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Construct validity of a new intermittent aerobic fitness field test in elite soccer players

Head title: **validity of a new intermittent field test in soccer**

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Conflict of interest statement

The Authors declare no conflict of interest.

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ABSTRACT

BACKGROUND: The study aimed to evaluate the construct validity of a novel constant-velocity intermittent recovery test (IRT), designed to evaluate aerobic fitness in the field in soccer players.

METHODS: Eighteen elite soccer players (age: 24.0 ± 7.2 years, body mass: 82.9 ± 6.8 kg, height: 184.7 ± 5.2 cm) completed the IRT test, consisting of 50-m runs at 18 km/h (10-s/50 m), interspersed by a recovery time initially set at 17 s, gradually decreased up to 2 s, and then held constant until exhaustion. The maximum oxygen uptake (VO_2max) measured by means of a portable gas analyser, and the distance covered during the test were recorded, and their relationships with a selection of physical performance indicators collected during official matches were assessed with Pearson's r correlation coefficients.

RESULTS: Small to moderate ($r \leq 0.45$), non-significant correlations (all $p > 0.05$) were observed between VO_2max and all the examined match performance variables. Conversely, the distance covered at exhaustion was largely and positively correlated ($r = 0.71$ to 0.76) to total distance covered, average metabolic power, distance covered at high metabolic power, and acceleration/deceleration distance (all $p < 0.01$).

CONCLUSIONS: In conclusion, the present findings reveal good construct validity of the distance covered in the IRT to predict match physical performance in elite soccer players.

KEYWORDS athletic performance; exercise test; football; oxygen consumption; physical endurance.

INTRODUCTION

In soccer, good levels of aerobic fitness are an important pre-requisite for performance [Stolen et al. 2005]. Therefore, the assessment of parameters related to aerobic capacity, including above all the maximum oxygen uptake (VO_2max), is somewhat relevant in the process of testing soccer players [Svensson et al. 2005, Bok et al. 2021].

In all sports in which running is the main locomotion mode, including most team sports, aerobic fitness can be assessed by means of graded treadmill tests [Riboli et al. 2022, Metaxas et al. 2021, Michaelidis et al. 2021, Slettalokken et al. 2014]. However, despite exhibiting high accuracy and reliability, laboratory running tests may be suboptimal for fitness assessments in soccer, due to non-specificity of straight continuous running [Stolen et al. 2005], motivational issues for athletes [Kemi et al. 2003], and mechanical differences between treadmill and on-grass running related to surface properties [Hong et al. 2012, Colino et al. 2020]. Therefore, the use of field-based running protocols has been advocated when testing soccer players [Koklu et al. 2020, Di Michele et al. 2009].

In the last decades, different field protocols have been developed to assess aerobic fitness in team sports players, in which typically no metabolic measures are carried out, and the main outcome is the velocity or distance achieved at exhaustion at the final stage of the test, from which it is possible to estimate the VO_2max [Leger et al. 1988, Bangsbo et al. 2008, Buchheit 2008]. Conversely, despite gas exchange can be measured also in the field by means of portable gas analysers, the assessment of VO_2max by means of field tests in soccer or other team sports players is still not frequently used [Kemi et al. 2008, Metaxas et al. 2005, Buchheit et al. 2009]. Kemi and coworkers [2003] used a graded exhaustive protocol involving soccer-specific actions such as ball dribbling, jumping, and changing direction, showing that players reached similar VO_2max values compared to a standard treadmill test. Soccer-specific tests, allowing to elicit

maximal physiological responses in an ecologically valid setting, indeed constitute an interesting approach to assess aerobic fitness in the field. Nevertheless, organizational aspects and the necessity of extensive familiarization may represent practical obstacles to routinely using this type of protocols. Ventilatory parameters and metabolic indices including the VO_2max have been also assessed in field tests such as the Yo-Yo intermittent endurance test [Metaxas et al 2005], and the 30-15 intermittent fitness test [Buchheit et al. 2009], whose protocols are reflective of the intermittent nature of soccer. These tests however consist of shuttle running, with multiple turns that can have an impact on fatigue of lower limb muscles possibly resulting in premature exhaustion and involve accelerations and decelerations that can affect VO_2 responses [Bekraoui et al. 2020].

