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Review

Test–retest reliability of the 30–15 Intermittent Fitness Test: A systematic review

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Abstract

Purpose: This review aimed to synthesize previous findings on the test–retest reliability of the 30–15 Intermittent Fitness Test (IFT).
Methods: The literature searches were performed in 8 databases. Studies that examined the test–retest reliability of the 30–15 IFT and presented the intraclass correlation coefficient (ICC) and/or the coefficient of variation (CV) for maximal velocity and/or peak heart rate were included. The consensus-based standards for the selection of health measurement instruments (COSMIN) checklist was used for the assessment of the methodological quality of the included studies.
Results: Seven studies, with a total of 10 study groups, explored reliability of maximal velocity assessed by the 30–15 IFT. ICCs ranged from 0.80 to 0.99, where 70% of ICCs were ≥0.90. CVs for maximal velocity ranged from 1.5% to 6.0%. Six studies, with a total of 7 study groups, explored reliability of peak heart rate as assessed by the 30–15 IFT. ICCs ranged from 0.90 to 0.97 (i.e., all ICCs were ≥0.90). CVs ranged from 0.6% to 4.8%. All included studies were of excellent methodological quality.
Conclusion: From the results of this systematic review, it can be concluded that the 30–15 IFT has excellent test–retest reliability for both maximal velocity and peak heart rate. The test may, therefore, be used as a reliable measure of fitness in research and sports practice.

Keywords: Data synthesis; Intermittent exercise; Repeatability; Reproducibility

1. Introduction

Many team sports have an intermittent structure; that is, they involve repeated high-intensity efforts that are interspersed with periods of lower-intensity activity.[1,2] Intermittent exercise is often characterized by short periods of high exertion that are associated with increases in oxygen consumption, heart rate, and blood lactate concentration, as well as decreases in blood and muscle pH.[3] Several tests have been developed for estimating an individual's capacity to perform intermittent exercise. Some of these tests include the Yo–Yo intermittent recovery test,[3,4] the 20-m shuttle run test,[5] the University of Montreal track test,[6] and the 30–15 Intermittent Fitness Test (IFT).[7–11] These tests are popular among sport and exercise practitioners because they give insights into the current levels of fitness of their athletes, providing a basis for the development of training programs.[3,11]

The 30–15 IFT has gained popularity in recent years in both research and sports practice.[7–11] The test requires a short amount of time to be completed (around 20–30 min) and allows for testing large groups of athletes simultaneously. The test protocol includes 30-s shuttle runs (between 2 lines that are 40 m apart) that are interspersed with 15 s of passive recovery initiated and ended by audio beeps. The starting velocity for this test is 8 km/h, and it is increased by 0.5 km/h in each successive 30-s stage. The test is terminated when the individual volitionally stops due to accumulated fatigue or when the individual is not successful in reaching the next 3-m zone (near the marked line) at the beep on 3 successive occasions. This test is valid for estimating cardiorespiratory fitness.[12] The most commonly assessed outcomes of this test are the maximal achieved velocity and peak heart rate. Scott et al.[13] reported that the maximal velocity in this test correlates with 300-m shuttle time, repeated-sprint time, "Agility 505" test time, and

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20-m flying sprint time. Maximal velocity in the 30−15 IFT is commonly used for the individual exercise prescription of high-intensity intermittent running, an aspect of the test that makes it very appealing for sports practitioners.[7,14−16]

Regardless of whether a test is used for an athlete's fitness assessment, for exercise prescription, or for estimating the effectiveness of a given exercise program, it is important to know its reliability.[17,18] Reliability refers to the independence of a test from measurement error.[17,18] For practitioners, information on reliability can help to determine whether the test scores are trustworthy enough to allow monitoring changes in an athlete's performance. In research, the reliability of tests is important, given that the use of tests with poor reliability may attenuate effect sizes and increase the probability of type II error.[17,18] The current body of evidence on the test−retest reliability of the 30−15 IFT is unclear. For example, Thomas et al.[19] reported a test−retest intraclass correlation coefficient (ICC) for maximal velocity of the 30−15 IFT of 0.80, whereas Kelly et al.[20] reported an ICC of 0.99. According to the classification of ICC values suggested by Koo and Li,[21] the test could be classified as having moderate reliability (if informed by the Thomas et al.[19] study) or as having excellent reliability (if informed by the Kelly et al.[20] study). Therefore, there appears to be no scientific consensus on the test−retest reliability of the 30−15 IFT. Given the inconsistent findings of previous studies, the present systematic review aimed to synthesize individual studies that have explored the test−retest reliability of the 30−15 IFT.

