Module 4: Integrative reading UNIT 4.1 Strength Evaluation in Team Sports

Strength Evaluation in Team Sports

The Concept of Strength Related to the Field of Sports

In most sports gestures, strength is applied to accelerate, decelerate or oppose the loads determined by the body itself, an implement or the action of an adversary, fundamentally carrying out dynamic actions in which the resistance to be overcome is constant or isoinertial. Therefore, and given the great importance of muscular strength on sport performance and on health, the evaluation protocols and criteria that are most commonly used for evaluating levels of strength in dynamic isoinertial movements, will be analyzed. These are a key tool for properly diagnosing, programming and monitoring strength training sessions (Naclerio, 2011).

Strength Evaluation: Concepts and Objectives

The objective of this development is for the professional related to (neuromuscular) strength based training in sport —at different levels of competition— to manage a basic strength evaluation methodology that allows them to carry out two very important processes.

The professional must:

- Evaluate and organize the results.
- Compare them intrasubject and intersubject.

To do this, the values obtained in tests should be classified as either intra and inter subject. In other words, by having subjects with different characteristics within a team, the tests are used to monitor the evolution of the player (intrasubect); but they can also establish groups of players with "similar" characteristics to determine relationships and comparisons (intersubjects).

Therefore, the strength evaluation, which forms a part of training monitoring, may seek objectives such as those presented by González Badillo and Rivas Serna (2002):

1) Monitor the training process/changes in performance.
2) Assess the relevance of strength and power on specific performance.
3) Define the strength and power needs.
4) Define the athlete's profile: strengths and weaknesses.

5) Check the relationship between progress in strength and power and specific performance: relationship between changes.
6) Predict results.
7) Prescribe the most appropriate training depending on:
    a. The strength and power needs in the sport and of the subject.
    b. The results of the tests conducted up to that point.
    c. Assessment of the influence of strength and power over other qualities.
    d. Differentiate between athletes from the same and different sports levels.
    e. Contribute toward the identification of talent.

Coinciding with the contribution made by Heredia Elvar (2005), we believe that the current approach in programs oriented toward neuromuscular fitness should consider a series of prerequisites in advance.

1. It must help to determine the neuromuscular training area or zone in which the subject is going to develop his program (depending on the phase).
2. It must ensure a direct transfer between the data obtained and its application to the training prescription.
3. It must be performed avoiding situations that involve potential risk of injury, ensuring safe and correct execution.
4. It must allow progress between measurements to be checked and, obviously, the assessment of the effects of the training. For this case, it is equally important to obtain feedback as positive reinforcement for the athlete. (Heredia Elvar, Chulvi Medrano, Ramón and Pomar, 2006).

The aspects that must be considered within a neuromuscular fitness program, following the FC Barcelona performance area structure (Seirul·lo Vargas, F., 2013) are:
1. Ensure healthy joint balance and control for the human athlete. Coadjuvant work.
2. Ensure variability in the proposals in regard to load levels and joint ranges. Coadjuvant or optimizer work.
3. Interrelate the conditional structure with the rest of the structures to optimize the complex system (human athlete). Optimizing work.

Measurements in Isokinetic Activations

Isokinetic dynamometers have been used in rehabilitation — especially on the knee— as a means of performing both concentric and eccentric dynamic exercises. These make it possible to work the muscle´s entire potential strength in all degrees of the range of movement (González Moro, 2004).

Isokinetic exercise can be used to calculate the capacity of a group of muscles to generate a torsional force or torque and as a form of exercise to regain strength levels after an injury, or simply as training (González Moro, 2004).

The main **advantages** of isokinetic evaluation are (González and Rivas, 2002; González Moro, 2004):

- It allows agonist and antagonist muscles to be compared.
- It allows measurement of isometric, concentric and eccentric movements.
- Limbs can be compared with each other (imbalances), bilateral discrepancies, to assess general muscular weaknesses, local atrophy and areas of weakness.

In addition, there are two major drawbacks for not assessing that option as plausible for use by the trainer:

- Validity, in terms of specificity of this diagnosis, since it is virtually impossible to get the movement speed through a joint axis to be constant in movements in our daily lives or in sports practice.
- Its enormous cost and the need for training of the personnel responsible (Heredia Elvar, Chulvi Medrano, Ramón and Pomar, 2006).

Measurements in Isometric Activations

Isometric force is measured as the maximum force or torque produced by a maximum voluntary isometric contraction (Mac Dougall, Wenger, Green, 1995).

We can also say that it consists of the execution of a maximum voluntary muscular activation against an insurmountable resistance (Gorostiaga Ayestarán and González Badillo, 1995).

Remember that these measurements are still part of the player's monitoring as an individual (coadjuvant training).

Isometric tests measure mainly the following:

a) The maximum force or torque (PMF).
b) The rate or velocity of force development (RFD).
c) The rate or velocity of muscular relaxation.

The value from isometric measurements raises some issues that should be considered as potential disadvantages for applying it in sports training programs:

- Its application must be performed at the angle in which peak force occurs on the specific gesture that is intended to be assessed. This implies a relationship in dynamic performance, which is questionable. In addition, there seems to be little relation between the neuromuscular, structural and mechanical adaptations between static and dynamic exercises (González Badillo and Ribas Serna, 2002).

- It is widely accepted and documented that (isometric) exercises with a high static component are contraindicated for people with cardiovascular disease, essentially due to the high increase of systolic blood pressure that is generated and to their potential as inducers of ischemia during the exertion (Pate et al., 1991; Jiménez, 2003). This tends not to be the case for athletes, but it is necessary to note this disadvantage (Heredia Elvar, Chulvi Medrano, Ramón and Pomar, 2006).

Measurements in Isoinertial Activations (Free Weights) in (Concentric) Miometric Action and (SSC Intense) Jumps with and without Technology

Strength measurement using free weights (and initially without technology) is perhaps the simplest, cheapest and most common system to measure force, although it can only provide us information on maximum dynamic force values expressed in kilograms displaced (González Badillo y Ribas Serna, 2002). The simplest example is obtaining the value of 1RM (repetition maximum) in an exercise. We could also obtain this RM value by using different formulas.

While it is true that for sports performance, the test with free weights can get us quite close to the actual situation of competition, this information is insufficient and will have to be completed. This is why a number of interesting instruments have been designed for the technician that will provide more information.

The technological revolution of strength training evaluation and monitoring can be applied to any manifestation of strength. The parameters that this technology offers us for strength evaluations are velocity, acceleration, time to reach the maximum velocity, time to reach the maximum acceleration; mean force, maximum force, time to reach the maximum force; mean power, maximum power, time to reach the maximum power and maximum angle (Pérez, 2004).

Linear Encoders (we can find two devices that provide us with data cited previously; the Ergopower (Bosco System), and;

Realpower (Globus)). Both have an electronic measurement system based on the linear encoder that can be adapted and applied to any bodybuilder machine that uses the force of gravity as external resistance. The bio-robot measures and records the velocity of displacement as a function of time. In this way, it can show all the derived parameters such as velocity, acceleration, power, work, etc. (Heredia Elvar, Chulvi Medrano, Ramón and Pomar, 2006).

Strength Evaluations in Sports Training: Initial Reflections

As we have explained, one of the key factors that will directly determine the strength evaluation, in this case in the field of sports training, is the training load. The determination of the strength training load (in this case with resistances, on anisometric-concentric activations with free weights or machines), implies the attempt to define the load intensity parameter. The intensity is the qualitative aspect of training, being the degree of exertion that an exercise requires (González and Gorostiaga, 1996).

The maximum intensity could be expressed by the weight used and compared with the percentage of this weight in relation to the maximum in the exercise. It is very frequent and practical to use the 1RM percentage (repetition maximum) as an expression of the training intensity.