To address some of the shortcomings of already existing field protocols when they are used to measure VO_2max in soccer players, a new discontinuous exhaustive intermittent recovery test (IRT), with fixed running and decreasing recovery time between bouts, has been recently designed [Meloni et al. 2024]. This test involves the repetition of 50-m runs at the fixed velocity of 18 km/h (i.e., 10-s/50 m). Runs are interspersed by a passive recovery period initially set at 17 seconds. The recovery time then gradually decreases after every 3 to 7 runs up to 2 seconds, and then is held constant, resulting in a total test duration of approximately 10 to 20 min, like that of continuous graded tests. Meloni et al. (2024) showed that the highest oxygen consumption value recorded during the IRT is very largely correlated ($r=0.75$) with and not different from VO2max assessed in a continuous graded test in semi-professional soccer players. Moreover, they showed good test-retest reliability of absolute and relative VO2max, maximum heart rate, peak ventilation and carbon dioxide production, and the total distance covered at exhaustion in the IRT (Meloni et al. 2004).

The IRT has been used by several professional soccer teams, but no study was conducted to assess its validity of in elite players. The purpose of this study was therefore to contribute to the validation of the IRT by exploring the construct validity of the IRT in a group of elite soccer players. To this aim, we assessed the relationships between the outcomes of the IRT and a selection of match physical performance variables collected during official soccer games.

MATERIAL AND METHODS

Participants

Eighteen male outfield soccer players (eight defenders, six midfielders, four forwards) belonging to an Italian Serie A team (age 24.0 ± 7.2 years, body mass 184.7 ± 5.2 cm, height 82.9 ± 6.8 kg) participated to the study. From all outfield players belonging to the involved team, those included in the sample were those who played at least 45 minutes in three or more official Serie A games performed in the six weeks after the testing date. All data used in the present study were acquired as part of routine testing in a professional club, therefore institutional ethical approval and informed consent were not required [Winter & Maughan 2009]. Nevertheless, the club provided consent to conduct the study and use the data anonymously and confidentially for research purposes.

IRT Protocol

The IRT was carried out in the in-season period, during a typical weekly training microcycle, at least three days after the last match.

The test was performed on a natural grass pitch. The warm-up for the test consisted of about 10-min of jogging, followed by flexibility and body-weight resistance exercises for lower limbs, and 5-min of high-intensity intermittent running, with 25-m runs (about 5 seconds) interspersed by recovery periods of 20 seconds.

The protocol consisted of running at a constant velocity of 18 km/h back and forth over a straight 50-m segment (covered in 10 seconds), with passive recovery phases between each 50-m run. An acoustic signal at the start and end of each 50-m trait helped the players to run at the prescribed 18 km/h velocity (Figure 1).

<<< Place Figure 1 here >>>

Figure 1. Schematic representation of the IRT

The recovery time between runs was set to decrease throughout the test. It was fixed to 17 seconds at the start of the test and was then decreased to: 15 and 13 seconds, respectively after every three runs; 11, 10, 9, and 8 seconds, respectively after every four runs; 7, 6, and 5 seconds, respectively after every five runs; 4 and 3 seconds, respectively after every six runs; 2 seconds after every seven runs. It was then held constant at 2 seconds from that point on (Figure 2). The test was performed to volitional exhaustion. The total distance covered (in metres) was calculated as the sum distance completed by the player until the end of the test, that, is 50 multiplied by the number of runs executed.

<<< Place Figure 2 here >>>

Figure 2. Duration of recovery periods between 50-m runs in the IRT protocol

Throughout the whole test, VO_2 was continuously measured using a portable gas analyser (K5, Cosmed, Rome, Italy) [Perez-Suarez et al. 2018]. VO_2max was calculated as the maximum

value of oxygen uptake measured during the 30-s before the end of the test. Heart rate was measured throughout the test with a Polar H10 chest strap (Polar Electr Oy, Kempele, Finland), and the maximum heart rate (HRmax) was determined as the maximum heart rate value measured during the test. Two minutes after the test, a 0.3 µl capillary blood sample was taken from the earlobe to determine the blood lactate (LA) concentration, using a lactate analyser (Lactate Pro-2, Arkray, Kyoto, Japan).