2. Methods

The guidelines proposed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses were employed for the purpose of this review. The search for the studies was conducted through Academic Search Elite, CINAHL, ERIC, PsycINFO, PubMed/MEDLINE, Scopus, SPORTDiscus, and Web of Science (including all Web of Science Core Collection: Citation Indexes) databases. Two authors (JG and BL) performed the searches for the studies independently. After conducting the searches, the included studies were cross-checked between the 2 authors, and a mutual consensus was reached for the final included/excluded studies. In all of the databases that were searched, the following combination of keywords and Boolean operators was used to identify the studies: ("30−15" OR "30 15" OR "intermittent fitness" OR "intermittent-fitness" OR "IFT") AND ("reliability" OR "repeatability" OR "reproducibility"). The search was conducted on January 6, 2020.

Studies that satisfied the following criteria were included in the present review: (1) published in the English language, (2) published in a peer-reviewed journal, (3) examined the test−retest reliability of the 30−15 IFT, and (4) presented ICC and/or coefficient of variation (CV) for maximal velocity and/or peak heart rate. We considered all studies, regardless of the participants' training status or their respective sport.

The following data were extracted from the included studies: (1) details of the sample, including the sample size, sex, and participants' sports experience; (2) the number of days between the first assessment (test) and the second assessment (retest); and (3) ICC and/or CV values. Two authors (JG and BL) independently extracted the data from the included studies. After data extraction, the authors compared the files. Any observed differences in the extracted data were rechecked in the original studies. We based our interpretation of the ICC values on the following thresholds: poor reliability (ICC < 0.50), moderate reliability (ICC = 0.50−0.75), good reliability (ICC = 0.76−0.90), or excellent reliability (ICC > 0.90).[21]

Form B of the consensus-based standards for the selection of health measurement instruments (COSMIN) checklist (designed for reliability studies) was used for the assessment of the methodological quality of the included studies.[22] This form has 11 items that refer to the number of measurements and their administration, the time between test and retest, the adequacy of the sample size, the reporting of ICCs, and any other methodological limitations of the study. The checklist is described in more detail elsewhere.[22] A maximum of 1 point per item is assigned to a study. The overall score on the checklist, therefore, ranges from 0 to 11 points. The following thresholds were used to classify the studies according to their overall methodological quality: excellent quality (9−11 points), moderate quality (6−8 points), and poor quality (fewer than 6 points). Two authors (JG and BL) of the review independently conducted the quality assessment; any differences between the independent assessments were resolved through discussion between the authors until they reached an agreement.

3. Results

Of the 547 search results identified through the databases, 516 were excluded based on their titles and abstracts, whereas 31 full-text papers were read. Seven studies were found to satisfy the inclusion criteria.[12,19,20,23−26] More details about the search and study selection process are presented in the flow diagram (Fig. 1).

The average number of participants per study was 23, while the pooled number of participants across all of the included studies was 159. All of the studies included athletes as participants. They were competitors in basketball, ice hockey, soccer, rugby, wheelchair rugby, and futsal. Four of the studies used a 7-day period between the tests, whereas the remaining 3 studies used 2-, 5-, and 9-day periods (Table 1). All included studies established reliability for maximal velocity, but one of them did not assess test−retest reliability for peak heart rate (Table 1). All included studies presented both ICCs and CVs as measures of test−retest reliability. The included studies are summarized in Table 1.

All studies scored 9 points on the COSMIN checklist and were, therefore, classified as being of excellent methodological quality (Table 2). None of the included studies received a point on Item 3 ("Was the sample size included in the analysis adequate?") or on Item 5 ("Were the administrations independent?").

Seven studies, with a total of 10 study groups, explored reliability of maximal velocity. ICCs ranged from 0.80 to 0.99, where 70% of ICCs were ≥ 0.90. CVs in the included studies for maximal velocity ranged from 1.5% to 6.0%.

