Documento de lectura

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1. Testing for speed in football

Before we describe tests to investigate speed, we would like elaborate on “speed” with regard to a football context.

The term speed is used for multiple purposes in football. Generally, it is used for **sprint running speed** which describes how fast a player can run over a certain distance. However, it is also used to express something **quick, explosive and abrupt in action.** Following terms will show what kind of speed can be tested and trained:

Straight line speed

How fast can a player cover a defined distances? Sprints with an **average distance of 18-20 m** are executed in a professional football game (1) - *see references below*, with the sprint type activities account for 6-12% of the total distance covered (2, 3). Additionally, there are positional specific amount of sprints with wide midfielders and attackers performing the highest amount of sprints in total (4).

Speed as part of agility and/or change of direction

How fast can a player accelerate, decelerate, cut, turn, run backwards etc. Only a small amount of sprints in football are in a straight line and most of the action performed at the players' highest pace include **variations of sprinting**. There seems to be evidence that both agility and change of direction are different physical qualities compared to straight line speed (5).

Execution speed of a movement

…is important in any individual technique in football. It describes how fast a player can execute a technique.

Dribbling speed

Handling the ball is a very important component in football. Dribbling speed herein refers to the speed a player can dribble and handle the ball whilst **moving in any direction**.

Besides the reasons already mentioned why testing is needed, it was suggested that the players individual maximum sprint speed will affect his speed during a game (6). Meaning if your player is slow, he will be slow during game time/competition

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2. Testing agility/change of direction in football

Before we start to describe tests which investigate agility, we would like elaborate on both terms (agility vs. Change Of Direction (COD)) to get a clear understanding when we talk about one or the other.

Agility vs. Change of direction

From a sport science perspective there seems to be a debate about the definition of agility (1) *- see references below* and somehow for change of direction as well.

“Quickness” and “cutting” are words that were also be found in the literature (1) with regard to agility and change of direction. Therefore we feel we need to define the two terms first before we go into testing.

The difference between the two was seen that change of direction (pre-planned) was thought to be part of agility.

Agility itself on the other hand incorporates perceptual and decision-making processes and can be seen as a response to a stimulus and therefore as an open skill (and not pre-planned) (2).

Why is that important?

Depending on the goal, testing and training (for agility) needs to incorporate the two mentioned things (perception and decision-making), or not (for COD).

Agility

Sheppard and Young (1) further divided perceptual and decision-making factors:

As it can be observed ALL 4 points are very important in football.

1. **Visual scanning** - Non-scientific performance reviews from FIFA world cup showed that players consistently scan the ball, players and their environment ~ 2-3 times every second
2. **Knowledge of situatio**n - should increase with “experience” or training hours and therefore players can react accordingly
3. **Pattern recognition** - seems to be more important in 1 vs. 1 and might help in decision making with regard to a stimulus
4. **Anticipation** - especially important when judging ball trajectory, ball speed and also movement of players

Testing for agility

Testing for agility is (more) “complicated” (from a sport science perspective), as it require technical support (contact mat, lights, video support, timing gates) and strict guidelines. Therefore only a few TRUE agility tests exist. Furthermore there is no agility tests specifically designed for football.

However, we have searched the literature to present agility tests (and their possible application in football).

Generally, all tests assess the players’ ability to react correctly and as fast as possible to a stimulus (3).

Stimuli were given by:

a) **A coach** (4-6)
b) **Flashing lights** (7)
c) **Video** (8, 9)

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3. Testing Change of direction in football

As usual we start with elaborating on terminology in order to get a clear understanding.

Agility vs. Change of direction

From a sport science perspective there seems to be a debate about the definition of agility (15) - *see references below* and somehow for change of direction (COD) as well. “Quickness” and “cutting” are words that were also be found in the literature (1) with regard to agility and change of direction. Therefore we feel we need to define the two terms first before we go into testing.

The difference between the two was seen that change of direction (pre-planned and therefore a close-skill) was thought to be part of agility. Agility itself on the other hand incorporates perceptual and decision-making processes and can be seen as a response to a stimulus and therefore as an open skill (and not pre-planned) (4).

