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Original Investigation

Reliability and validity of the 30-15 intermittent fitness test in female soccer players

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Purpose: The main purpose of the study was to examine the reliability and validity of the 30-15 Intermittent Fitness Test (30-15IFT).
Methods: Forty-eight young female soccer players (age = 17.33±1.15 years; height = 175.11±6.10 cm; weight = 67.20±7.13 kg) from three national level competitive clubs were recruited. Test-retest reliability was performed 7 days apart and the 30-15IFT outcome measures were correlated against the Bruce continuous running test protocol.
Results: Vmax (ICC = .90; CV = 1.02%, P< .001), HRpeak (ICC =.91; CV = 1.00%, *P*< .001) and VO2max (ICC = .91; CV = 1.10%, *P*< .001) exhibited high reliability properties. Correlations between the 30-15IFT and continuous running yielded very large effects for Vmax (*R*= .72; SEE = .65 km*h-1, *P*< .001), HRpeak (R= .77; SEE = 5.09 b.p.m., P< .001) and VO2max (*R*= .73; SEE = 1.96 ml*kg-1*min-1, *P*< .001).
Conclusions: This study shows that the 30-15IFT is highly reliable and satisfactory valid tool for assessing aerobic capacity in young female soccer players.

Keywords: Soccer; 30-15 Intermittent Fitness Test; Psychometric properties; Bruce protocol; Aerobic performance.

Introduction

Soccer is considered the most popular sport worldwide regarding the number of professional and recreative participants and spectators.[1] As a result of such global phenomenon, competitive soccer has become accompanied by an increase in skill levels and physical demands.[2] Talent identification and recruitment is constantly improving, because of physical, technical, and tactical components that are critical for success.[3] During the game, physiological characteristics indicate, that soccer players cover ≈ 9-11 km, with 7-8% running at high intensity, 5% striding and 3% sprinting,[4] denoting that movements performed at a high intensity discriminate successful and unsuccessful soccer teams.[5] Given the fact that the game of soccer is constantly evolving in terms of greater physiological loadings,[6] players are required to have aerobic and anaerobic functional capacities at high levels.[7,8]
Over the years, measuring cardiorespiratory physical fitness using objective methods has been a cornerstone for planning and programming training interventions.[9,10] Although such approach has merit in terms of generating 'true data', shortcomings often include high costs, time consummation, and having an experienced practitioner monitoring the process.[11] Moreover, evidence highlights that there is still a considerable lack of understanding of the information obtained from valid intermittent aerobic fitness tests.[12] Thus, the need of reliable and valid cost-effective field-based tests to predict the level of aerobic capacity has emerged. Due to a complex relationship between physical, technical, and tactical elements of soccer, research has tried to develop a multi-faceted and easy-to-perform tool for assessment of talent identification and individualized training protocol creation.[13-16] Despite the fact that all these tests have acceptable reliability and validity properties, a major limitation is that players who achieve lower maximum running speeds tend to perform at supramaximal level, often exceeding 120% of aerobic capacity.[17] This would suggest that slower players need to utilize more anaerobic speed reserves to maintain the same pace as faster players.
To overcome this problem, the 30-15 Intermittent Fitness Test (30-15IFT) was developed.[18] The test includes 2 lines that are 40 m apart. At the signal, an individual tries to complete 30-s shuttle runs interspersed with 15 s of passive recovery managed by audio beeps. The velocity starts at 8 km*h-1 and is gradually increased by 0.5 km*h-1 after each stage.[19] The test is stopped if an individual cannot perform, due to accumulated fatigue or fails to reach the next 3-m zone at the signal on 3 occasions. The outcome measures include the maximal running velocity (Vmax) achieved at the last completed stage and peak heart rate (HRpeak). From the Vmax, gender, age and body mass, an estimated maximal oxygen uptake (VO2max) is calculated.[18] Along with estimating maximal aerobic capacity, the 30-15IFT is able to capture anaerobic capacity, neuromuscular and change-of-direction changes, and adequate time for recovery.[12]
Due to its easy administration and tackling various physiological characteristics, previous studies have aimed to investigate reliability and validity properties of the 30-15IFT in team sports, including handball,[12,18] ice hockey,[20,21] basketball,[12,18,22,23] and rugby,[24,25] while the majority of studies have been conducted