Match performance indices

Match performance data were monitored by means of an optical tracking system (Ball and Player Tracking, Hawk-eye Innovations Ltd, Basingstoke, United Kingdom). This system showed high reliability as assessed using the official FIFA test protocol for Electronic and Performance Tracking Systems. The test report is available at the FIFA website: https://inside.fifa.com/technical/football-technology/resource-hub?id=f2f604804d5a4664a31c9199dad05ebd.

From all physical performance variables obtained from the dedicated software, the following variables were examined:

-total distance covered (m/min);

-high-intensity (>20 km/h) distance (m/min);

-sprint (>25 km/h) distance (m/min);

-high-intensity acceleration (> 2 m/s^{-2}) distance (m/min);

-high-intensity deceleration (<- 2 m/s^{-2}) distance (m/min);

-average metabolic power (W/kg);

- high metabolic power (>20 W/kg) distance (m/min).

Data of the six official Serie A games played immediately after the testing date were used. For all players, the average values over all available games out of the six examined ones, with an individual playing time ≥45 min, was calculated for each variable and taken for subsequent analyses.

Statistical analysis

All data are presented as the mean ± the standard deviation (SD). For each examined variable, the distribution was examined with Shapiro-Wilk tests, and all variables showed a normal distribution. Pearson's *r* correlation coefficients were calculated to assess the relationships between MAP test outcomes and match performance variables. The magnitude of the correlation was qualitatively assessed as trivial ($r<0.1$) small ($0.1<r<0.3$), moderate ($0.3<r<0.5$), large ($0.5<r<0.7$), very large ($0.7<r<0.9$), and extremely large ($r>0.9$) [Hopkins et al. 2009]. For all analyses, statistical significance was set at $p<0.05$. The analyses were performed with the software R, version 4.3.1 (The R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

On average, the total test duration was 17:04 ± 2:33 min, while the total distance covered was 2889 ± 594 m. The VO_2max and HRmax were, respectively, 60.1 ± 6.8 ml/min/kg and 187 ± 7 bpm, while the blood lactate concentration measured at the end of the test was 6.6 ± 1.5 mmol/l. The mean values of the examined match physical performance variables are shown in Table 1 for descriptive purposes.

<<< Place Table 1 Here >>>

Table 2 shows the correlations between the IRT variables and the match physical performance variables, whereas Figure 3 displays the correlations between the IRT outcome variables and total and high-intensity distances covered during match play. There were small (r = 0.21 to 0.25) to moderate (r = 0.38 to 0.45), non-significant correlations (all $p>0.05$) between VO_2max and match performance variables. Conversely, there were large (r = 0.71 to 0.76) significant correlations ($p<0.01$) between total distance covered during the IRT and match performance variables, with exception of high-intensity and sprint distance, showing non-significant ($p>0.05$) correlations (Table 2).

<<< Place Table 2 Here >>>

<<< Place Figure 3 here >>>

Figure 3. Correlations between the total distance covered in the IRT and the total distance covered during match play (A), the VO2max achieved in the IRT and the total distance covered during match play (B), the total distance covered in the IRT and the high-intensity distance covered during match play (C), and the VO2max achieved in the IRT and the high-intensity distance covered during match play (D). r: Pearson's r correlation coefficient.

DISCUSSION

This study aimed to assess the construct validity of the IRT, a newly developed test designed to assess aerobic fitness, and most specifically VO_2max, of soccer players in a field setting. The findings, taken together, show large relationships between the total distance covered in the test and the examined match physical performance metrics, with the exclusion of high-

intensity and sprint distances. Conversely, we observed weak relationships between match performance indicators and VO_2max.