Why is that important?

Depending on the goal, testing and training (for agility) needs to incorporate the two mentioned things (perception and decision-making), or not (for COD).

Change of direction:

Brughelli et al. (4) elaborated on the qualities of change of direction. The factors were:

1. **Technique**
2. **Straight sprinting speed**
3. **Leg muscle qualities** (reactive strength, concentric strength and power, left-right muscle imbalances)
4. **Anthropometry** – only small body of research investigated the connection between anthropometry and COD, however it seems logical that players with higher lean leg muscle mass are more likely to be faster than players with higher amount of fat (10)

As it can be observed at least the first three components are very important and trainable and therefore important to test.

1. **Technique** - we feel that technique (foot planting during cutting, low center of gravity etc.) is important, however the testing is rather complicated, most of the time based on qualitative methods and therefore somewhat hard to accomplish.
2. **Straight line sprinting speed** - sprinting is always needed in football. Although it was mentioned that COD and straight line speed seemed to be distinct qualities (5, 18), we feel that straight sprinting speed will affect COD performance.
3. **Leg muscle qualities** - might built the foundation of COD performance (and also injury prevention) (2, 3, 14). It would be expected that a player with good concentric strength and power can apply more force to the ground with each leg, accelerate faster and as a result is quicker.
4. **Anthropometry** - should be tested anyway with regard to weight and body fat. It seems logical that with high percentage of lean leg muscle, COD should be better compared to lower percentage of lean leg muscle. However, there is no great deal of literature with regard to anthropometry and its effect on COD

Testing for change of direction

First we want to describe “common tests” and discuss their suitability for football.
Due to the amount and diversity of different COD tests, we pre-grouped them into

A) forward and cutting COD test
B) multi-movement/directional tests

A) Forward and cutting COD tests

- **Illinois agility test** (6)
- **505** (7)
- **Balsom agility test** (1)
- **Three corner run** (12)
- **Four line sprint** (12, 17)
- **T-test** (9)
- **Zig-Zag tests** (10, 11)
- **4 x 5 meter test** (16)
- **Sprints with 90° test** (16)
- **Sprint 9-3-6-3-9 meter with 180° turns or with backwards sprinting** (16)

The tests outlined are similar (more or less) evaluating acceleration, deceleration and cutting ability. Differences between those tests are angle of cutting and distances to accelerate/decelerate.

However, the zig-zag tests also showed reliability when using/dribbling a football (meaning assessing dribbling agility). Therefore, those tests can/should be preferred. Additionally, comparisons with and without dribbling a ball are possible as well.

B) Multi-movement/directional tests

- **Box Drill Fitness Test**
- **A new change of direction test for team sports** (13)

The two multipurpose tests included different movements (like shuffle sideways, running backwards) besides acceleration and deceleration and therefore seemed to be more soccer specific. Especially the “New COD test for team sport” proposed by Rumpf et al. (13) seemed to incorporate many football specific movements.

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4.Testing aerobic endurance in football

Before we start to describe tests that assess aerobic endurance, we would like elaborate on the term with regard to a football context.

Performance in football dependents heavily on the aerobic endurance (or aerobic system) of players (1) *- see references below*. Individuals operate on average at about **70% of their maximum oxygen uptake**, at about **80-90% of maximum heart rate** (2), with **blood lactate of 2-10 mmol/l** (3, 4) while they cover approximately 8-12 km distance during a professional football match (5, 6). Women reveal similar values; however youth players reported lower values, which increased with increasing age.

The importance of the aerobic system was also seen in differences in competitive team ranking, team level and distance covered during a match (7-9).

Generally, aerobic endurance can be tested in a laboratory and/or field-setting.

1) Laboratory measurements
Usually aerobic endurance will be measured **on a treadmill** (and not necessarily on a bike ergometer, as its football and it involves running and not cycling).

Measurements will include spirometry (and therefore measurements involving ventilatory/pulmonary system) and/or lactate in connection with heart rate, distance and running speed on the treadmill.