As we will see, even after conducting a 1RM test and estimating the maximum weight that we could mobilize in that exercise in "that" moment, if we establish the training intensity dynamic, the estimated intensity (for example 60%) will not always correspond to this value in relation to the maximum possibility of the subject. Other factors, such as the speed of execution for example, are going to be determinant. When the resistance (this term is much more appropriate) used is equal to or greater than 90% of 1RM, the execution speed has to be the maximum possible, given that the speed cannot be regulated with those %. However, with percentage values lower than 85-90%, it may or may not be very significant that the movement is performed at the maximum speed (Heredia Elvar, Chulvi Medrano, Ramón and Pomar, 2006).

RM for Determining Strength Training Load: Usefulness, Problems, and Proposals

Let us think about this for a moment. (Heredia, Miguel and Abril, 2005):

- Several authors have written of the need to take into account that amateur subjects experience significant improvements in their strength values in successive evaluation sessions due to their familiarization with the test, with the equipment and with the type of muscular movement required (Kroll, 1962; Reinking et al., 1996; cited by Brown and Weir, 2001; Jiménez, 2004).

- It only determines the performance capacity in myometric movements (concentric) and not information about the plyometric capacity (Jiménez, 2004)

- The value obtained in 1RM is limited by the point of least mechanical efficacy in the entire ROM (sticking point) (MacArdle et al., 1996; Jiménez, 2004)

- They depend on the individual psycho-biological status on that day and time.

- The incorrect measurement of 1RM. For example, when measuring this value in a bench press, if the mean velocity of the movement has been equal to or greater than 0.3m (0.33 yards) s^{1}, the measured RM will be lower than the real one, which could mean that from then on the training would tend to be conducted with resistances lower than those that were theoretically programmed.

In general, we could consider the initial proposal of discouraging or limiting maximum strength tests from being conducted (other values or parameters may be more useful to determine the intensity of the exercise in strength training).

In this respect, based on González Badillo's proposal (1996) (in Heredia et al., 2006), we understand that applying alternatives to this traditional RM concept is much more useful and, possibly more thorough. An example of this could be considering the **nature of the exertion** (González Badillo, 1997) and execution speed as complementary means of monitoring the training intensity, focused on the individual supervision of the subject, of course.

The use of Perceived Exertion Scales (Robertson et al., 2003) is widely documented and is a valuable tool for the technician. The OMNI-Resistance scale (0-10) would have advantages for perceiving the exertion intensity in intermittent activities such as strength training (Day et al., 2004; Pincivero et al., 2003; Naclerio in Jiménez, 2004). The use of this scale seems to need a period of adaptation and learning with adequate instructions regarding its application (Glass and Satanon, 2004; Noble and Robertson, 1996; Naclerio in Jiménez, 2004), estimated to last between 8 and 12 sessions, in which the subject must become familiar with the use of the scale (Naclerio in Jiménez, 2004). (Heredia Elvar, Chulvi Medrano, Ramón and Pomar, 2006).

Estimating 1RM based on the Speed of Movement

With respect to the evaluation of muscular force in athlete subjects, Naclerio (2011) proposes the possibility of measuring velocity during the execution of a submaximal test, and, knowing the mobilized mass, estimating the value of 1RM in certain exercises used for strength training.

Naclerio (2011) cites some studies that have described a linear, inverse and very high ratio (r2 from -0.83 to 0.99) between the mobilized weight and the speed reached. This ratio would make it possible to analyze the variations of muscular performance and estimate the maximum strength value, due to the fact that the speed is inverse to the weight used (Kellis et al., 2005; Rhamani et al., 2002).

This prediction model, which takes speed as an independent variable (predictor) and the mobilized mass as a dependent variable (predicted), is based on the following assumptions:

- The ratio between 1RM% and speed reached in the exercise is directly proportional.
- The variations of the maximum speed reached with low and moderate weights indicate the modifications of the weight used (1RM%).

Dr. Naclerio, with his team from Universidad Europea de Madrid, developed equations for predicting 1RM in exercises with free weights (bench press and half squats), based on the vertical speed of the bar in subjects that are athletes (Naclerio, 2011).

Calculating Mean Speed of Execution

In many cases, the devices for measuring the speed and acceleration of the training implements are not available, which is why these variables cannot be monitored. Therefore, the goal to be accomplished gets ignored and falls out of reach. In turn, this is why the speed of execution of the strength exercises tends to be the least recorded variable even though it is possibly the one that has the greatest influence when causing one type of adaptation or another (Tous, 1999).

In the event that a speed monitoring device (linear encoder) is unavailable, the mean speed can be calculated through a less accurate system. In this way, the mean speed of execution will be calculated multiplying the number of repetitions that the subject is capable of doing by the total movement of each repetition, and dividing this product by the block of time that is designated to be monitored or evaluated (Tous, 1999).

Strength Evaluation using Eccentric System

The maximum eccentric force is estimated based on the largest load (weight) that the subject can endure in a specific muscle group and exercise during the eccentric phase of muscular contraction.

Hollander (2007) proposes determining the eccentric 1RM when a minimum rhythm of 3 seconds cannot be tolerated while performing the eccentric phase of an exercise.

Eccentric force values may exceed those of concentric force from 10% to 60% in males, and from 20% to 46% in females. The differences were greater in exercises for upper limbs. On the other hand, Meylan et al. (2008) recommends assessment using the eccentric system to be able to determine the eccentric workloads, and not to determine them based on predominantly concentric test results.

Agonist – Antagonist Ratio

This ratio compares the level of manifestation of strength between agonist and antagonist muscles in different muscular contraction systems. The agonist (concentric)/antagonist (concentric) ratio has generally been used as a reference (Zatsiorsky, 1995; Verkhoshansky, 2000).

Strength Difference (Agonist-Agonist Contralateral Ratio)

This ratio relates the strength level indicated by the weight (Kg.) mobilized in an exercise that preferably, makes it possible to isolate a specific muscle group. It is generally an open kinetic chain (OKC), monoarticular exercise, and the maximum force is assessed (with a 1RM test or with a multiple maximum repetitions test).

The objective of this test is to compare the force between contralateral agonist muscles, in a single muscular contraction system and at a similar speed.

The optimal ratio should be near 1 (+/- 5 %) (Acero, 2007). This balance is considered acceptable when the force difference between agonist and contralateral agonist muscles is equal to or less than 10% (Newton et al., 2006). They indicated that the difference between the forces transmitted through the lower right and left limbs must not be greater than 10%.

Evaluation of the Stretch-Shortening Cycle (SSC). Evaluation of Explosive Strength through Jumping Ability

Another interesting way of evaluating strength and its indicators is by using jumps. If the jump is on a contact platform connected to a timer (for example, Ergojump, Bosco System, those made by Globus, or the Chronojump contact platform software; a free software suggestion), when properly implemented, it is possible to know the flight time and, therefore, the height reached, by the athlete's center of mass:

This will allow us to establish the influence of contractile components, of recruitment and synchronization, arm movement usage ratio, elasticity and neuromuscular reactivity, and use this data to establish the profile of said capacities and relate to a specific profile with regards to sports specialties. It will also help us determine what factors should be prioritized in the training strategy (Vélez, 1997). (Heredia Elvar, Chulvi Medrano, Ramón and Pomar, 2006).

Contact Platform Tests (SJ, RJ, CMJ, 10 and 30 second Test, DJ, etc.)

The athlete´s level of active and reactive explosive strength in the lower body can be evaluated through standardized tests that include the Bosco battery test. These require the use of a contact platform or classic jump tests that only need a tape measure, chalk and a wall, or a tape measure and a jumping box, to execute them.

Explosive strength can be estimated based on the athlete´s jumping capacity. In this case, the execution of explosive and reactive strength tests using a contact platform are going to be described first.

