# The role and development of sprinting speed in soccer

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This is the author's version of an article published in the journal:

*International Journal of Sports Physiology and Performance,* 2014, 9, 432-441

http://dx.doi.org/10.1123/IJSPP.2013-0121

# The role and development of sprinting speed in soccer

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## Abstract

The overall objective of this review was to investigate the role and development of sprinting speed in soccer. Time motion analyses show that short sprints occur frequently during soccer games. Straight sprinting is the most frequent action prior to goals, both for the scoring and assisting player. Straight line sprinting velocity (both acceleration and maximal sprinting speed), certain agility skills and repeated sprint ability are shown to distinguish groups from different performance levels. Professional players have become faster over time, indicating that sprinting skills are becoming more and more important in modern soccer. In research literature, the majority of soccer related training interventions have provided positive effects on sprinting capabilities, leading to the assumption that all kinds of training can be performed with success. However, most successful intervention studies are time consuming and challenging to incorporate into the overall soccer training program. Even though the principle of specificity is clearly present, several questions remain regarding the optimal training methods within the larger context of the team sport setting. Considering time-efficiency effects, soccer players may benefit more by performing sprint training regimes similar to the progression model used in strength training and by world leading athletics practitioners, compared to the majority of guidelines that traditionally have been presented in research literature.

## Introduction

Performance in soccer depends upon a variety of individual skills and the interaction among different players within the team. Technical and tactical skills are considered to be predominant factors, but physical capabilities must also be well developed in order to become a successful player. During the last decade, the focus in soccer-related research literature has shifted from aerobic to anaerobic demands. Recent studies suggest that elite or professional players have become faster over time, while aerobic capacity has plateaued or decreased slightly.[1-3] While the physiology of soccer has been well explored, several aspects regarding the role and development of sprinting speed remain unclear. The aim of this review is three fold: 1) to synthesize the research that has been undertaken so far regarding the role and development of sprinting speed in professional soccer, 2) identify methodological limitations and concerns associated with these investigations, and 3) outline specific training recommendations. Hopefully, this review can contribute to improve best practice regarding sprint conditioning of soccer players.

## Literature search

The databases of PubMed and SPORTDiscus were used to search for literature. For scientific studies, only peer-reviewed articles written in English were included. The search was conducted in two levels; type of sport and type of athlete. Regarding the first level, the terms "soccer" and "football" were used. In order to narrow the search, studies including the terms "American football", "Australian football", "Australian Rules football", "Gaelic football", "rugby" and "futsal" were excluded. Secondly, to ensure that the involved players were of a certain playing standard, the search was restricted to > 16 yr athletes categorized as "elite", "professional", "high level", "top class", "first division", "upper division", "top level", "high class", "high standard" or "national team". Only the studies who investigated the role or development of sprinting skills in soccer were included. In addition, the reference lists and citations (Google Scholar) of the identified studies were explored in order to detect further relevant papers. To ensure updated sprinting demands, test results reported before the year 2000 were excluded. In order to restrict the total number of references, only the most recent studies were referred when multiple investigations reported identical findings.

## Sprinting demands during match play

A large number of soccer players from the best European soccer leagues have been analyzed according to motion during match play. Data are commonly generated by either semiautomatic video analysis systems or global positioning systems (GPS). The analyses show that both male and female outfield soccer players cover 9-12 km during a match.[4-9] Of this, 8-12 % is high intensity running or sprinting.[4,6,8,9] Wide midfielders and external defenders perform more high intensity running and sprinting compared to the other playing positions.[5,6] Reported peak sprint velocity values among soccer players are 31-32 $km \cdot h^{-1}$.[6,7] Number of sprints in the range 17-81 per game for each player has been reported,[4,5,9] Mean sprint duration is between 2 and 4 s, and the vast majority of sprint displacements are shorter than 20m.[4,8,9] The varying estimates of sprints reported is likely due to varying intensity classifications, as different running velocities (18-30 $km \cdot h^{-1}$) have been used to distinguish sprint from high speed running. It is important to note that running speed in the range 20-22 $km \cdot h^{-1}$ is equivalent to the mean velocity in male elite long distance running, and mediocre sprinters run faster than 35 $km \cdot h^{-1}$. Therefore, definitions based upon absolute velocity are methodologically problematic in terms of validity and reliability, in addition to limiting comparisons across studies. Furthermore, absolute speed values exclude short accelerations from analysis. Players perform 8 times as many accelerations as reported sprints per match, and the vast majority of these accelerations do not cross the high-intensity running threshold.[10] Thus, high intensity running and sprinting undertaken may be underestimated.[10,11] Measuring methods that capture accelerations would markedly strengthen game analyses.