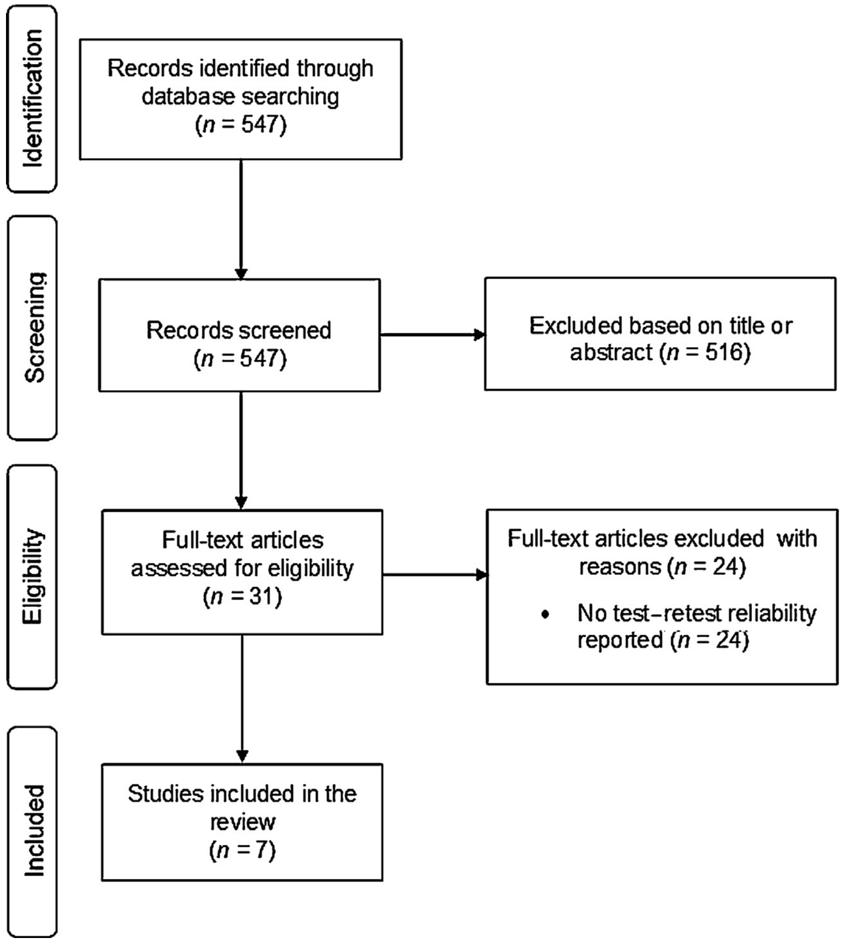

Fig. 1. Flow diagram of the search and study selection process.

Six studies, with a total of 7 study groups, explored reliability of peak heart rate. ICCs ranged from 0.90 to 0.97 (i.e., all ICCs were ≥0.90). CVs in the included studies for peak heart rate ranged from 0.6% to 4.8%.

4. Discussion

This review found that the 30−15 IFT has excellent test−retest reliability for maximal velocity, as shown by high ICCs (≥0.80) and low CV values (≤6.0%). We also found that the 30−15 IFT has excellent test−retest reliability for peak heart rate, given that the ICCs for this outcome were high (≥0.90) and the CVs were low (≤4.8%). All included studies were classified as being of excellent methodological quality, which adds to the credibility of these findings.

As noted previously, the 30−15 IFT is widely used by practitioners.[7−11] Therefore, it is important to compare the reliability of this test with other similar tests that are popular in practice, such as the Yo−Yo test. A recent review summarized findings from 19 studies that explored the test−retest reliability of the Yo−Yo test.[27] Across the included studies, ICCs for the Yo−Yo test ranged from 0.78 to 0.98 (97% of all ICCs were above 0.80), whereas CVs ranged from 3.7% to 19.0% (75% of all CVs were below 10%).[27] Based on this comparison of results, the reliability of the 30−15 IFT seems to be similar to the reliability of the Yo−Yo test.

Interestingly, a study modified the 30−15 IFT and explored its test−retest reliability among athletes competing in wheelchair rugby.[20] The test was performed on an indoor court of 28 m (the length of a court for wheelchair rugby), where the participants were required to push back and forth between the allocated lines.[20] In this modified 30−15 IFT, the authors observed high ICCs and low CVs for maximal velocity (ICC = 0.99; CV = 1.9%) and peak heart rate (ICC = 0.95; CV = 4.5%). The results of this study suggest that the modified 30−15 IFT is a reliable test among wheelchair rugby players.