This allows us to obtain the flight time of the subject in milliseconds when making a specific jump. The flight time is then converted to centimeters and we obtain the data that may later be compared with new tests or with reference charts, if desired.

The contact platform allows us to obtain the time of contact of the jump in a specific type of jumps (drop jump), which is an indication of how quickly the subject applies force against the ground.

The jumps belonging to the Bosco test, and some others introduced by Palazzi, are as follows:

1) *Squat jump* (SJ) or a jump without a counter movement, from a static ½ squat.

2) *Counter movement jump* (CMJ).

3) *Rocket jump* (RJ) or jump from a deep flexion.

4) *Drop jump* (DJ), or jump with a landing from varying heights (20 to 100 cm) (7.9 to 39.4 in).

5) CMJ reactive or continuous jumps, with a duration ranging from 5 to 60 seconds (preferably 5 to 15 seconds).

6) Squat Jump while lifting variable loads (20 – 100 kg [44.1 – 220.5 lbs]) with the bar over the shoulders) and particularly with loads similar to body weight (SJbw).

7) Reactive or continuous jumps with rigid knees, with a duration from 5 to 7 seconds, with or without clearing obstacles, and with or without help from the arms.

The conventional jumps that can be performed without the contact platform are:

1) Jump and reach test (Abalakov or CMJ test with arm boost).

2) *Maximum jump* (Max., MJ)

3) Long jump or horizontal jump tests.

In the FCB Basketball Training department, monaxial force platforms are used for monitoring jumps with the players. The following variables are monitored and checked, mainly:

- Peak concentric force (N).
- Concentric contraction time (s).
- Eccentric phase time (s).
- Time from start of movement until the peak of maximum force (s).
- Mean force applied in concentric phase (N).
- Mean force applied in eccentric phase (N).
- Ratio of the mean force applied in concentric-eccentric phase (%).
- Flight time (s).
- Flight height (cm).
- Peak relative maximal force in concentric phase (N/kg).
- Maximal velocity in concentric phase (m/s).
- Peak relative power (W/kg).
- Peak landing force (N).
- Peak relative landing force (N/kg).
- RFD on landing (N/s).
- Asymmetry of force applied in concentric phase (% L,R).
- Asymmetry of the peak maximum force (% L,R).

Regularly scheduled jumps are made for monitoring these variables.

Speed and Agility Assessments

Generalities about the Evaluation of Change of Direction Speed and Agility

Introduction to Speed and Agility Assessments

The complex way in which agility manifests itself in the athletes´ distinct motor skills means that the process for evaluating this agility is also complex. For this, taking into account all the considerations from previous courses, it is necessary to differentiate agility evaluation from the evaluation of change of direction speed.

Young, James and Montgomery (2002) presented a concept of agility that includes the perceptual factors and decision making and, on the other hand, the change of direction speed (in which the movement technique, linear acceleration speed and muscular qualities are all taken into account).

This previous concept made it possible for Young, James and Montgomery (2002) to differentiate the term speed from that of change of direction, in which the movement is produced without a reaction to a stimulus; but also that of agility, as well as the rapid movement in response to a stimulus. For this, taking the foregoing into account, in the event that a test is conducted in which everything that has to be done is known, in which there is only one stimulus that indicates the reaction to this (given that this is known), and the subsequent sequence of movements, the change of direction speed would be evaluated specifically.

Therefore, aspects constituting the evaluation of change of direction speed could be analyzed (called agility by its authors), such as:

- Acceleration capacity.
- Deceleration capacity.
- Stability and dynamic balance.
- The movement technique (mainly changes of direction).
- Braking, braking action.
- The speed of changes of direction.

Agility should be considered as a motor response to a stimulus (through a displacement that includes acceleration, deceleration and changes of direction). Therefore, the tests that intend to assess it should include these stimuli, and based on them, the subjects should react and express the best change of direction speed (COD), as well as acceleration and deceleration included in the test.

Therefore, the agility assessment must contain:

- The stimulus.
- The reading of the situation.
- The decision making.
- The specific motor action (acceleration, deceleration, change of direction speed).

Evaluation of Change of Direction Speed

The basic movement patterns of many sports require the athlete to make sudden changes in body direction in combination with quick arm movements. But the player´s ability to use these maneuvers successfully in the current sport also depends on other factors, such as visual processing, coordination, reaction time, perception and anticipation. Although all of these combined factors are reflected in the athlete´s field agility, the purpose of the agility tests, for a long time, has been to simply measure the ability to quickly change body position and direction in the horizontal plain.

Characteristics and Classification of Different Change of Direction Tests

The duration and intensity of the change of direction speed tests will determine the relative contribution of the predominant energy system in providing the suitable fuel for the performance. Gastin (2001) explains that the anaerobic energy system depends on phosphocreatine for the first five seconds of exercise and, then, glycolytic energy is used, preferably followed by the energy produced by the aerobic system. In this way, tests of different durations may be subject to energetic influences more than the fair assessment of COD ability.

The complexity of each test can be categorized by the number of CODs required, or by the type of movements and force that are used, mainly by means of the test.

Cognitive Considerations for the Assessment of Agility

It is considered that specific elements of the athlete and the sport must be respected in agility assessment. This makes reference to the assessed patterns of movement, the perception of specific stimuli and the decision making with respect to the dynamics of the sport. Thus, an aspect that differentiates high performance athletes is directly related to the capacity to anticipate the opponents' movements. In fact, significant differences have been noted between high performance athletes and non-elite athletes in that respect (Abernethy y Russel, 1987).

It is important, then, that the specific demands of each sport are known for the design and application of valid, reliable and reproducible agility tests. In some cases, tests have been developed that have required the athletes to watch videos of sporting situations, and quickly resolve them through a change of direction in speed (Farrow, Young, & Bruce, 2005; Sheppard and Young, 2006). Tests have also been created in which the athlete reacted to the opposing movement of a defender, thus drawing nearer to the specificity of the sport (Wheeler and Sayers, 2010). In this manner, it would be necessary to create a specific test for each game model. In this sense, it may be more efficient to create different *preferential simulator situations* (tasks) where these types of parameters can be monitored.

In summary, the tendency in the agility test application is to achieve the greatest specificity possible in:

- a replica of sports situations (offense and defense).
- perception of specific situations.
- decision making.
- anticipation.
- Specific motor skills of the sport (with or without the element, adapted to the positions and/or functions, with or without tactical actions).

Evaluation of Change of Direction Speed (Closed Skill Agility) and Agility (Open Skill Agility)

Programmed or Closed Agility Assessment

T-Test (Semenick, 1990)

Test Characteristics

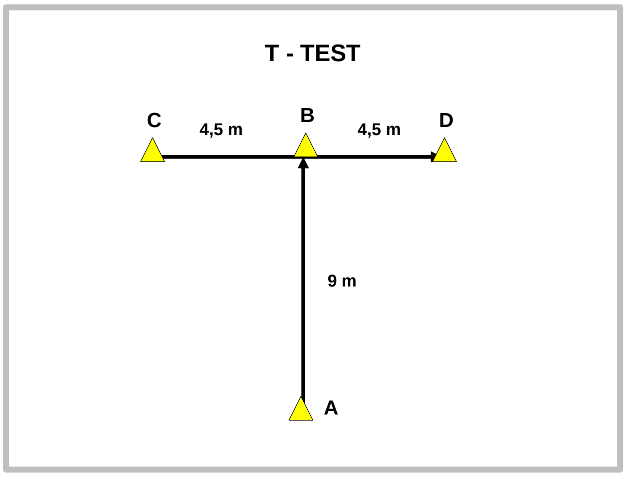
- Type: programmed or preprogrammed.
- Number of COD: low number of COD (4).
- COD complexity: high (90° and 180° COD).
- Force application: predominantly horizontal.
- Test time: ranges from 8.5 to 12 seconds (predominance of glycolytic anaerobic system).