To date, no full game analyses have quantified the movement patterns of intense actions across playing level or positions in terms of sharp turns, rotations, change of direction, etc. with and without the ball. However, Faude et al. have used visual inspection to analyze videos of 360 goals in the first German national league.[12] They reported that the scoring player performed straight sprints prior to 45 % of all analyzed goals, mostly without an opponent and without the ball. Frequencies for jumps and change-in-direction sprints were 16 and 6 %, respectively. Straight sprinting was also the most frequent action for the assisting player, mostly conducted with the ball.

## Sprinting characteristics of soccer players

### Straight line sprinting skills

In research literature, straight line sprinting is commonly categorized as acceleration, maximal running velocity and deceleration. Since game analyses have shown that more than 90 % of all sprints in matches are shorter than 20 m, acceleration capabilities are obviously important for soccer players in this context.[9] However, the importance of peak velocity increases when sprints are initiated from a jogging or non-stationary condition. Practically all soccer related studies have used testing distances in the range 5-40 m. Since sprint performance differences that separate the excellent from the average are relatively small on an absolute scale, and the effects of training interventions are even smaller, valid and reliable timing and test procedures are critical. Haugen et al. demonstrated that the starting method and timing system used can combine to generate differences in “sprint time” up to 0.7 s.[13] Thus, the method of sprint timing used can result in greater differences in sprint time than several years of a conditioning training program. Time differences can be explained by inclusion or exclusion of reaction time, center of gravity placement at time triggering and horizontal center of gravity velocity at time triggering.[13] Furthermore, footwear, running surface, wind speed and altitude can generate further time differences over short sprints.[14-16] A review of published studies monitoring speed performance reveals considerable variation and/or insufficient information regarding timing methods, hardware manufacturers, testing procedures and method of reporting (i.e. best sprint vs. mean sprint time of several trials). It is therefore important to describe the methodological sprint test approach as detailed as possible.

Several studies have concluded that mean sprinting velocity (both acceleration and maximum sprint capacity) distinguishes soccer players from different standards of play.[1,17-19] Sprint time comparisons across studies based on available correction factors for time initiating/starting procedures,[13] wind,[16] footwear and running surface,[14] indicate that professional players from the best European soccer leagues sprint slightly faster than professional soccer players from lower ranked soccer nations.[1,19,20] We calculate that the fastest soccer players are ~ 0.6 s slower than the world`s fastest sprinters over 40 m.[1,21] However, individual test results from recent studies have shown that the very fastest male soccer players may achieve 40-m sprint times on par with 60-m sprint finalists from national athletics championships.[1,13,14]

In practical terms, individual differences in sprinting skills are even more critical than mean differences among groups of players. Database material from the Norwegian Olympic Training Center, including 40-m sprint tests of 628 male and 165 female elite players between 1995 and 2010,[1,18] shows that the 75$^{th}$ -25$^{th}$ percentile difference is 0.13 and 0.16 s over 20 m sprint for male and female players, respectively (Table 1). Based on average velocity over the distance, the fastest quartile is at least 1 m ahead of the slowest quartile over 20 m. Similarly, the 90$^{th}$ -10$^{th}$ percentile difference over 20 m sprint is equivalent to more than 2 m. Furthermore, the 10 % fastest players run 1 m further than the 10 % slowest players for each second during peak sprinting. According to Hopkins et al., the smallest worthwhile performance enhancement/change in team sport is 0.2 of the between-subject standard deviation.[22] Based on the present database material, this corresponds to ~0.02 s over 20-m sprint, which is quite similar to typical variation associated with sprint testing (CV 1-1.5 %).[13,14] In practical settings, a 30-50 cm difference (~0.04-0.06 s over 20m) is probably enough in order to be decisive in one-on-one duels by having body/shoulder in front of the opposing player. Thus, the ability to either create such gaps as an attacker or close those gaps as a defender can be fundamental to success in elite level soccer. The chance of dribbling an opponent out of position, or successfully defending an attack, increases with greater acceleration and sprinting ability.