A learning effect is a well-recognized factor that may influence the reliability of a given exercise test.[18] An individual may become more proficient in a given test with increased experience. This may subsequently decrease the amount of random error in the test results and, hence, improve the reliability of the test. Therefore, in studies focusing on the reliability of exercise tests, Currell and Jeukendrup[18] have suggested that the participants should be familiarized with the testing protocol by performing at least 1 practice session before the main sessions commence. However, of the 7

Table 1
Summary of the studies included in the review.

Study	Sample	Familiarization with the test as a part of the study design	Days between tests	ICC and 95%CI (if reported)	CV (%) and 95%CI (if reported)
Buchheit et al. (2011)[12]	Male elite ice hockey players ($n = 17$)	None	7 days	Maximal velocity: 0.96 (0.91−0.98) Peak heart rate: 0.97 (0.91−0.99)[a]	Maximal velocity: 1.6 (1.3−2.3) Peak heart rate: 0.7 (0.5−1.1)
Čović et al. (2016)[23]	Female elite soccer players ($n = 17$)	None	7 days	Maximal velocity: 0.91 (0.80−0.96) Peak heart rate: 0.94 (0.85−0.97)	Maximal velocity: 1.8 (1.4−2.7) Peak heart rate: 1.2 (0.9−1.7)
Jeličić et al. (2020)[24]	Female basketball players ($n = 19$)	None	7 days	Maximal velocity: 0.85 (0.66−0.93) Peak heart rate: 0.96 (0.81−0.98)	Maximal velocity: 6.0 (4.8−8.2) Peak heart rate: 4.8 (3.8−6.6)
Kelly et al. (2018)[20]	Male elite wheelchair rugby players ($n = 10$)	None	2 days	Maximal velocity: 0.99 Peak heart rate: 0.95	Maximal velocity: 1.9 Peak heart rate: 4.5
Scott et al. (2015)[25]	U16 ($n = 19$), U18 ($n = 21$), and U20 ($n = 15$) male rugby players	One practice session	Within 9 days	Maximal velocity (U16): 0.94 (0.86−0.98) Maximal velocity (U18): 0.92 (0.81−0.97) Maximal velocity (U20): 0.83 (0.56−0.94) Peak heart rate (U20): 0.96 (0.89−0.99)[b]	Maximal velocity (U16): 1.8 (1.3−2.7) Maximal velocity (U18): 2.1 (1.6−3.0) Maximal velocity (U20): 2.0 (1.4−3.1) Peak heart rate (U20): 0.6 (0.5−1.0)
Thomas et al. (2016)[19]	Male semi-professional soccer players ($n = 14$)	None	7 days	Maximal velocity: 0.80 (0.65−0.91)	Maximal velocity: 2.5 (1.9−3.8)
Valladares-Rodríguez et al. (2017)[26]	Male ($n = 13$) and female ($n = 14$) futsal players	None	5 days	Maximal velocity (male): 0.92 (0.82−0.97) Maximal velocity (female): 0.96 (0.89−0.98) Peak heart rate (male): 0.90 (0.63−0.98) Peak heart rate (female): 0.91 (0.79−0.96)	Maximal velocity (male): 1.5 (1.2−2.3) Maximal velocity (female): 1.5 (1.1−2.2) Peak heart rate (male): 1.4 (1.0−2.7) Peak heart rate (female): 1.3 (1.0−1.9)

Note: None of the studies reported ICC type.
[a] Peak heart rate data were obtained from 12 participants.
[b] Peak heart rate data were obtained for a subsample of the U20 group ($n = 13$).
Abbreviations: 95%CI = 95% confidence interval; CV = coefficient of variation; ICC = intra-class correlation coefficient; U16 = under 16 years old; U18 = under 18 years old; U20 = under 20 years old.

Table 2
Results from the methodological quality assessment using Form B of the COSMIN checklist.