There are several testing protocols and variables that are assessed in a laboratory settings, however we don’t want to go into detail too much as we believe that most of the coaches/teams will not have access to an exercise physiolgy labs (and probably and exercise physiologist). Additionally, using a laboratory system is time consuming (as you can only test one player at a time), expensive and not the best practical solution (10).

However laboratory measurements might give the **most accurate information** (and can be seen as gold standard) about a player's aerobic endurance.

2) Field measurements

Field measurements can be continuous or intermittent in nature (11). Football specific tests are more or less continuous but interchange in activity so it seems to depend on definition what they are in nature.

- **Continuous tests**

1. Cooper test (12)
2. Multistage 20-m shuttle run test/Beep test (13, 14)
3. Universite de Montreal track test (15)

- **Intermittent tests**

1. Loughborough Test (16)
2. Yo-Yo tests (17-20)
3. 30-15 Intermittent fitness test (21)
4. 45-15 test (23)

- **Football specific endurance tests**

1. Bangsbo-test (11)
2. The Hoff-test - a soccer specific dribbling test (22)

As football is more intermittent in nature, we suggest the equivalent tests. However, continuous tests will also provide information about the player's aerobic endurance due to the fact, that continuous tests were correlated with intermittent test (11, 22).

The field tests can also be used to predict VO2max (13) (the maximal oxygen consumption) and therefore might substitute laboratory measurements (which are considered the gold standard, due to the actual measurement of variables).

However, due to their practicability (and possible limitation in time, money, and manpower anyway), field test might be the **preferred choice in testing aerobic endurance.**

Depending on purpose of tests and further usage of data (such as training prescription) tests can/should be appropriately.

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5.Testing anaerobic endurance in football

Before we start to describe testing that assess anaerobic endurance, we would like elaborate on the term with regard to a football context.

We described that performance in football heavily dependents on the aerobic endurance (or aerobic system). However, in order to be able to perform short burst of high intensity running and or sprinting the anaerobic system is needed heavily as well. Therefore, ALL system work at the same time (9, 13) *- see references below*.

Physiology of the anaerobic system

Energy in the anaerobic system is produced through ATP (adenosine triphosphate) without oxygen. This occurs in the cellular plasma in the muscle.
There are two possible ways to receive ATP in this context:

A) Utilization of ATP and creatin phosphate (or phosphorcreatine = PCr) without accumulation of lactate (=anaerobic-alactacid)

B) Incomplete usage of glycogen and accumulation of lactate (=anaerobic-lactacid)

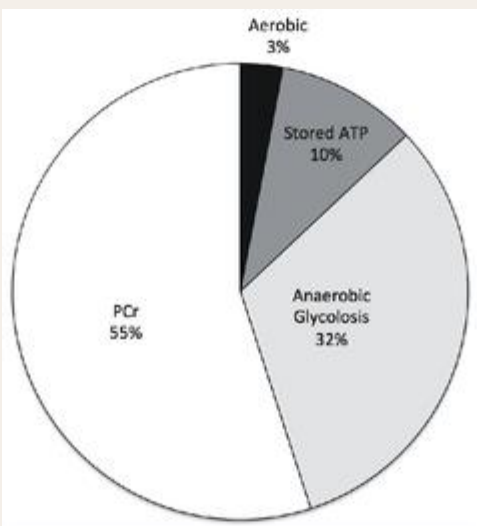

Figure 1. Energy delivery in accordance to (11)

As we said earlier ALL systems (aerobic +) anaerobic-(a)lactacid work at the same time. For example, the energy delivery for 30-second maximal efforts was seen to derive from aerobic processes (38%), anaerobic glycolosis (45%) and alactic anaerobic processes (17%) (13). Furthermore, the relative contribution of the anaerobic glycolosis and alactic anaerobic processes was determined as 44% and 50% respectively for maximal efforts with a duration of under 10 seconds (3), see Figure 1 (12). However the intensity (primarily) decides about the energy pathways and not the duration of activity (9).