**** Table 1 about here ****

While sprint velocity for males peaks in the age range 20-28 yr, with small but significant decreases in velocity thereafter, female soccer players struggle to improve their sprinting skills after their teens.[1,18,23] Increased non-lean body mass might contribute to the failure of continued training to result in improved sprint velocity and power performance among female players.

The majority of sprint test results shows that forwards are faster than defenders, midfielders and goalkeepers, respectively.[1,18,24-26] Similar relationships are observed among youths, suggesting selection processes in early junior talent development as a possible explanation for the rank of speed pattern among playing positions.[27] However, sprinting ability can also be seen in relationship to the physical demands of the different positions on the field. Forwards and defenders are perhaps the fastest players because they are involved in most sprint duels during match play.[5,6] Players in different positions should therefore prioritize different physical conditioning regimes in order to solve positional dependent tasks during play.

## Agility

During the last decade, several authors have emphasized the importance of agility skills in soccer. Agility was originally defined by Clarke as "speed in changing body positions or in changing direction".[28] More recently, Sheppard & Young defined agility as "a rapid whole-body movement with change of velocity or direction in response to a stimulus," based on the conception that agility has relationships with both physical and cognitive components.[29] The vast majority of agility tests in soccer are designed to evaluate the physical qualities of the players, without cognitive (i.e. choice reaction) challenges. Zig zag runs, 90-180° turns, shuttle runs, sideways, and backwards running with maximal intensity are commonly used drills.

Agility patterns may vary as a function of playing role, and Sporis et al. suggested different tests for different positions.[30] Published agility tests do not reflect the nature of deceleration and turning performed during elite soccer matches. In fact, the vast majority of turning movements are initiated from a stationary or jogging condition, while change-in-direction within sprinting movements rarely occur.[31]

Marcovic reported a poor relationship between strength and power qualities and agility performance.[32] Little & Williams and Vescovi et al. concluded that straight sprint, agility and vertical jump capabilities are *independent* locomotor skills.[33,34] This is demonstrated on the YouTube video of Christiano Ronaldo racing against the Spanish 100 m champion, Angel David Rodriguez (http://www.youtube.com/watch?v=hZqEj-Qyg6U). Ronaldo lost by 0.3 s over 25 m straight sprint, but won by 0.5 s when running in a zig zag course over the same distance.

Several studies have reported that professionals or elite players have better agility skills compared to players of lower standard.[19,35-37] However, Rösch et al. found no differences across a broad range of playing standard.[38] The literature is equivocal regarding agility performance across playing positions.[24,26,30] Interestingly, midfielders perform relatively better in agility tests compared to linear sprint tests. The literature also suggests that when change-of-direction is preceded by braking from a nearly full sprint, the agility difference across position categories shrinks. In classical mechanics, the kinetic energy of a non-rotating object of mass $m$ travelling at a speed $v$ is $\frac{1}{2} mv^2$. Thus, faster players with more body mass must counteract a larger kinetic energy during sharp turns while sprinting. Since midfielders in general have lower body mass and lower peak sprinting speed,[1,25] it is reasonable to expect smaller performance differences in certain agility tests compared to linear sprint tests.

Timing of ground reaction forces, body configuration and center of gravity placement are crucial biomechanical elements when changing direction while sprinting. By lowering the center of gravity while changing direction, the involved lower extremity muscles can work under more optimal conditions. By leaning the upper body towards the intended direction during turns, combined with foot placement in the opposite intended running direction away from the vertical center of gravity-line during ground contact, more kinetic energy can be counteracted. Correct technique during change-in-direction movements is also important from an injury prevention perspective.