among soccer players.[2,12,17,18,26,27] Although evidence in soccer indicates that the 30-15IFT is a reliable tool[2,17,19] with excellent intraclass coefficient correlation (ICC) for Vmax (ICC =.91,[2] ICC = .80,[17] ICC = .88[27]) and HRpeak (ICC =.94,[2] ICC = .89[27]), less data have been presented regarding validity against objective methods.[2,28] A study by Čović *et al.*[2] showed medium to large correlations between in-laboratory continuous running test and 30-15IFT for Vmax (*R*= .57), HRpeak (*R*= .77) and VO2max (*R*= .67) among female soccer players. Another two studies found somewhat larger correlations (*R*= .75,[26] *R*= .82[27]); however, the 30-15IFT was compared to the Yo-Yo Intermittent Recovery (YYIR) test, instead of performance in laboratory conditions. Because of its great popularity and effectiveness to monitor intermittent fitness changes,[2,19] it is necessary to confirm high reliability and determine validity, in comparison to a standard continuous incremental running test in female soccer players. If the aforementioned properties yielded good results, the 30-15IFT should be considered as the field method being able to adequately predict aerobic performance based on Vmax, HRpeak, and VO2max.

Therefore, the main purpose of the present study was to examine reliability and validity of the 30-15IFT in female soccer players. According to previous findings, we hypothesized that the 30-15IFT would exhibit excellent test-retest reliability (ICC > .69)[20] and acceptable validity.[2]

Materials and methods

Study participants

Forty-eight female soccer players (age = 17.33 ± 1.15 years; height = 175.11 ± 6.10 cm; weight = 67.20 ± 7.13 kg) from three national level competitive clubs were recruited. The inclusion criteria were fully active outfield soccer players who had experienced no injury or musculoskeletal pain prior testing and playing soccer for >8 years. The exclusion criteria included a soccer player having an injury – related problem and who failed to attend >85% of training sessions during the competitive season. All data related to inclusion and exclusion criteria were collected by a questionnaire. The G*power analysis calculator showed that by using a two-sided *P* value of .05, an effect of at least .70 presented as the correlation between the observed and the 'gold standard' method,[20] and the statistical power of .80, the appropriate sample size should be n = 17. All participants trained regularly 3 days per week in the afternoon hours (between 17:00 h and 19:00 h). A common type of training consisted of a set of technical and tactical components (shooting, dribbling, passing and running with the ball) with a cooperation of a goalkeeper and other players, strength and conditioning part consisted of small – sided games (5 vs. 5 or 10 vs. 10 soccer players including goalkeepers), and injury – prevention exercises most commonly performed at the end of a training session. The experimental protocol and potential risks were explained to all participants before they provided written consent. All the procedures were anonymous and in accordance with the Declaration of Helsinki. This study was approved by the xxx and was carried out following the Helsinki Declaration. All examinees signed a statement expressing their willingness to proceed with all the testing for this research. To protect participant confidentiality, all data were anonymized and stored securely. We ensured that participants were free to withdraw from the study at any time without any repercussions.

30-15IFT

As previously explained (for reference, please see the 'Introduction' section), the 30-15IFT was used to assess aerobic capacity.[18] All participants needed to complete 30 s shuttle runs interspersed with 15 s active recovery periods on a distance of 40 m running back and forth, while pacing according to pre-recorded audio signals. The starting speed was set at 8 km*h-1 and gradually increased by .5 km*h-1 after every 30 s successive stage. The test was considered over, if an individual was unable to complete the distance, due to exhaustion or fatigue, or was unable to reach the next 3-m zone after the beep on 3 successive occasions.[2,18] The final speed recorded was used as the Vmax, from which an estimated VO2max was calculated using the following formula: VO2max_30-15IFT (ml*kg-1*min-1) = 28.3 – (2.15*(gender; male = 1, female = 2)) – (.741*age in years) – (.0357*weight in kg) + (.0586*age*Vmax in km*h-1) + (1.03*Vmax).[18] HRpeak was monitored at frequency of 1 Hz (Polar Electro Oy, Finland).[2]