The total acyclic trajectory distance is 40 meters (32.8 yards). Cone A (the start and end position of the test) is located 9 meters (9.8 yards) from cone B. Perpendicular to cone B, cones C and D are located 4.5 meters (4.9 yards) to the right and 4.5 meters (4.9 yards) to the left respectively (Figure 1).

Execution

The test procedure consists of running 9.14 m (10 yards) in a linear manner from cone A to cone B. On reaching cone B, the athlete must touch its base with the right hand. The subject then turns to the right, moves laterally 4.57 m (5 yards) and touches the base of cone C with the left hand. The athlete immediately turns to the right, runs laterally 9.14 meters (10 yards) to cone D and touches its base with the right hand. The subject then turns to the left, moves laterally and touches the base of cone B with the left hand. Then there is a run backwards to cone A, at which moment the stopwatch stops.

Figure 1: Semenick T-Test (1990), adapted by Harman, Garhammer and Pandorf (2000, cited in Baechle and Earle, 2007)



Source: Baechle and Earle, 2007.

Test T (Pauole, Madole, Garhammer, Lacourse and Rozenek, 2000)

Test Characteristics

- Type: programmed or preprogrammed.
- Number of COD: low number of COD (4).
- COD complexity: high (90° and 180° COD).
- Force application: predominantly horizontal.
- Test time: ranges from 7 to 9 seconds.

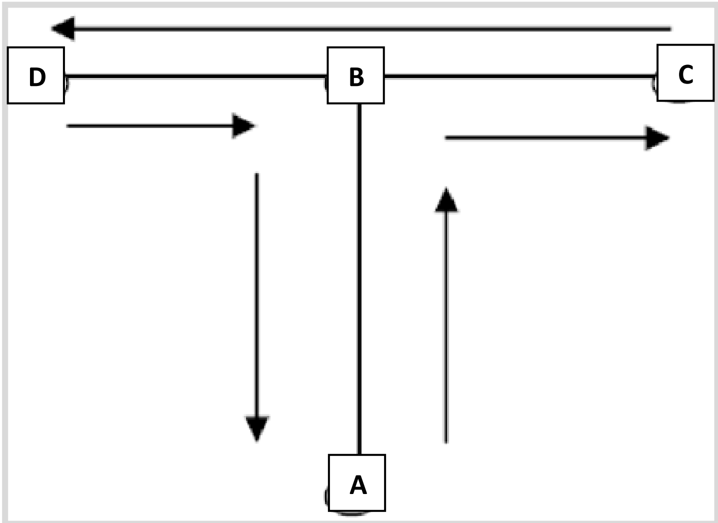
The total acyclic trajectory distance is 30 meters (32.8 yards). Cone A (the start and end position of the test) is located 5 meters (9.8 yards) from cone B. Perpendicular to cone B, cones C and D are located 5 meters (4.9 yards) to the right and 5 meters (4.9 yards) to the left respectively (Figure 2).

Execution

4 cones are placed in the form of a T, separated from the nearest one by 5 meters (5.5 yards) (Figure 2). The gate is located at the cone forming the base of the T.

When the subject crosses a light beam of the photoelectric cell at the gate, he begins running straight forwards until his hand touches the cone located 5 meters (5.5 yards) ahead of the gate. He then begins running laterally 5 meters (5.5 yards) until he touches the cone located on the left with his hand. He then runs laterally 10 meters (10.9 yards) until he touches the cone located to the right of the T, to return and run laterally 5 m (5.5 yards) to the cone located at the top of the T. Last, the subject runs backward 5 meters until he passes the cone located at the base of the T and the light beam of the second photoelectric cell. (Sainz de Baranda Andujar and Ayala, 2009).

Figure 2: T Test, with a Total Trajectory of 30 m (32.8 yards) in the Form of a T (Pauole et al., 2000)



Source: Pauole, Madole, Garhammer, Lacourse and Rozenek, 2000.

Illinois Agility Test

Test Characteristics

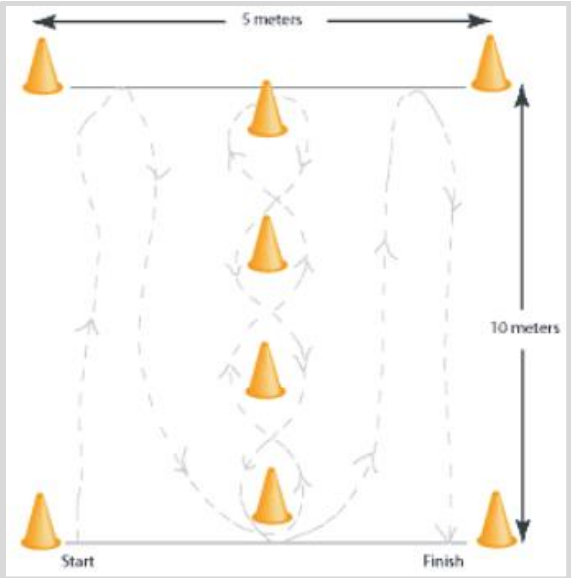
- Type: programmed or preprogrammed.
- COD number: high number of CODs (12).
- COD complexity: high (45° and 180° COD).
- Force application: predominantly horizontal.
- Test Time: ranges from 15 to 20 seconds for men and 17 to 22 seconds for women.

The total acyclic trajectory distance is approximately 65 meters (71 yards). The cones are organized as described in figure 3.

Execution

The starting position is lying face down, with the subjects' head above the start line and their hands placed at shoulder height. At the start signal, the players must stand-up quickly and run at maximum speed, following the trajectory shown in figure 3. The race must be done without knocking over the cones, and the entire trajectory run-time is recorded. The time is recorded in seconds and hundredths of seconds.

Figure 3: Representation of the Run Trajectory During the Illinois Agility Test



Source: [Untitled image about the Illinois Agility *Test* , 2]. (undated). Taken from http://goo.gl/c9mURr.

Agility Test 5-0-5 (5-0-5 test)

Test Characteristics

- Type: programmed or preprogrammed.
- Number of COD: low number of COD (1).
- COD complexity: high (180° COD).
- Force application: predominantly horizontal.
- Test time: lasts less than 10 seconds.

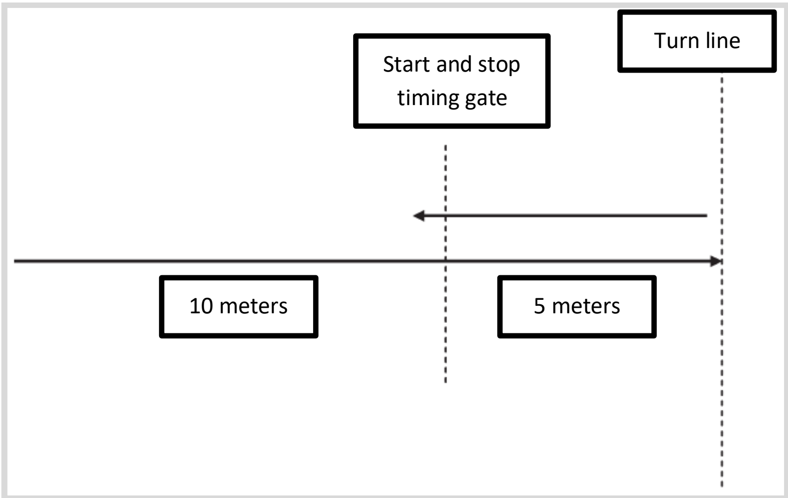
The test has a total trajectory of 20 meters (21.9 yards), of which only the final 20 meters (21.9 yards), including a 180° change of direction, is recorded with a stopwatch.