## Repeated sprint ability

Repeated sprint ability (RSA) is the ability to perform repeated sprints with brief recovery intervals.[39] In recent years, this topic has received increasing attention as a central factor in most field-based team sports. Numerous field tests have been developed to evaluate RSA. Sprint distances of 15-40 m x 3-15 repetitions have been used in elite or professional soccer, and the vast majority of tests have included 15-30 s recovery periods between sprints (Table 2). Several tests have combined agility and repeated sprints.[49-53]

**** Table 2 about here ****

Primarily two measures have been used in order to evaluate RSA: total time and/or deterioration in performance. Total time or mean sprint time have been used as performance indices, and results from RSA tests have been shown to differentiate professionals from amateur players.[7,43,49,51] Deterioration in performance, calculated as sprint decrement, has generally been used to quantify the ability to resist fatigue during such exercise.[58] Fatigue resistance depends upon a wide range of physiological factors, mostly related to aerobic metabolism, and athletes with a higher $VO_{2\,max}$ have smaller performance decrements during repeated sprint exercise.[42] This is most likely explained by the linear relationship between PCr resynthesis and mitochondrial capacity within muscle.[59] A full review of the physiological mechanisms related to RSA is beyond the scope of this review, but this topic is well described elsewhere.[60]

The outcome and usefulness of the repeated sprint tests has been questioned over the years. Insufficient timing information and variations in testing protocols complicate comparisons across studies. Based on the short recovery periods between each sprint, most RSA test protocols simulate the most intensive game periods, leading to a possible overrating of the aerobic demands. Pyne et al. reported that total time in a RSA test was highly correlated with single sprint performance and concluded that RSA was more related to short sprint than endurance capacity.[61] In order to detect the "sprint endurance" component, repeated sprint test protocols with higher total volume is perhaps required. According to Balsom et al., it is more difficult to detect detrimental effects with shorts sprints (15 m) compared to slightly longer sprints (30-40 m).[62] Medical data derived from American football indicate that extensive sprint testing/training without prior gradual progression increases the risk of hamstring injuries.[63] This is perhaps why most repeated sprint test protocols are designed with a relatively small total volume of sprinting.

# Training to improve sprint performance

## Soccer related intervention studies

In research literature, the majority of interventions involving soccer players have provided positive effects, leading to the assumption that all kinds of training can be performed with success. A plausible explanation is that the majority of studies have been performed on young players (16-18 yr). Less experience with physical conditioning provides more potential for stimulating positive effects. A well-trained professional soccer player can be considered untrained in terms of sprint training. When evaluating research literature, it is important to keep in mind that successful interventions vary in terms of training time investment, and time consuming interventions will probably be rejected by team coaches. A great deal of knowledge can be gathered from non-successful conditioning programs as well, which so far are underrepresented in research journals. With these considerations in mind, we have tried to identify criterions for success in order to improve soccer related sprinting skills. Future research regarding dosing strategies should be designed to validate these recommendations.

## Principles of sprint training in soccer

*Specificity:* A review of published sprint intervention studies on soccer players confirms the principle of specificity. Short sprint training (sprinting distance $\leq$ 30 m) improves short sprint ability,[64] while longer sprints (~ 40 m) improves maximal sprint velocity.[55] Prolonged sprints ($\geq$30 s) have limited effects on acceleration or peak velocity.[65] Linear sprint training does not improve performance in sprints with changes of direction.[56,66] Agility training improves the specific agility task performed during practice.[56] Repeated sprinting improves RSA.[50,55,67] The superiority of resisted or assisted sprint training compared to normal sprinting has so far not been clearly established.[64,68]

Several "less specific" training forms have also been explored in order to improve sprinting skills of soccer players. Contrast training (combination of strength, power and sport specific drills) has provided positive effects on soccer-specific sprint performance,[69,70] but twice weekly training sessions do not seem to be more beneficial than one weekly session.[71] Plyometric training interventions have so far provided limited effects on soccer players` sprint performance.[72-74] Furthermore, strength training with heavy weights does not consistently improve sprinting capabilities.[75-77] Sedano et al. stated that improved explosive strength can be transferred to acceleration capacity, but a certain time is required for the players in order to transfer these improvements.[73] Kristensen et al. recommend normal sprinting over other training forms in order to obtain short distance sprinting improvement in a short period of time.[78]