The VO_2max values measured with the IRT in the present sample of elite players (on average approximately 60 ml/min/kg) are in the range of VO_2max data previously observed in elite senior soccer players [Stolen et al 2005, Metaxas et al 2021, Kalapotharakos et al 2021, Ingebritsen et al. 2012]. Furthermore, the maximum achieved heart rate (187 ± 7 bpm) is similar to that reported when using intermittent field tests at exhaustion in soccer players of similar age than ours [Ingebritsen et al. 2012, Rampinini et al. 2010]. These results suggest that our players were able to achieve maximal effort and cardiorespiratory responses by performing the IRT. The blood lactate concentration measured at the end of the test (6.6 ± 1.5 mmol/l) was instead somewhat lower than values previously measured in elite soccer players after graded exhaustive intermittent field tests (11-12 mmol/l) [Metaxas et al 2005, Rampinini et al 2010]. Regarding this observation, it is worth noting that the IRT involves sub-maximal constant-velocity running at 18 km/h, allowing to reach exhaustion because of decreased recovery time between runs rather than velocity increases. Since the 18 km/h velocity similar on average to the velocity associated to VO_2max for elite soccer players [Kalapotharakos et al. 2011, Tonnessen et al. 2013], it can be supposed that such exercise intensity allows lower amount of energy by the anaerobic metabolism, compared to graded exhaustive protocols. This aspect may be of interest when the goal is testing aerobic fitness excluding a significant contribution of the anaerobic lactic system.

In the present study, we observed low to moderate, non-significant relationships between VO_2max and all examined match physical performance parameters, including the total and high-intensity distances (Table 2, Figure 3). The above findings is consistent with previous studies showing weak associations between VO_2max (assessed with treadmill tests) and soccer match performance in youth [Rebelo et al. 2014] and senior elite [Metaxas 2021] players. Interestingly,

the present results highlight that VO_2max is not highly correlated with soccer match performance although it is assessed by means of a field, intermittent test performed on a grass pitch. This suggests that the moderate relationships between VO_2max and physical match performance variables are not a consequence of the protocol used for VO_2max assessment. Probably, factors linked to the playing position and tactical requirements placed on players have a meaningful role on their match physical performance. Distances covered during match play are therefore overall unrelated to aerobic fitness when examined independently from playing position [Metaxas 2021, Buchheit et al 2010]. A limitation of this study is that we have not examined subsets of players according to their playing positions, due to the limited size of the examined sample. Moreover, it should be remarked that, in contemporary elite soccer, players are often required to play in different positions (for example, defender and midfielder) across a season [Schuth et al. 2016], making difficult to assign a player to a given position. It will be therefore interesting to assess the relationships between fitness and match performance under an individual player vs. playing position perspective [Altmann et al. 2021].

Despite VO_2max seems almost useless as a predictor of match physical performance in elite soccer players, its assessment is still useful for other purposes in soccer. Indeed, in high-level players, VO_2max is sensitive to training interventions [Helgerud et al. 2001, Michaelides et al. 2021], and its periodic assessment may provide useful information to verify if aerobic is maintained over the season [Kalapotharakos et al. 2011, Casajus et al 2001]. Considering the effectiveness and specificity of field-based fitness protocols for testing soccer players, the IRT has been designed to provide an efficient protocol to directly assess VO_2max on a grass pitch by means of a portable gas analyser. Compared to other field-based exhaustive aerobic fitness tests, novel characteristics of the IRT are the running velocity held constant at 18 km/h throughout the test, and its intermittent protocol with a decreasing recovery time. Besides reflecting more closely the intermittent nature of soccer compared to a continuous protocol, discontinuous

protocols have been shown to elicit similar VO_2max than continuous protocols in soccer players [Riboli et al. 2022], supporting their validity for VO_2max assessment. In the IRT, moreover, the recovery time between runs is equal to or higher than two seconds, allows to avoid any abrupt accelerations, decelerations, and change of directions. This feature may reduce lower-limb muscle fatigue compared to protocols based on shuttle running, with a positive impact on the feasibility of the test. Future studies are warranted to investigate this point.