Execution

Only forward movement is included in the test. The subject begins the test by running 10 meters (10.9 yards), accelerating as fast as possible. There is a photoelectric cell at a distance of 10 meters (10.9 yards) to mark where to being recording the time. The athlete runs 5 meters (5.5 yards), performs a 180°change of direction, re-accelerates, and runs 5 meters (5.5 yards) in the opposite direction. The test ends when the photocell signal is crossed, and the test time is recorded.

Then the test has a total trajectory of 20 meters (20.9 yards), of which only the final 10 acyclic meters are recorded with a stopwatch. The time is recorded in seconds and hundredths of seconds.

Figure 4: Execution of a 5-0-5 Test



Source: Buttifant, Graham & Cross, 1999.

L-Test

Test Characteristics

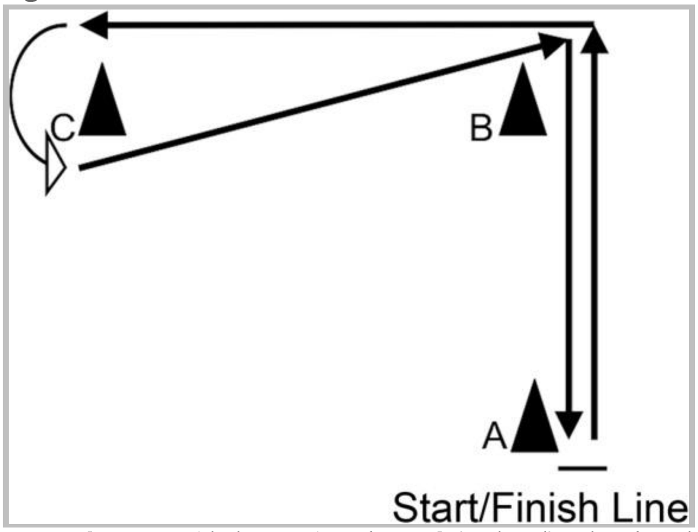
- Type: programmed or preprogrammed.
- Number of CODs: average number of CODs (5).
- COD complexity: high (90° and 180° COD).
- Force application: predominantly horizontal.
- Test time: lasts around 10 seconds.

The L-Test requires three cones to be placed at a 90° angle, distributed to form an L, separated from one another by 5 yards. The test has a total trajectory of 30 yards, given that there are 10 yards when running to and from, and then 20 yards in L (Figure 5).

Execution

The test objective is to measure the subject's change of direction speed. The athlete must run a to and from trajectory of 10 yards, and then run 20 yards in the form of an L, as is indicated in Figure 15. The time is recorded in seconds and hundredths of seconds.

Figure 5: Execution of the L-Test



Source: [Image entitled execution of L-*Test*]. (undated). Taken from https://goo.gl/mJGRG9

Non-Programmed or Open Agility Assessment

Reactive Agility Test (The reactive agility test for Netball) (Young and Farrow, 2006)

Young and Farrow (2006) developed the reactive agility test in the Australian Sports Institute in Canberra, Australia, in which incorporates the element of sudden stoppages of movement specific to a given sport. This protocol used a pre-recorded video of several movements in *netball* as stimuli for the participants.

Test Characteristics

- Type: non-programmed or non-preprogrammed.
- COD number: low number of CODs (3).
- COD complexity: high (180°, 90° and 45° CODs, approximately).

- Force application: application of predominantly horizontal and lateral forces.

Execution

The test began when the participant triggered the photocell, located at the start of the test, in reaction to a visual stimulant. The participant had to run a linear trajectory, perform a 180° change of direction and return to the beginning in the opposite direction. Then, when approaching the second photocell, having observed a screen with recorded images of the game, take the correct decision to react to the right or to the left.

Test of Planned or Reactive Agility with Luminous Visual Stimuli (Oliver and Mayers, 2009)

Test Characteristics

- Type: with programmed or planned variants, and non-programmed or non-preprogrammed variants.
- COD number: low number of CODs (1), or none, in the event that only linear acceleration is required.
- COD complexity: average (45° COD, approximately).
- Force application: application of predominantly horizontal and lateral forces.

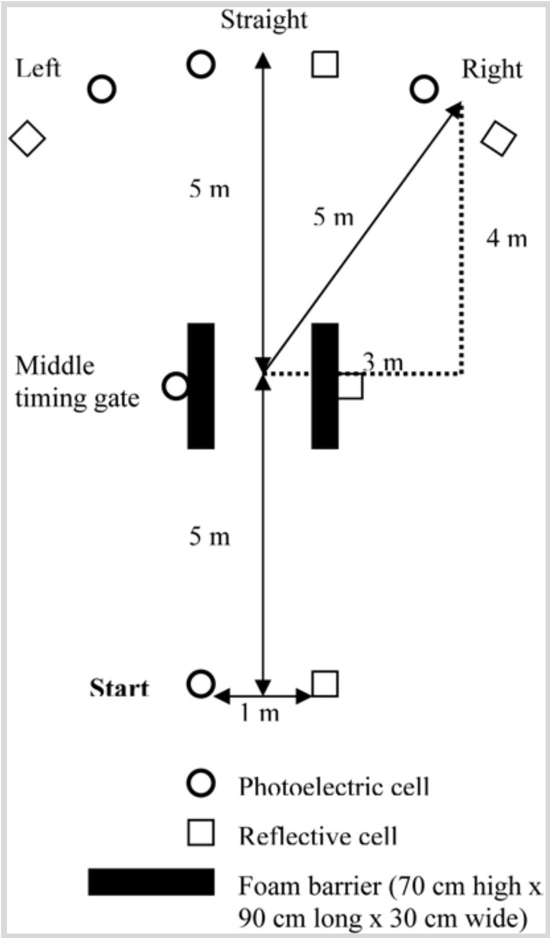
Organization

The test requires for the start line, cones and photocells to be marked as indicated in figure 6.

Execution

As was previously clarified, this test can be executed in a planned or unplanned manner. In the event of planned, the subject must execute the linear acceleration or accelerations with changes of direction in speed, having previously determined in what direction the test must be carried out. In the event of unplanned, the test requires that the athlete accelerates in a straight line of 5 meters (5.5 yards) and be ready for a luminous signal that will show the orientation of the change of direction (to the right or left), or for the linear trajectory to continue. Ten attempts are made and the execution time of each attempt is recorded. The average is then obtained for each participant.

Figure 6: Planned or Reactive Agility Test Execution with Luminous Visual Stimuli (Oliver and Mayers, 2009)



Source: Oliver & Meyers, 2009.

Reactive Agility Test in Rugby (Wheler & Sayers, 2010)

Test Characteristics

- Type: non-programmed or non-preprogrammed.
- COD number: low number of CODs (2).
- COD complexity: high (COD of 45° and 90°, approximately).
- Force application: application of predominantly horizontal and lateral forces.

Organization

The test requires for the start line, cones and photocells to be marked as indicated in figure 20.

Execution

The athlete begins from the start line with the transfer of the element (ball). After passing the first cone or mark (3.72 m (4 yards) from the start), the pre-change of direction phase begins, and there the defender begins the forward movement. Having passed the second mark (3.72 (4 yards) from the previous mark), the athlete begins the change of direction phase, where, based on the location of the defender, the attacker must pass them with a change of direction. The defender must try to touch the attacker before they pass the final lines or goals determined by cones. Six attempts are made. In addition, the execution time of each attempt is recorded. The average is then obtained for each participant.

Repeated Sprint Acceleration Tests (RSA)

Assessment of the Ability to Do Repeated Sprints

In team sports, athletes must have the ability to recover very quickly from short moments of high intensity exercise. Players barely have sufficient time to fully recover between repeated series of sprints (that is, to produce a full re-synthesis of phosphocreatine).

Because of this, it is necessary to measure the players´ recovery ability between repeated series of sprints or accelerations.