That means that duration and intensity are inverted with each other - The longer the duration the lower the intensity and the other way around.

In order to understand the anaerobic system (endurance) in football we need to further describe the two anaerobic pathways.

A) Anaerobic-alactacid

The stores of ATP and PCr in the muscles are very small and the source of energy therefore is only available for 6-10 (max of 15) seconds - This energy pathway is used for sprints and short duration of high(-est) intensity and was seen to depend on fitness level of the player/sprinter (5). Due to the limited substrate availability, the system is supposed to be reloaded (at least incompletely) very quickly, within probably 10 seconds (12) (and we also speculate that the fitness level will also determine the quickness of PCr recovery (2)).

B) Anaerobic lactacid (or anaerobic glycolysis)

The primary energy source in the anaerobic glycolysis derives from glycogen stored in the muscle. Again, due to its availability, the duration to utilize this pathway is limited to 15-45 (maybe 60) seconds. Lactate is the result of the incomplete breakdown of glycogen and can reach values of up to 103.6 mmol/kg dm after repeated sprinting (2).

In this context we want to explain that lactate is NOT a limiting factor of performance (nor is it responsible for the “burning” sensation in the muscles), it is a sign of acidosis in the muscle.

Furthermore, lactate is a different form of energy and it can be used to restore energy systems. However, due to the presence of hydrogen ions in the muscle, lactate will accumulate as well and therefore be seen as a marker in which the muscle shows a shift in energy delivery (from anaerobic to aerobic system) (1). When maximal accumulation of lactate is exceeded, the lactate will diffuse into the blood circulation (and that is why it is possible to measure it by pricking earlobes).

When the intensity (and/or the activity) stops, the liver (and possibly some “non-working” muscles) can restore energy from lactate to pyruvate into glucose which can be again stored and used in the (“working-“)muscle as glycogen. This procedure is called gluconeogenesis. Furthermore, it is also thought that the initial fast phase of PCr resynthesis is dependent on oxygen availability (4, 12).

Anaerobic endurance in football

As it seems evident from the paragraphs that the anaerobic endurance is important in intense sequences during football (7).

In order to test for anaerobic endurance the intensity needs to be high(est) (14), rest period limited and as a result.

In conclusion, anaerobic endurance in football is tested (most of the times) in a repeated sprint set-up (6, 10, 11, 14).

Repeated sprint tests also provide data which enables to calculate a fatigue index (14). The fatigue index basically shows the coach how long the player can maintain their highest (sprint) performance (therefore resist fatigue) and as a consequence show the ability to perform during intense sequences during the match.

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6.Testing strength and power in football

Strength and power needs to be assessed due to their importance with regard to speed (5, 6, 30, 40, 43, 45), change of direction (3), jumping (6, 34, 40, 45) kicking (6, 11, 13, 23, 30-32, 34, 41, 45, 48) and injury prevention (2, 8, 10, 12, 14, 20, 28, 29, 36, 37, 47). Differences in these components were also seen in level of play (7, 15, 16, 19) or age (21), with regard to positional specific characteristics (44) of players as well as their overall player development (6, 15, 22, 24, 26, 27, 45) *- see references below*.

As it seems evident **strength** and **power** plays a **crucial role in football**, however, there seems to be many questions with regard to strength and power testing in football - *what* to test and *how* to test, the debate about strength and power testing with regard to football specific strength and power testing and finally the targeted areas for testing in football specific strength/power training.

What to test?

Generally, testing the major muscle groups of the legs seemed to be appropriate. The major muscle groups can be divided into leg extensors and leg flexors.

Additionally, we believe it is appropriate to test the core and shoulder stability/performance.

Furthermore, it is also important what specific component of strength (i.e. maximum, reactive, and/or rate of force development (17, 18)) and power should be tested. However, we want to (indirect) elaborate on this in the next section (how to test).

How to test?

Generally, strength and power is tested by lifting a certain amount of weight for a certain amount of times. Usually the procedures involve the 1-repetition maximum (1RM) test. However, if equipment is available, a more scientific and in depth analysis can be performed. In this case (and most of the times) an isokinetic dynamometer (41) will be used.

