, this instrument is

ideal for testing muscle imbalances and the forces produced over the full range of joint movement.

There was a research question which was raised at Army Sports Institute where I was working earlier and we were looking at seeing whether a standard field test can be substituted for a standard laboratory test and to our surprise, we found that the standing broad jump test and the Wingate test were significantly positively correlated. What I mean to say by this is if an exercise physiology laboratory is not available, you can get good data regarding your athlete by using standard, valid and reliable field tests also.

Anaerobic power tests are classified as ultra short-term tests and short-term tests. Ultra short-term and short-term power tests should be sport specific in order to provide the athlete and the coach with feedback about the athlete's current fitness level. Several sport specific tests have been developed for on-field testing.

Muscular strength is defined as the maximum force that can be generated by a muscle or muscle group. Evaluation of muscular strength is useful in assessing training programs for athletes who are involved in power sports or events. Muscular strength can be evaluated by isometric testing, free weight testing, isokinetic testing or by variable resistance devices and the testing can be tailored to available equipment and manpower. As we saw in the study which I discussed which we had conducted at Army Sports Institute, you can tailor the testing based upon the available equipment and the available manpower.

These are the references which I have used for preparing this lecture. I strongly urge you to go through them.

I seem to have finished, ladies and gentlemen. Thank you for listening and thank you for your patience. We will be glad to respond to any questions, any queries and comments which you may put up to the email id shared below. Thank you very much for listening, ladies and gentlemen. Thank you and Jai Hind.