Treadmill-based test

VO2max was conducted using a ramp protocol on a motorized treadmill and determined by a breath – by – breath pulmonary gas exchange system (Quark b2, COSMED, Italy). The starting speed was set at 7 km*h-1 and it was increased by 1 km*h-1 every 1 min until volitional exhaustion. The following criteria for exhaustion included: i) a VO2 of <1.0 ml*kg-1*min-1 after an increase in speed; ii) exchange ratio >1.1; and iii) peak lactate of >6 mmol*L-1 after exercise.[29] If the participant reported any bodily pain or discomfort, the test was stopped. The recovery period after the exercise included walking at 4.5 km*h-1 for 5 min. Aerobic data regarding VO2max were averaged on a 5 s basis and included as a proxy of cardiorespiratory capacity in further analyses. Along with VO2max, HRpeak at VO2peak was monitored at frequency of 1 Hz (Polar Electro Oy, Finland) and Vmax was presented as the final running speed.

Data analysis

Data normality was checked using Kolmogorov-Smirnov test with Q-Q plots and the homogeneity of variance using Levene test. Basic descriptive statistics are presented as means and standard deviations (SD) with 95% confidence interval limits (95% CI). Test-retest reliability (7 days apart) was calculated by standardized mean differences. The magnitude of difference was examined with effect size (ES) classified as trivial (>.2), small (.2–.5), moderate (.5–.8); large (.8–1.60), and very large (>1.60).[30] Agreements between trial 1 and trial 2 were determined using intraclass correlation coefficient (ICC), where values of .1, .3, .5, .7, .9, and 1.0 indicated low, moderate, high, very high, nearly perfect, and perfect correlation.[2,20] According to Bucheit *et al.*,[20] good reliability is considered when the coefficient of variation (CV) is < 5% and ICC > .69. The same methodology has been used previously.[2] The validity properties of the 30-15IFT outcomes (Vmax, HRpeak and VO2max) against objective methods were examined using Pearson's product–moment correlation (*R*) indicating small (*R*= .1–.3), moderate (*R*= .3–.5), large (*R*= .5–.7), very large (*R*= .7–.9), and almost perfect (*R*= .9–1.0) associations. All statistical analyses were performed in SPSS v27.0 software (IBM, Armonk, NY, USA) with an alpha level set a priori at *P*< .05 to denote statistical significance.

Results

Reliability of the 30-15 IFT

Trivial ESs and nearly perfect ICCs were observed between trials in the 30-15 IFT outcomes in table 1. No significant differences between trial 1 and trial 2 for Vmax (CV = 1.02%; *t* – value = -1.897, *P*= .064), HRpeak (CV = 1.00%; *t* – value = -.546, *P*= .587) and VO2max (CV = 1.10%; *t* – value = -1.301, *P*= .198).

Table 1. Test-retest reliability measures of the 30-15 IFT in male soccer players; data are presented as mean±SD.

30-15 IFT outcomes	Trial 1	Trial 2	Mean diff. (95% CI)	ES	ICC (95% CI)	Rating
Vmax (km*h-1)	16.09±0.92	16.19±0.93	-.10 (-.21; .01)	.11 (trivial)	.90 (.84; .94)	Excellent
HRpeak (b.p.m.)	191.37± 8.90	191.62± 8.23	-.25 (-1.17; .67)	.03 (trivial)	.91 (.86; .95)	Excellent
VO2max (ml*kg-1*min-1)	53.21±2.81	53.40±2.58	-.19 (-.48; .10)	.07 (trivial)	.91 (.86; .95)	Excellent

Mean diff.: standardized mean difference between two trials; *ES:* effect size; ICC: intraclass coefficient of correlation; 95% CI: 95 percent confidence interval; *Vmax*: maximal running velocity achieved at the final distance; *HRpeak*: peak heart rate; *VO2max*: maximal oxygen uptake; $p < 0.05$

Validity of the 30-15 IFT

The 30-15IFT outcomes overestimated the 'true' values for Vmax (3.11%, t – value = -5.504, $P< 0.001$), HRpeak (6.85%, t – value = -17.563, $P< 0.001$) and VO2max (5.49%, t – value = -10.876, $P< 0.001$). Table 2 shows very large correlations between the 30-15IFT and Bruce protocols for Vmax (SEE = .65 km*h-1), HRpeak (SEE = 5.09 b.p.m.) and VO2max (SEE = 1.96 ml*kg-1*min-1).