The present results show large correlations between the total distance covered in the IRT, and many of the examined descriptors of match running performance (Table 2), revealing good construct validity of such outcome of the IRT to predict match physical performance in elite soccer players. This finding is consistent with many previous studies observing that in soccer players match running performance is related to the final velocity or total distance reached in graded aerobic fitness tests [Bangsbo et al 2008, Rebelo et al 2014, Rampinini et al 2007]. However, we observed a moderate ($r = 0.46$, $p=0.06$), correlation between the distance covered in the MAP test and high-intensity distance covered during match play. Also, the total distance in the MAP test was not correlated to sprint distance (Table 2). Therefore, the distance covered in the MAP test would seem to predict the ability of soccer players to cover a longer overall distance in a soccer match, rather than greater high-intensity (> 20 km/h) distance, differently from the total distance covered in the Yo-Yo IR1 test, that is instead correlated to high-intensity running distance covered during match play [Bangsbo et al 2008]. This observation is consistent with the hypothesis that the distance covered in the IRT is relatively low affected by anaerobic capacity, and the test mostly reflects the aerobic performance capacity of a player. Further studies are needed to verify this hypothesis. Future research perspectives also include the assessment of the validity of the IRT in different groups of soccer players, including youth and female players.

CONCLUSION

In the present study, we observed large correlations between the total distance covered in the IRT and the total distance covered during match play, as well as other variables related to match physical performance. Therefore, the distance covered in the IRT exhibits good construct validity in predicting some aspects of match physical performance. While the IRT was primarily designed as a field-based protocol to assess VO_2max in elite soccer players, the present result support the assessment of the total distance covered in the IRT as a predictor of total distance covered during matches in elite soccer players.

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REFERENCES

1. Stølen T, Chamari K, Castagna C, Wisløff U. Physiology of soccer: an update. Sports Med. 2005;35(6):501-36. doi: 10.2165/00007256-200535060-00004
2. Svensson M, Drust B. Testing soccer players. J Sports Sci. 2005 Jun;23(6):601-18. doi: 10.1080/02640410400021294
3. Bok D, Foster C. Applicability of Field Aerobic Fitness Tests in Soccer: Which One to Choose? J Funct Morphol Kinesiol. 2021 Aug 18;6(3):69. doi: 10.3390/jfmk6030069
4. Riboli A, Coratella G, Rampichini S, Limonta E, Esposito F. Testing protocol affects the velocity at VO_{2max} in semi-professional soccer players. Res Sports Med. 2022 Mar-Apr;30(2):182-192. doi: 10.1080/15438627.2021.1878460.
5. Metaxas TI. Match Running Performance of Elite Soccer Players: V̇o2max and Players Position Influences. J Strength Cond Res. 2021 Jan 1;35(1):162-168. doi: 10.1519/JSC.0000000000002646.