Several authors have reported that a combination of high-intensive interval training and heavy strength training have enhanced sprinting performance in soccer players.[54,79,80] These interventions are extensive and time consuming, as they include at least 4 weekly training sessions. Some authors recommend high-intensive aerobic interval training (80-90 % of $VO_{2\ max}$) in addition to repeated sprint in order improve RSA.[20,60,81] However, Ferrari Bravo et al. demonstrated that repeated sprint training was superior to high-intensity aerobic interval training in terms of aerobic and soccer specific training adaptations.[50] Tønnessen et al. showed that elite soccer players were able to complete repeated sprints with intensity closer to maximum capacity after repeated sprint training once a week, without additional high-intensive intervals.[55] Even though the principle of specificity is clearly present, sprinting skills in soccer may be improved in several ways.

*Individualization*: Unfortunately, most interventions in sport science are limited to answering typical one-dimensional questions, more specifically whether certain types of training are more effective than others. In practice, however, coaches are concerned with three dimensions; 1) what kind of training should be performed, 2) by which individuals, 3) at what time point in the season. Similar to medical consultations, a broad range of performance factors should be tested and evaluated before necessary treatment is prescribed. Capacity profiles are essential in order to diagnose each individual and develop training interventions that target the major limiting factors. We were somewhat surprised by the relatively small differences in physical skills across playing positions in Norwegian professional soccer, as goalkeepers and midfielders showed practically identical values for vertical jump performance (~ 2 cm difference) and $VO_{2\ max}$ (only ~ 5 ml difference).[1,2] Logistically, individualized training of physical capacity is demanding to organize in a team sport setting. This is probably a greater problem in high-level female and youth soccer, where team staff is smaller compared to male professional teams. In such cases, most soccer coaches perform similar training for all outfield players within the team, despite large individual differences in capacity profiles. However, it is unlikely that similar training doses lead to similar responses for players belonging to opposing extremes. Surprisingly, there has been little research about how individual capacity profiles can be developed in team sports. The data presented in table 1 can form a basis for capacity profiles for linear sprinting skills, but similar profiles should also be developed for agility, RSA and other soccer related capabilities.

*Familiarization, progression and periodization*: Sprinting is the most frequent mechanism associated with hamstring injuries, and age/previous injuries are the most important risk factors.[82] About 17 % of all injuries in soccer are hamstring injuries, and more than 15 % of all hamstring injuries are reported as re-injuries.[82] Players that have not been fully rehabilitated following sprint-related injury, or who have had such injuries during the previous weeks, should be particularly cautious. Many hamstring injuries occur during the short pre-season period because of the relative deconditioning that occurs in the off-season.[63] Thus, during the initial weeks of a sprint training program there should be a gradual familiarization, both in terms of intensity and the number of sprint repetitions. Somewhat surprisingly, we have not identified progression or periodization models regarding sprint training in the research literature. In contrast, a classic linear model of periodization is well established in strength training research. This is characterized by high initial training volume and low intensity. During the training cycle, volume gradually decreases and intensity increases.[83,84] This periodization model is similar to the sprint training philosophy developed by athletic sprint pioneer coach Carlo Vittori in the mid-1970s.[85] Pre season conditioning for his athletes was initiated with short sprints at low intensity. As training progressed, the intensity and/or total volume gradually increased in order to improve alactic capacity. To the author`s knowledge, Vittori first published the repeated sprint training-method (at that time termed "speed endurance training"). He was national team sprint coach and personal coach to Pietro Mennea, Olympic gold medalist in 1980 and former world record holder for the 200 meter. Recently, we have performed sprint training interventions with a similar progression model.[55,67] These studies have provided positive and time-efficient effects on soccer-related sprinting skills. Further studies are warranted in order to establish progression and periodization models for sprint development.

*Integration of sprint training*: According to acknowledged practitioners in soccer, physical conditioning of players must be integrated with the remaining soccer-specific training.[86] It is important to keep in mind that playing soccer is an important contribution to the overall fitness level of the players. Sporis et al. reported that starters developed sprinting skills to a higher level compared to non-starters.[87] Successful off-field interventions will not automatically be accepted by the soccer coaches. It is therefore essential that the small amount of time available for physical training is used effectively. Hoff et al. demonstrated how aerobic endurance training can be integrated into soccer specific training,[88] and a similar approach should also be used in order to improve sprinting skills.