Table 2. Criterion validity of the 30-15 IFT outcomes against the progressive Bruce treadmill protocol; data are presented as mean±SD.

30-15 IFT outcomes	30-15 IFT	Bruce	Mean diff. (95% CI)	ES	*R* (95% CI)	Rating
Vmax (km*h-1)	16.10±0.92	15.60±0.94***	-.49 (-.67; -.31)	.54 (medium)	.72 (.58; .82)	Very large
HRpeak (b.p.m.)	191.37± 8.90	178.27±7.92***	13.10 (11.61; 14.59)	1.56 (large)	.77 (.64; .85)	Very large
VO2max (ml*kg-1*min-1)	53.21±2.81	50.29±2.83***	2.92 (2.38; 3.46)	1.04 (large)	.73 (.58; .83)	Very large

Mean diff.: standardized mean difference between two trials; *ES:* effect size; 95% CI: 95 percent confidence interval; *R*: Pearson's coefficient of correlation; *Vmax*: maximal running velocity achieved at the final distance; *HRpeak*: peak heart rate; *VO2max*: maximal oxygen uptake; $p < 0.05$.

Discussion

The main purpose of the study was to examine the reliability and validity properties of the 30-15IFT in young female soccer players. Findings suggest that the 30-15IFT is highly reliable for Vmax, HRpeak and estimated VO2max (CV < 2.0% and ICC ≥ .90) and is correlated with objective data ($R>$ .70).

Very high reliability of the 30-15 IFT in this study is in line with previous findings.[2,12,17,18,20-27] Evidence suggests that the 30-15IFT is highly reliable for male and female team sport athletes from handball,[12,18] ice hockey,[20,21] basketball,[12,18,22,23] rugby,[24,25] and soccer.[2,12,17,18,26,27] A recent systematic review by Grgić *et al*.[19] showed that the reliability properties of the 30-15IFT were adequate for male elite ice hockey players (ICC for Vmax = .96, CV = 1.6%; HRpeak = .97, CV = .7%), female elite soccer players (Vmax = .91, CV = 1.8%; HRpeak = .94, CV = 1.2%), female basketball players (Vmax = .85, CV = 6.0%; HRpeak = .96, CV = 4.8%), male elite wheelchair rugby players (Vmax = .99, CV = 1.9%; HRpeak = .95, CV = 4.5%), male rugby players (Vmax = .83 – .94, CV = 1.8 – 2.1%; HRpeak = .96, CV = .6%), male professional soccer players (Vmax = .80, CV = 2.5%), and male and female futsal players (Vmax = .92 – .96, CV = 1.5%; HRpeak = .90 – .91, CV = 1.3 – 1.4%). Although we observed slightly higher values for Vmax, HRpeak and VO2max in trial 2, indicating a potential learning effect, small ES and non-significant test-retest differences indicated that soccer players had a lack of experience in performing the test.[2] Similar reliability findings have been obtained for other intermittent field-based tests, including the Yo-Yo IR1[31,32] and Yo-Yo IR2.[32,33] Data from these tests showed very low CV (< 2.0%).[31,32] On the other hand, the Yo-Yo IR1 and Yo-Yo IR2 have been used as indicators of individual's ability to repeatedly perform intense exercise (Yo-Yo IR1) and the ability to recover from repeated exercise with a high contribution from the anaerobic system (Yo-Yo IR2).[33] Because of these discrepancies of measuring different physical capacities in athletes, studies have shown that the 30-15IFT and Yo-Yo IR are highly correlated in sub-elite female netball players (R= .71; 95% CI .35 – .89),[34] and young soccer players (R= .75; 90% .57 – .86).[26] This would suggest that both tests yield similar intervention changes and sensitivity to training.[26]