6. Michaelides MA, Parpa KM, Zacharia AI. Effects of an 8-Week Pre-seasonal Training on the Aerobic Fitness of Professional Soccer Players. J Strength Cond Res. 2021 Oct 1;35(10):2783-2789. doi: 10.1519/JSC.0000000000003209.
7. Slettaløkken G, Rønnestad BR. High-intensity interval training every second week maintains VO2max in soccer players during off-season. J Strength Cond Res. 2014 Jul;28(7):1946-51. doi: 10.1519/JSC.0000000000000356.
8. Kemi OJ, Hoff J, Engen LC, Helgerud J, Wisløff U. Soccer specific testing of maximal oxygen uptake. J Sports Med Phys Fitness. 2003 Jun;43(2):139-44.
9. Hong Y, Wang L, Li JX, Zhou JH. Comparison of plantar loads during treadmill and overground running. J Sci Med Sport. 2012 Nov;15(6):554-60.
10. Colino E, Felipe JL, Van Hooren B, Gallardo L, Meijer K, Lucia A, Lopez-Fernandez J, Garcia-Unanue J. Mechanical Properties of Treadmill Surfaces Compared to Other Overground Sport Surfaces. Sensors (Basel). 2020 Jul 9;20(14):3822. doi: 10.3390/s20143822.
11. Köklü Y, Alemdaroğlu U, Demirhan R, Arslan Y. A Comparison of Incremental Running Field and Treadmill Tests in Young Soccer Players. J Hum Kinet. 2020 Jul 21;73:193-201. doi: 10.2478/hukin-2019-0143.
12. Di Michele R, Di Renzo AM, Ammazzalorso S, Merni F. Comparison of physiological responses to an incremental running test on treadmill, natural grass, and synthetic turf in young soccer players. J Strength Cond Res. 2009 May;23(3):939-45. doi: 10.1519/JSC.0b013e3181a07b6e.
13. Léger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci. 1988 Summer;6(2):93-101. doi: 10.1080/02640418808729800.
14. Bangsbo J, Iaia FM, Krustrup P. The Yo-Yo intermittent recovery test : a useful tool for evaluation of physical performance in intermittent sports. Sports Med. 2008;38(1):37-51. doi: 10.2165/00007256-200838010-00004.
15. Buchheit M. The 30-15 intermittent fitness test: accuracy for individualizing interval training of young intermittent sport players. J Strength Cond Res. 2008 Mar;22(2):365-74. doi: 10.1519/JSC.0b013e3181635b2e.
16. Metaxas TI, Koutlianos NA, Kouidi EJ, Deligiannis AP. Comparative study of field and laboratory tests for the evaluation of aerobic capacity in soccer players. J Strength Cond Res. 2005 Feb;19(1):79-84. doi: 10.1519/14713.1.
17. Buchheit M, Al Haddad H, Millet GP, Lepretre PM, Newton M, Ahmaidi S. Cardiorespiratory and cardiac autonomic responses to 30-15 intermittent fitness test in team sport players. J Strength Cond Res. 2009 Jan;23(1):93-100. doi: 10.1519/JSC.0b013e31818b9721.
18. Bekraoui N, Boussaidi L, Cazorla G, Léger L. Oxygen Uptake, Heart Rate, and Lactate Responses for Continuous Forward Running and Stop-and-Go Running With and Without Directional Changes. J Strength Cond Res. 2020 Mar;34(3):699-707.
19. Meloni A., Codella R., Arrighi T., Festa L., Ceci G., Faraci G., Manari G., Manari D., Filipas L. An intermittent recovery test for soccer players: a validation study. J Sports Med Phys Fitness 2024 Sep 03. doi: 10.23736/S0022-4707.24.16105-1.