*Physical coaching expertise*: Research has highlighted the importance of direct supervision in order to obtain optimal training outcomes.[89] Coaching centers to a larger degree on continually evaluating and making adjustments to the training process. In research related intervention studies, such opportunities are limited due to issues of standardization and validation. However, sprinting skills are heavily dependent upon technical elements, increasing the needs of feedback during practice. Continuous presence of a physical conditioning expert probably increases the odds for a more successful outcome in soccer.

## Essential loading factors

*Intensity:* To the authors` knowledge, the vast majority of soccer studies make no other recommendations than that sprint velocity should be maximal throughout. However, recent studies of soccer players and track & field athletes have shown that 40 m linear sprint performance is significantly reduced already after 3-4 maximal repetitions.[13,14] Thus, the intensity (calculated as percentage of maximal sprint velocity) should perhaps be reduced in order to complete a higher number of repetitions during practice. The lowest effective sprinting intensity for stimulating adaptation is so far not established in research literature. Successful sprint coaches have performed sprint training sessions with an intensity as low as 90 % during the initial pre-season conditioning.[85] Recent successful intervention studies have revealed that most soccer players through gradual progression are capable of completing at least twenty 40-m sprint repetitions with intensity >95 %.[55,67] Future randomized controlled trial studies should explore the impact of different sprinting intensities. In strength training literature, greater loading/intensity is needed for 1RM improvements as one progresses from untrained to more advanced levels of training.[90,91]

*Recoveries:* Recovery duration between repetitions and sets is one of the most important variables in manipulating the training intensity. Shorter recovery time forces lower intensity per sprint repetition. The longer the recoveries, the more repetitions can be completed at a high intensity. Balsom et al. found that when soccer players ran 15x40 m at maximal intensity, separated by 30 s recovery, the performance drop-off was 10 %. However, when the same training was performed with either 60 or 120 s recovery, the performance drop-off was reduced to 3 and 2 %, respectively.[62] To date, no studies have investigated the effect of recovery duration during sprint training on soccer related sprinting skills. In strength training research, long-term studies have shown greater maximal strength improvements with long (2-3 min) versus short (30-40 s) recovery periods between sets.[92,93]

*Sprint training frequency*: Recent sprint training regimes conducted on elite soccer players have shown positive effects following sprint training as little as once a week.[55,67] The question remains whether even greater effects would have occurred with more frequent training sessions. No studies have so far compared the effects of different sprint training frequencies. If a greater number of sprint training sessions per week results in only marginally better training effects, it is likely that the majority of soccer coaches would choose to implement only one session per week. This is in order to reduce the risk of injury, in addition to allowing more time for soccer-specific training.

*Season time considerations:* Dupont et al. reported positive training effects after repeated sprint training in-season.[20] Other studies suggest that the largest effects are seen when sprint training is conducted in the off-season or early pre-season.[55,56,67] Soccer specific training contributes to maintaining RSA gained during pre-season training. Sprinting ability depends to a large degree on the athlete being well rested and is therefore difficult to combine with other forms of training. This is particularly relevant in soccer, which is driven primarily by aerobic metabolism. Recently, we had to abort an intervention study performed at the end of pre-season and season start due to drop-out issues caused by injuries. Future intervention studies should report the number of injuries sustained during the intervention period, along-side any potential training effects, as this is equally important in soccer.

*In summary*, sprinting ability in soccer is regulated by a complex interaction of multiple factors. Our understanding of this interaction is far from complete, a reality that is likely part of the reason that intuition, experience and tradition carry so much weight in the training and coaching of elite athletes. Conditioning programs should be ideally be focused on closing the gap between the positional demands of play and actual individual capacity. Several questions remain regarding optimization of training methods, and it is reasonable to believe that there is a gap between science and best practice regarding sprint development of soccer players. We believe that future studies regarding this topic should be based upon progression models and program design recommendations from scientific strength training literature, as this research field is much more developed per se.