Bangsbo Sprint Test

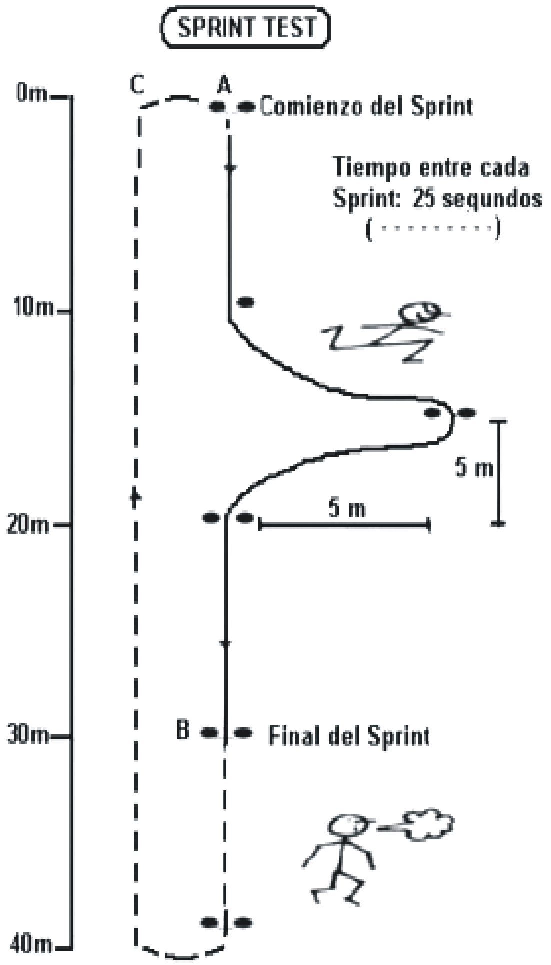
The test consists running a trajectory of 30 meters (32.8 yards), executing 7 (seven) repetitions at maximum intensity, with pauses of 25 seconds for recovery between each repetition. The trajectory begins with an initial acceleration for 10 meters (10.9 yards), from the high starting point, followed by three changes of direction (zigzag) and a final acceleration for 10 meters

(10.9 yards). Subsequently, the subject returns to the starting point jogging with very low intensity. The execution time of each repetition must be measured with a photoelectric cell and a stopwatch.

Variables obtained from the sprint test

- Best time in seconds: shows the peak strength during the test.
- Average time (seconds): allows the player´s capacity for intra and post-effort recovery to be observed.
- Fatigue rate: this is the percentage difference between the slowest and fastest time. This indicates how the alactic and lactic anaerobic performance is being affected.
- Final lactate level mmol/L: indicates the metabolic cost produced in the test. Values from 9-14 mmol/L are generally obtained.

Figure 7: Graphic Representation of the Sprint Test Proposed by Jens Bagsbo



Source: Bangsbo, 2005.

Anaerobic Intermittent Running Test

The test consists of making 10 sprints of 20 meters (21.9 yards) with a pause of 20 seconds between each sprint. The run direction must alternate for each sprint. In other words, the final position of a sprint must be transformed into the initial position of the next. Rudolf et. al. (2006), analyzed the reliability and validity of this test in a study in which 29 young, elite soccer players of a Czech club participated. They performed the test two times under the same conditions within the same week. Capillary blood tests were taken during both tests at 2, 4 and 6 minutes after the test for assessing the lactate concentrate. Through the two-way variance analysis, it was reported that the average time of the 10 sprints was not significantly different between both evaluations.

Summary of Endurance Assessment in Acyclic Sports

Assessment of Aerobic and Anaerobic Physical Condition in Athletes

Objectives for the Assessment of Endurance in Sports

As developed by Vargas (2008), the evaluation process can be summarized by seven large aspects:

1) Diagnosis: we will know the condition of the test-subject, and, based on this, we will be able to begin working right away.
2) Dysfunction detection: when the responses to a specific test are not as expected, we have a "difficulty".
3) Selection: With the test-person profile, we can place them within specific groups of similar characteristics, according to existing tables.
4) Planning: knowing the individual capacities of each athlete, we will be positioned to prepare personalized training programs.
5) Forecast: under specific circumstances, we will be able to trace the possible goals that an athlete can reach through the training program.
6) Control: using the same, we can calculate the evolution of the athletes, obtaining the "strong points" and "weak points" of the athlete.
7) Motivation: the distinct results obtained in the tests help us find elements of individual assessment, which serve as motivation for the achievement of different objectives.

Types of Assessment

Although some authors insist on the validity of the subjective assessment, derived only from professional work experience, we will postulate the need to become familiar with an objective evaluation, given that this is a consequence of the use of measuring elements through processes and/or techniques developed through scientific investigation (Vargas, 2008).

From the point of view of the instruments that we are going to use, we will hereinafter call them tests. Sports Tests are scientific constructions aimed at measuring determined physical qualities with a certain percentage of veracity (Vargas, 2008). These are the results of detailed scientific studies regarding human responses to specific stimuli. This implies a full investigation process: formulation of the problem and the hypothesis, selection of bibliographic material, laboratory studies on effort conditions, correlations between laboratory and field results, communication of the final conclusions, placed for consideration, discussion by internationally recognized scientific authorities, etc. (Vargas, 2008).

Due to the current demands of acyclic field sports (soccer, rugby, hockey, basketball, etc.), athletes require a high range of motor skill development, such as strength, power, as well as aerobic and anaerobic endurance (Dupont and cols., 2004; Helegrund and cols., 2001). For an optimal development of these parameters, the training intensity should be individualized according to the athletes´ skills (Vargas, 2008).

Test Classifications

The endurance tests must be classified and contextualized to be better understood, so we must understand classification of this capacity in (Massafret, 1998):

- General endurance.
- Specific endurance.
  - Technique endurance.
  - Decision-making endurance.
  - Endurance to the game system or competition.

Based on this, the proposals of the test vary.

In performance sports, endurance is understood as a physiological physical quality, understanding the player as the person who is solely responsible for the performance, in which the performance and the state of this quality are closely related. Different authors (García Manso, Ruiz Caballero, Navarro Valdivielso, 1996) use different taxonomies based on the criteria:

- Based on the effort duration:
  - Short-term endurance.
  - Mid-term endurance.
  - Long-term endurance.

- Based on the number of muscular groups implied:
  - General endurance.
  - Local endurance.

- Based on the predominant energy system:
  - Aerobic endurance.
  - Lactic anaerobic endurance.
  - Alactic anaerobic endurance.

- Based on the relationship with other qualities:
  - Resistance to force.
  - Resistance to speed.

- Based on how the muscles intervene:
  - Static endurance.
  - Dynamic endurance.

- Based on the specificity level:
  - General endurance.

- Specific endurance.

Endurance in sport with changing situation must be understood as: “The capacity to be able to withstand and adapt to the physical, technical and tactical demands established by a specific system of play during the match and throughout the competition” (Massafret, 1998).

Here the following is important:

1) The role of the player within the system of play.
2) The characteristics of the system of play.
3) The type of direct adversary.

An adaptation takes place here based on the needs of the sport, establishing a different classification:

1) General endurance: fundamentally set by the bioenergetic structure of the human being, in addition to the coordinative, cognitive, conditional and socio-affective structures.
2) Specific endurance:

   a. Technique endurance: specifically developing content of already automated individual technique, with unspecific decision making. Its purpose is to optimize the coordination structure in different fatigue stages.
   b. Decision-making endurance: specifically, where the decision making is specific and is related to the system of play. Its main purpose is to optimize the cognitive structure in different fatigue stages.
   c. Competition endurance: this seeks the best coordination and synergic participation of all structures in order for the players to be able to resolve the competitive situations to optimize the system of play.