We believe that most environments will not have that relatively expensive type of equipment, and/or not the manpower and more importantly the time, therefore we would like to elaborate on strength and power testing using free weights or machines.

Strength and power vs. football specific strength and power

First of all we would like to give some thoughts about the mentioned “issue” about strength and power tests vs. football specific strength and power tests. In order to do so, we would like to consider the speed of execution (during a football movement).

Usually any movement in football is quite fast compared to the speed in strength and power testing (and training).

The scientific name for that phenomena is called “force-velocity relationship” and basically saying that the faster a movement, the less force and power produced due to the less cross bridges in the muscle, as it is more likely to activate (more) fast twitch fibers. Therefore, does a normal 1RM-strength and power test replicate the football specific strength and power?

With those information in mind the question arise how to test for football specific strength and power. Well, kinematic analysis of kicking (42) revealed how to test (scientifically) for a particular movement, and therefore video and or accelerometers might present a possibility to test for football specific strength and power.

However, having said that and with the limitation in mind it seems that this setup is really impractical and we have not heard/read of any reliable test. As a result, testing for a classical 1-repetition maximum (1RM) in relation to body mass (44) seems to be a reliable way to test football players.

Strength and power assessments in football

Leg strength/power should be measured as presented in the literature with a (half) back squat (1, 25, 34, 39, 40, 46), leg extension (34), isometric (30) leg press (6, 34), leg curl (25, 34), step up (25) for lower body and bench press (6, 38, 46) for upper body in a practical set-up.

Strength and power assessments utilizing a isokinetic dynamometer (41) (- just in case you have access to one, the time and knowledge to use it) should incorporate (35):

- dominant and non-dominant limb (4, 22, 33) - to detect possible asymmetries for injury prevention
- quadriceps to hamstring concentric (8, 11, 12, 14-18, 20, 21, 24-28, 31, 33, 37, 39-41, 47-49, 51, 52, 54, 57-63, 65, 70) and eccentric (12, 14, 16, 17, 20, 21, 24, 26-28, 31, 33, 39, 52, 57, 61, 62, 65, 70) ratio - to detect possible signs for muscles weaknesses or re-injuries
- abductor to adductor (9)

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7.Testing football skills

Skill seems to be a very broad term that describes the application of cognitive, perceptual or motor skill (or everything at the same time) (3) *- see references below*.

Those three components are more or less evident throughout football performance and therefore skills were described as **“***open***”** or **“***closed***”** skills (7).

Both type of skills seemed to be present in football, however while closed skill (such as a free kick) are evident in football, it seems that the execution of skills in a dynamic context are more important and therefore mainly open skills are performed in football (7).

“Skill can be seen as selecting and performing a learned technique as determined by the demands of the situation” (1) and therefore involves decision making and/or (a possible) fatigue state of the player.

With those information in mind, it seems plausible why testing for football skills and the application of those results seems to be highly debatable (as the “true” skill depends on cognitive, perceptual and/or motor skills and fatigue).

However, as there has been multiple publications regarding testing football skills we want to elaborate on why, what and when should be tested?

Why testing for skills in football?

Testing for skills in football can have following purposes:

- Talent identification/discrimination
- Measuring pre- and post-intervention
- Measuring individual strength and weaknesses

What skills should be tested in football?

As mentioned already, cognitive, perceptual and/or motor skills are important in football and several tests are present to test for one, two or all of the three (1).

Typical motor tests, included heading (11), juggling (5, 11, 15), wall-volley (9, 10, 15), dribbling (6, 8, 10, 14), shooting (2, 10, 11), passing (2, 4, 11, 12), or multi faceted tests (13, 16) which combined multiple tests.

Interestingly, cognition was also tested whilst performing a football specific task (dribbling a ball) in female youth football players (15).

When should coaches test for skills?

As mentioned earlier, testing for skills might be an important aspect in talent identification therefore appropriate between the ages 9-14 (or whenever coaches feel the importance of talent identification).

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