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## TABLES

**Table 1:** Percentiles (PCTL) of split times, peak velocity (PV) and countermovement jump (CMJ) for male professionals and female elite soccer players

**Table 2**: Repeated sprint field test protocols [sets x (repetitions x distance)] used on elite or professional soccer players >16 yrs ranged according to total sprinting distance (TSD) during the test. Recovery is reported as time between each sprint.

**Table 1**. Percentiles (PCTL) of split times, peak velocity (PV) and countermovement jump (CMJ) for male professionals and female elite soccer players.

| | **Males (n=628/411 for sprint/CMJ)** | | | | | | **Females (n=165/165 for sprint/CMJ)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PCTL | *10m (s)* | *20m (s)* | *30m (s)* | *40m (s)* | *PV* $(m \cdot s^{-1})$ | *CMJ (cm)* | *10m (s)* | *20m (s)* | *30m (s)* | *40m (s)* | *PV* $(m \cdot s^{-1})$ | *CMJ (cm)* |
| 99 | 1.40 | 2.58 | 3.65 | 4.69 | 9.71 | 52.1 | 1.55 | 2.86 | 4.10 | 5.30 | 8.55 | 41.0 |
| 95 | 1.42 | 2.61 | 3.70 | 4.77 | 9.43 | 47.0 | 1.57 | 2.90 | 4.13 | 5.34 | 8.33 | 37.3 |
| 90 | 1.44 | 2.64 | 3.75 | 4.84 | 9.30 | 45.2 | 1.59 | 2.93 | 4.15 | 5.41 | 8.20 | 35.4 |
| 75 | 1.48 | 2.70 | 3.82 | 4.92 | 9.10 | 42.0 | 1.64 | 3.00 | 4.29 | 5.54 | 7.94 | 32.7 |
| 50 | 1.52 | 2.76 | 3.91 | 5.04 | 8.81 | 38.7 | 1.69 | 3.08 | 4.37 | 5.69 | 7.65 | 29.4 |
| 25 | 1.56 | 2.83 | 4.00 | 5.17 | 8.55 | 35.7 | 1.72 | 3.16 | 4.53 | 5.86 | 7.40 | 26.8 |
| 10 | 1.60 | 2.89 | 4.08 | 5.26 | 8.36 | 33.3 | 1.79 | 3.23 | 4.64 | 6.02 | 7.19 | 24.5 |

Note: For the sprint tests, a floor pod placed on the start line was used for time initiation.

**Table 2**: Repeated sprint field test protocols [sets x (repetitions x distance)] used on elite or professional soccer players >16 yrs ranged according to total sprinting distance (TSD) during the test. Recovery is reported as time between each sprint.

| Study | Test protocol | TSD (m) | Recovery (s) |
|---|---|---|---|
| Krustrup et al.[40] | 1x(3x30m) | 90 | 25 |
| Gabbett[41] | 1x(6x20m) | 120 | < 15 |
| Aziz et al.[42] | 1x(6x20m) | 120 | 20 |
| Aziz et al.[43] | 1x(8x20m) | 160 | 20 |
| Mujika et al.[44] | 1x(6x30m) | 180 | 30 |
| Dellall et al.[45] | 1x(10x20m) | 200 | 25 |
| Dupont et al.[46] | 1x(7x30m) | 210 | 20 |
| Chaouachi et al.[47] | 1x(7x30m) | 210 | 25 |
| Meckel et al.[48] | 1x(6x40m) | 240 | ~ 25 |
| Meckel et al.[48] | 1x(12x20m) | 240 | ~ 17 |
| Impellizzeri et al.[49-51] | 1x(6x20+20m) | 240 | 20 |
| Bangsbo et al.[52,53] | 1x(7x34.2m) | 240 | 20-25 |
| Wong et al.[54] | 1x(9x30m) | 270 | 25 |
| Tønnessen et al.[55,56] | 1x(10x40m) | 400 | 60 |
| Dupont et al.[20] | 1x(15x40m) | 600 | 25 |
| Little & Williams[57] | 1x(15x40m) | 600 | ~ 8-12 |
| Little & Williams[57] | 1x(40x15m) | 600 | ~ 20-30 |