20. Winter EM, Maughan RJ. Requirements for ethics approvals. J Sports Sci. 2009 Aug;27(10):985. doi: 10.1080/02640410903178344.
21. Perez-Suarez I, Martin-Rincon M, Gonzalez-Henriquez JJ, Fezzardi C, Perez-Regalado S, Galvan-Alvarez V, Juan-Habib JW, Morales-Alamo D, Calbet JAL. Accuracy and Precision of the COSMED K5 Portable Analyser. Front Physiol. 2018 Dec 21;9:1764. doi: 10.3389/fphys.2018.01764.
22. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sports Exerc. 2009 Jan;41(1):3-13. doi: 10.1249/MSS.0b013e31818cb278.
23. Kalapotharakos VI, Ziogas G, Tokmakidis SP. Seasonal aerobic performance variations in elite soccer players. J Strength Cond Res. 2011 Jun;25(6):1502-7. doi: 10.1519/JSC.0b013e3181da85a9.
24. Ingebrigtsen J, Bendiksen M, Randers MB, Castagna C, Krustrup P, Holtermann A. Yo-Yo IR2 testing of elite and sub-elite soccer players: performance, heart rate response and correlations to other interval tests. J Sports Sci. 2012;30(13):1337-45. doi: 10.1080/02640414.2012.711484.
25. Rampinini E, Sassi A, Azzalin A, Castagna C, Menaspà P, Carlomagno D, Impellizzeri FM. Physiological determinants of Yo-Yo intermittent recovery tests in male soccer players. Eur J Appl Physiol. 2010 Jan;108(2):401-9. doi: 10.1007/s00421-009-1221-4.
26. Rebelo A, Brito J, Seabra A, Oliveira J, Krustrup P. Physical match performance of youth football players in relation to physical capacity. Eur J Sport Sci. 2014;14 Suppl 1:S148-56. doi: 10.1080/17461391.2012.664171.
27. Kalapotharakos VI, Ziogas G, Tokmakidis SP. Seasonal aerobic performance variations in elite soccer players. J Strength Cond Res. 2011 Jun;25(6):1502-7. doi: 10.1519/JSC.0b013e3181da85a9.
28. Tønnessen E, Hem E, Leirstein S, Haugen T, Seiler S. Maximal aerobic power characteristics of male professional soccer players, 1989-2012. Int J Sports Physiol Perform. 2013 May;8(3):323-9. doi: 10.1123/ijspp.8.3.323.
29. Buchheit M, Mendez-Villanueva A, Simpson BM, Bourdon PC. Match running performance and fitness in youth soccer. Int J Sports Med. 2010 Nov;31(11):818-25. doi: 10.1055/s-0030-1262838.
30. Schuth G, Carr G, Barnes C, Carling C, Bradley PS. Positional interchanges influence the physical and technical match performance variables of elite soccer players. J Sports Sci. 2016;34(6):501-8. doi: 10.1080/02640414.2015.1127402.
31. Altmann S, Forcher L, Ruf L, Beavan A, Groß T, Lussi P, Woll A, Härtel S. Match-related physical performance in professional soccer: Position or player specific? PLoS One. 2021 Sep 10;16(9):e0256695. doi: 10.1371/journal.pone.0256695.
32. Helgerud J, Engen LC, Wisloff U, Hoff J. Aerobic endurance training improves soccer performance. Med Sci Sports Exerc. 2001 Nov;33(11):1925-31. doi: 10.1097/00005768-200111000-00019.
33. Michaelides MA, Parpa KM, Zacharia AI. Effects of an 8-Week Pre-seasonal Training on the Aerobic Fitness of Professional Soccer Players. J Strength Cond Res. 2021 Oct 1;35(10):2783-2789.

34. Casajús JA. Seasonal variation in fitness variables in professional soccer players. J Sports Med Phys Fitness. 2001 Dec;41(4):463-9.
35. Rampinini E, Bishop D, Marcora SM, Ferrari Bravo D, Sassi R, Impellizzeri FM. Validity of simple field tests as indicators of match-related physical performance in top-level professional soccer players. Int J Sports Med. 2007 Mar;28(3):228-35. doi: 10.1055/s-2006-924340.

TABLES:

Match performance variables	
Total distance (m/min)	114.6 ± 10.8
High-intensity distance (m/min)	9.2 ± 2.0
Sprint distance (m/min)	2.3 ± 0.9
Acceleration distance (m/min)	5.4 ± 0.7
Deceleration distance (m/min)	4.7 ± 0.7
Average metabolic power (W/kg)	10.3 ± 1.0
Distance at high metabolic power (m/min)	30.4 ± 5.8

Table 1. Mean ± SD values of the match physical performance variables

	VO_2max	**Total distance covered in the IRT**
Total distance	0.43 (-0.05 to 0.75)	0.73* (0.41 to 0.89)
High-intensity distance	0.25 (-0.25 to 0.64)	0.46 (-0.01 to 0.76)
Sprint distance	0.21 (-0.28 to 0.61)	0.10 (-0.38 to 0.54)
Acceleration distance	0.45 (-0.02 to 0.76)	0.74* (0.41 to 0.90)
Deceleration distance	0.38 (-0.11 to 0.72)	0.71* (0.36 to 0.88)
Average metabolic power	0.44 (-0.04 to 0.75)	0.76* (0.45 to 0.90)
Distance at high metabolic power	0.42 (-0.06 to 0.74)	0.71* (0.36 to 0.88)

Table 2. Pearson's r correlation coefficients between the examined variables (with 95% CIs).

**p<0.05*