The objectives, according to the definition of endurance as it pertains to sports with changing situations, are:

1) Resist weariness, fatigue and bioenergetic wear, conditional and cognitive, which the system of play entails.
2) Optimize the player´s performance when executing technical maneuvers and decision-making during the entire game.
3) Increase the average intensity of the system of play, avoiding temporary periods in which control of the command of the game is lost due to fatigue.
4) Accelerate the recovery process between the micro-pauses of the game.

Other criteria are added for classification of the tests, in the endurance assessment framework in the sport that can serve to comprehend their character.

Direct Tests

Taking Vargas (2000) into account, the direct tests are those that directly measure a specific physical capacity, that is, without the need for mathematical calculations in between. They allow for a more objective and reliable result than indirect tests. For example: measurement of the maximum direct VO_2 with a gas analyzer.

Indirect Tests

As stated by Vargas (2008), indirect tests are those that estimate a specific physical capacity through mathematical calculations, which, therefore, result in higher errors than direct tests. For example, the VO_2max estimated through the Multi-Stage Fitness Test (Leger, 1982). This test has an r=0.90 regarding the VO_2max directly measured through a gas analyzer (automatic) (Vargas, 2008).

Another classification, in the case of endurance tests applied to the sports environment, is the following:

Cyclic (or Linear) Tests

This type of test shows the motor skill of the run, maintaining a sequence of movements without changes with respect to their direction.

These tests can have a constant speed, in which the same speed will be maintained throughout the development of the test; or, incremental speed, in which the executed protocol will determine, through some type of signal (generally audible, through sounds or beeps), progressive increases in the movement speed in the area in which the test is carried out.

Acyclic (or Changes of Direction) Tests

This type of test evaluates the ability to accelerate, decelerate, change direction and re-accelerate, while generating changes of direction in the athlete´s movement.

In the same manner as in the cyclic tests, these can have a constant speed, in which the same speed will be maintained throughout the development of the test; or, incremental speed, in which the executed protocol will determine, through some type of signal (generally audible, through sounds or beeps), progressive increases in the speed of movement in the area in which the test is carried out. In general they are incremental type tests, such as the Multi-Stage Fitness Test, the *Yo-Yo endurance test* or the *30-15 IFT*, which will be described and analyzed hereafter.

Field Endurance Tests in the Context of Sports

General Endurance Test I

Cyclic, maximum and indirect tests

Cooper Test or the 12 Minute Test (Cooper, 1968)

Material: athletics track or a place that is accurately measured with no slopes or significant modifications. Stopwatch.

Protocol: this consists of a 12 minute continuous run, attempting to cover the most distance in that time. The individual does not stop, but can walk if they need to. The distance is recorded at the end of the time. It can be performed by men and woman over 13 years of age. This test allows several subjects to be simultaneously assessed, without the need for sophisticated means, with only a few monitoring personnel. The different studies regarding its efficiency grant it a validity that ranges between an r=0.24 and 0.94 (Cazorla, 1990) with respect to the VO_2 maximum.

Klissouras Test or the 1000 Meter (1093.6 yard) Test (Klissouras)

This test is preferably used to estimate the VO_2 max. in children whose chronological age is less than 13-14 years, which does not mean that it is not adapted for adults. We recommend the use of this average performance athletes´ test with the purpose of verifying the vVO_2max. or maximum aerobic speed (MAS).

ACSM Test on Treadmill

This test estimates the VO_2max, and is a maximum and direct test conducted on a treadmill. This can be applied both to athletes as well as recreational subjects in good health.

5-Minute Test (Berthoin, Fellmann, Bedu, Beaune, Dabonneville, Coudert, & Chamoux, 1997)

The general characteristics of this test are the following:

- Stable maximum continuous (cyclic) test.

- 5 minute trajectory attempting to achieve the most distance possible.
- Surface adaptation (footwear and terrain).

The test protocol is as follows:

- It begins with a 5/10 min. warm up to 70% HRmax, which enables the subject to begin the test at their maximum potential.
- A constant rhythm for 5 minutes is required to obtain the maximum performance.
- One cannot rest during the test.
- The shuttle technique was excluded due to introducing additional factors (muscular strength, change of direction technique, reactivity) that can modify the performance.

The main objective of the test is to estimate the maximum aerobic speed (MAS) or vVO_2max.

University of Montreal Track Test (UMTT) (Leger & Boucher, 1980)

The main objective of the test is to estimate the VO_2 max, and associated with this, estimate the maximum aerobic speed (MAS or vVO_2max.). This is a maximum continuous and incremental test, and it is intended for use with athletes.

Some considerations about the UMTT.

The University of Montreal Track Test (UMTT) is a reliable and valid test used to estimate the VO_2max. (Lancour, Padilla-Magunacelaya, Chatard, Arsac, & Barthelemy, 1991). The speed developed in the UMTT (vUMTT) accurately provides an estimation of the vVO_2max., as with measurements on a laboratory treadmill (Leger and Boucher, 1980).

The greatest accuracy level in determining the VO_2max can be aided by pre-recording the gradual incremental speed and eliminating the variation caused by self-stimulation. However, in spite of the high accuracy, it has also been reported that the vVO_2max. directly recorded in a laboratory is likely to be slightly lower (1.2%; 0.07 m/s) than the vUMTT (Billat & Koralsztein, 1996; Lancour, Padilla-Magunacelaya, Chatard, Arsac, & Barthelemy, 1991). It is possible that the test protocol can cause this discrepancy, as each stay during the UMTT lasts 2 minutes in comparison with the vVO_2max. protocol on a treadmill, in which the stages may last up to 4 minutes and include inclination (Eston & Reilly, 2009).

The UMTT protocol could also allow a slight increase in contribution of the anaerobic energy production system due to the test conclusion, and the MRS (maximum run speed) is calculated with the complete exhaustion of the athlete once they have finished (Leger & Boucher, 1980). This test has only been used previously in sports such as soccer, although this test could be more applicable for all endurance sports using a linear and continuous movement style (Clarke et. al., 2016).

MAS Eval Test (Cazorla and Léger, 1993)

The main test objective is to estimate the VO_2max, and associated with this, estimate the maximum aerobic speed (MAS or vVO_2max.). This is a maximum continuous and incremental test, and it is intended for use with athletes.

General Endurance Test II

Acyclic, maximum and indirect tests

The 20 meter (21.9 yards) shuttle test, commonly called 20-M Shuttle Run Test (20SRT) (Leger & Lambert, 1982), is a continuous test of incremental speed, with the shuttle modality designed to predict the VO_2 max. (Leger & Lambert, 1982). This test has been used in sports such as squash (St. Clair Gibson, Broomhead, Lambert, & Hawley, 1998) and soccer (Aziz, Yau & Chuan, 2005), and also with recreationally active subjects, children and adults (Leger et al., 1988; Ramsbottom, Brewer & Williams, 1988).

Objective: estimate/predict the VO_2 max.

The initial protocol used stays of 2 minutes (Leger & Lambert, 1982), and was later adapted to use stays of 1 minute due to the time necessary to record the vVO_2max. (Leger et al., 1988). This procedure was revalidated in successive investigations to predict VO_2max in children and adults (Leger & Lambert, 1982; Ramsbottom et al., 1988), continuously showing reliability through multiple executions (Aziz, Yau & Chuan, 2005).

Yo-Yo Endurance Test (Bangsbo, 1996; 1997)

Bangsbo (1996; 1997) developed a new version of the Multi-Stage Fitness test (Leger and Lambert, 1982; Leger et al., 1988). The execution is similar to its predecessor, as well as the conversion chart, and the end result is in meters or completed shuttle runs. The start speed is 8 km/h (5mph), and the increases are 0.5km/h (0.3 mph) for each minute.

Objective: estimate/predict the VO_2max.