Regarding the validity of the 30-15IFT, we found very large correlations with outcome measures of objective data derived from laboratory methods. In specific, we obtained that correlation coefficients were $R>$ .70, denoting good validity properties of the 30-15IFT outcomes in female soccer players. Unfortunately, the validity of the 30-15IFT has yet to be investigated, due to a relatively small number of studies with small sample sizes and different sporting activities.[28] A study by Scott *et al*.[35] showed that the 30-15IFT was largely correlated with other field-based tests (R= .63 - .79) and was a useful tool to predict performance in several anaerobic tasks. However, the relationship was based on estimated, rather than laboratory-based data. The most similar study in soccer by Čović *et al.*[2] exhibited strong positive correlations between the 30-15IFT and continuous running for VO2max (R= .67; 90% CI .28 – .87), HRpeak (R= .77; 90% CI .46 – .91) and Vmax (R=.57; 90% CI .13 – .82), which is somewhat in line to our study. Our data indicated a slightly higher coefficient of correlation for VO2max (R= .73; 95% CI .58 – .83) and higher coefficient of correlation for Vmax (R= .72; 95% CI .58 – .82). A certain discrepancy between the studies might be explained by characteristics of a sample (male vs. female soccer players[2]) and size (n = 48 vs. n = 13[2]). Most recently, a study by Paulsen et al.[27] found a strong relationship between the 30-15IFT and Yo-Yo IR (R= .68 – .82) for performance with ad without the ball, respectively. When observing correlations between Yo-Yo IR 1 and 2 and aerobic capacity, studies found strong correlations among elite female soccer players (R= .70)[33], while Krustrup et al.[36] observed moderate correlations (*R*= .55). According to previous evidence, mean values of Vmax, HRpeak and VO2max were larger for the 30-15IFT in comparison to continuous running, which agrees with our findings.[2] However, data from this study showed that the mean difference in Vmax as the primary outcome of the 30-15IFT was .5 km*h^{-1}, which is lower from previously predicted differences ranging from 2 – 5 km*h^{-1}.[12] Nevertheless, we showed that the outcome measures of the 30-15IFT were valid against the continuous running as ‘the golden standard’ for assessing aerobic capacity in young female soccer players.

This study is not without limitations. Given the potential small sample size (n = 60), we cannot exclude the possibility of the lack of statistical power.

Practical Applications

Based on our findings, the 30-15IFT is confirmed as a reliable and examined as a valid field-based tool to estimate aerobic capacity in team sports, such as soccer. Although the reliability properties have been widely established, validity studies are still lacking, making it relatively impossible to predict Vmax, HRpeak and VO2max from less objective methods. Because of very large correlations between laboratory- and field-based data, the 30-15IFT may serve as an adequate stimuli for monitoring physical capacities and giving an insight into athlete’s physical capabilities and achieving maximal output.[28] Since the test is easy-to-administrate, simple, cost-effective, and can be conducted in larger groups of athletes,[12] it serves as a good alternative to measure important factors of sports performance, like Vmax and HRpeak. Thus, it’s practical ability to estimate someone’s performance level may help strength and conditioning coaches to plan and program training interventions.

Conclusions

In summary, we found that the test-retest reliability of the 30-15IFT was at almost perfect level, and the validity was supported by very large correlations against objective methods. Although differences between the 30-15IFT and continuous running were significant and ESs seemed to be moderate-to-large, the tendency of linear relationship was present. Therefore, the change of speed by .5 km*h^{-1} during 30-s periods interspersed by 15-s recovery intervals is a meaningful time period for athletes to increase or even maintain their aerobic capacity at high level.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Ethical Committee approval

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Topic

Sport science

Conflicts of interest

The authors have no conflicts of interest to declare.

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Author-s contribution

Conceptualization, D.A.; methodology, D.A. and D.Č.; software, D.A.; validation, D.A. and G.S.; formal analysis, D.A. and G.S.; investigation, D.A.; resources, D.A.; data curation, D.A., G.S. and D.Č.; writing—original draft preparation, D.A. and G.S.; writing—review and editing, D.A. and G.S.; visualization, D.A.; supervision, D.A. and G.S.; project administration, D.A CD. All authors have read and agreed to the published version of the manuscript.

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