This test, in particular, has two versions: one for beginners and another for advanced subjects. The first version (Level1) begins at 8 km/h (5 mph), while the second (Level2) begins at 11.5 km/h (7.1 mph). Passing from one version to the next requires that the level 1 evaluated subject reaches level 17 speed (minimum VO_2max level of 68 ml/kg/min).

Intermittent endurance assessment

Intermittent endurance and intermittent recovery *Yo-Yo tests* evaluate the capacity to quickly conduct work phases for a prolonged period of time, and to recover during a progressively increasing effort, respectively.

Yo-Yo Intermittent Endurance Test (YYIE) (Bangsbo, 1996; 1997)

Main objective: progressively introduce a subject's maximum response to intermittent exercise. Related to this objective is the assessment of the athlete's ability to endure an exertion of increasing intensity in an intermittent endurance exercise.

Yo-Yo Intermittent Recovery Test (YYIRT) (Bangsbo, 1996; 1997)

This test evaluates the individual ability to perform intense exercises (Bangsbo, 2008). This includes accelerations, decelerations and high intensity changes of direction (COD). It also has incomplete recoveries in high intensity exercise.

Main objective: progressively introduce a subject's maximum response to intermittent exercise with pauses. Related to this objective is the assessment of the athlete's ability to recover in high intensity intermittent endurance exercises with short intra-workout rests.

This test (both levels) focuses on the ability to recover from an intense intermittent exercise with high aerobic (level 1) and anaerobic (level 2) contribution.

The test results consider the steps/levels reached, the total number of round trips, the total number of runs and the final speed.

This test is particularly important for the evaluation of sports in which the alternation from phases of activity to high intensity (16 to 25 km/h [10 to 15.5 mph]) predominate, with average or low intensity phases (running, jogging, walking or static), such as soccer, basketball, volleyball, tennis, handball, rugby, etc. We must recognize, then, that a good ability for intra-workout recovery will surely be an aid to the subject's technical capability.

It is important to clarify that this YYIRT must not be used to estimate the VO_2max or the maximum aerobic speed (MAS) of the athletes. There is low accuracy in the estimation of the VO_2max. due to contribution of the anaerobic energy production systems, the development of the change of direction (COD) ability, as well as the capacity for intra-exertion recovery during said test (Bangsbo et al., 2008).

30-15 Intermittent Fitness Test (30-15 IFT) (Buchheit, 2008)

The main test objective is to provide a reference speed to program intermittent high intensity training sessions that include changes of direction (Buchheit, 2008) (Del Rosso, 2013a).

Some characteristics of this test are the following:

- Shuttle test.
- This includes accelerations, decelerations and changes of direction (COD).
- It alternates between 30 seconds of work and 15 seconds of rest.
- It has a significant metabolic component in accelerations.
- It expresses a significant neuromuscular (mechanical) component in decelerations and COD.

Important considerations of 30-15 IFT.

The final speed of 30-15 IFT (vIFT) is closely correlated to the VO_2max. (r=0.68), height counter-movement jump (CMJ) (r=0.65) and acceleration speed in 10 meters (10.9 yards) (r=0.63) (Buchheit, 2008).

Due to the ability to change direction over the shuttle speeds, a value of 0.7 seconds is subtracted from the run period of each change of direction (Buchheit, 2008). For example, a speed of 11.5 km/h (7.1 mph) with side movement could cover 96 meters (105 yards) in 30 seconds, although when 40 shuttle meters (43.7 yards) are used, requiring two changes of direction (2 x 0.7 seconds), the run distance is reduced to 91.6 meters (100.2 yards) (11.5 km/h (7.1 mph) in 28.6 seconds) (Buchheit, 2008).

This conversion helps the 30-15 IFT to provide valid and reliable measurements of performance in multi-directional accelerations (Buchheit, 2008). The provided vIFT differentiates players with different physiological profiles to achieve a similar level of cardio-respiratory demand during the training (Buchheit, 2008), developing a test very suitable for the individualization of the multi-directional supramaximal conditioning in intermittent sports like soccer, basketball and rugby (Buchheit, 2008).

Considerations on Maximal Field Tests (Cyclic and Acyclic) for Determining Training Speed

The prescription of generalized training, in which the training intensities of the athletes are all low or all high, could not cause adaptation or generate over-training (Kuipers et al., 1988). It has been reported that the use of training speed can be accurate and highly effective during the development of aerobic and anaerobic physical aptitude (Blondel, Berthoin, Billat, & Lensel, 2001; Buchheit, 2008). Although there is information regarding the implementation of the high variable training speed (Baquet, Berthoin, Gerbeaux, & Van Praagh 2001; Berthoin, Manteca, Gerbeaux, & Lensel-Corbeil, 1995; Buchheit, 2008; Buchheit & Laursen, 2013; Denadai, Ortiz, Greco, & de Mello, 2006; Dupont et al., 2010; Wong, Chaouachi, Chamari, Dellal, & Wisloff, 2010), there are very few investigations available that compare the range of tests capable of determining an appropriate speed.

The accurate evaluation of the individual aerobic and anaerobic function must be optimal during laboratory conditions (Clarke et. al., 2016). The procedures shall frequently produce a measurement that refers to a specific physiological state, for example, ventilation or lactate threshold speed, and speed at the maximum consumption of oxygen (VO_2max.) or vVO_2max. (Billat, 2001). The vVO_2max. was defined as the lowest running speed that provokes the maximum consumption of oxygen during a continuous exercise test (Billat & Koralsztein, 1996). Taking into account the result of the test such as a speed, instead of a physiological marker such as VO_2max., future training can include the individualized prescription and monitoring within the session. For example, a session prescribed at an intensity of 100% of the VO_2max. is not easily applicable due to the difficulties of measuring the desired work. However, a session prescribed at 100% of the vVO_2max. is easily applied due to the distance and application time. For example, a session with an intermittent method must be designed with a training intensity of 120% of vVO_2max. for 15 seconds of work and 15 seconds of passive recovery, this stimulus being repeated for 5 minutes and 2 series.

Although it is considered that the lactate threshold or the direct measurement of the VO_2max. could be beneficial, many athletes cannot have access to it due to the costs, difficulties or time required for each evaluation. However, simple procedure field tests are available for an indirect determination of physiological states, because from the range in physiological demands during field tests it is most appropriate to determine the speed produced as maximum running speed (MRS) before the vVO_2max (Clarke et. al., 2016). When comparing the tests and their MRS records, the protocol used determines the total physiological stress and, subsequently, the average physiological state. For example, intermittent tests are susceptible to having a higher anaerobic energy contribution and being adapted for the prescription of supramaximal training sessions (above the vVO_2max). In comparison, continuous versions could be dominant more by aerobic and adapted for the prescription of below maximum training (at the level of or below the VO_2max.) (Clarke et. al., 2016).

Conclusions

1) Determine the endurance that is going to be evaluated, if it is general or specific endurance and, within the specific endurance, if it is endurance for the technique, when making decisions or for the system of play.

2) If the objective is to make an assessment of the general physical aptitude of the athletes, it would be convenient to lean toward the Yo-Yo tests (YYIRT level 1 and YYIRT level 2).

3) If the objective is to estimate VO_2max., the Multi-Stage Fitness Test (20SRT) can be an option. If spacious facilities are not available (for example, basketball), other tests such as the UMTT can also be used.

4) If the objective is to determine the MAS, the UMTT, the 5 Minute Test or the MAS-EVAL test should preferably be used.

5) If the objective is to prescribe intermittent training, the 30-15 IFT would be the test of choice (Del Rosso, 2013b).

6) If the objective is to prescribe cyclic endurance training, with intermittent methods (between the Uan and the VO_2max.) it is convenient to determine the MAS using the UMTT, MAS-EVAL or 5 minute test.

7) If the objective is to prescribe acyclic endurance training, with intermittent methods (speed > VO_2max.), it would be convenient to determine the work speed using the 30-15 IFT.

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