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Total score
Buchheit et al. (2011)[12]	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	No	Yes	9
Čović et al. (2016)[23]	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	No	Yes	9
Jeličić et al. (2020)[24]	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	No	Yes	9
Kelly et al. (2018)[20]	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	No	Yes	9
Scott et al. (2015)[25]	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	No	Yes	9
Thomas et al. (2016)[19]	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	No	Yes	9
Valladares-Rodríguez et al. (2017)[26]	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	No	Yes	9

Abbreviation: COSMIN = consensus-based standards for the selection of health measurement instruments.

studies included in our review, only Scott et al.[25] reported that a familiarization session was provided to the participants as a part of the study design. Despite the overall lack of familiarization with the test, both maximal velocity and peak heart rate generally had excellent test−retest reliability. These results suggest that a familiarization session is not needed for an excellent test−retest reliability of the 30−15 IFT. It might be that a familiarization session would even further increase the reliability of 30−15 IFT. It is worth noting that the sample in all the included studies in our review comprised competitive athletes who, in some cases,[12,19] may have already been familiar with similar testing (or training) procedures. Therefore, it remains unclear whether similar results would be observed in untrained individuals. This merits future research, given that the test may also have applications for populations of untrained individuals.

In addition to familiarization with the exercise test, practitioners should also consider that several other factors may impact test reliability. For example, encouragement during the test could introduce another source of random variation because the encouragement may differ among trials, and the participants' responses to the encouragement might not be uniform in each trial.[18] Research has also established that various components of exercise performance vary according to the time of day, with better performance generally observed in the evening hours.[28−30] Additionally, the use of certain supplements, such as caffeine and sodium bicarbonate, has been found to enhance performance in tests similar to 30−15 IFT.[31,32] Practitioners should attempt to standardize these factors as much as possible when conducting trials. For more details on this topic, see the work by Currell and Jeukendrup.[18]

Research has shown that women are more fatigue resistant than are men.[33] Given this physiological difference between sexes, it is possible that men and women would have different responses in the context of test−retest reliability. Of the 7 studies included in our review, only Valladares-Rodríguez et al.[26] included both men and women in their trials. In their study, 13 male and 14 female futsal players performed the 30−15 IFT on 2 occasions. The results of Valladares-Rodríguez et al.[26] indicated that the test was highly reliable both for men (ICC = 0.92; CV = 1.5%) and for women (ICC = 0.96; CV = 1.5%). However, given that this was the only study conducted involving both sexes, future studies with similar research designs are warranted. Additionally, given that the studies included in our review were conducted among basketball, hockey, rugby, soccer, and futsal players (with preliminary data reported for handball),[7,8,11] more research is also needed on the reliability of 30−15 IFT among athletes competing in other sports, particularly those with an intermitted structure, where this test has high applicability.

For the assessment of study quality, we adhered strictly to the guidelines set forth by the research group that developed the COSMIN checklist.[22] This research group has recommended that a sample of 100 participants is needed to classify a reliability study as a study with adequate sample size. It should be noted, however, that this is an arbitrary threshold. The required sample size will depend greatly on the expected ICC and the width of its confidence interval that is deemed acceptable. For example, to achieve the width of 95%CI of ±0.02, the required sample size estimated using the Bonett's[34] calculation would be around 90 participants for the expected ICC of 0.95, or about 350 participants for the expected ICC of 0.90. Nevertheless, given that the largest sample size in the included studies had 55 participants,[25] future studies exploring the test−retest reliability of the 30−15 IFT would definitely benefit from using larger sample sizes.

5. Conclusion

From the results of this systematic review, it can be concluded that the 30−15 IFT has excellent test−retest reliability for both maximal velocity and peak heart rate. Therefore, this test may be used as a reliable measure of fitness in research and sports practice. In particular, the 30−15 IFT can be used as a reliable test for monitoring athletes' performance and for determining the efficacy of a given training program.

Authors' contributions

JG conceived the idea for the review, conducted the literature searches, data extraction, and methodological quality assessment, and drafted the manuscript; BL conducted the literature searches, data extraction, and methodological quality assessment and critically revised the manuscript content; ZP conceived the idea for the review and critically revised the manuscript content. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

References

1. Stølen T, Chamari K, Castagna C, Wisløff U. Physiology of soccer: An update. *Sports Med* 2005;**35**:501–36.
2. Waldron M, Twist C, Highton J, Worsfold P, Daniels M. Movement and physiological match demands of elite rugby league using portable global positioning systems. *J Sports Sci* 2011;**29**:1223–30.
3. 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**:37–51.
4. Krustrup P, Mohr M, Amstrup T, et al. The Yo−Yo intermittent recovery test: Physiological response, reliability, and validity. *Med Sci Sports Exerc* 2003;**35**:697–705.
5. Léger LA, Lambert J. A maximal multistage 20-m shuttle run test to predict VO_{2max}. *Eur J Appl Physiol Occup Physiol* 1982;**49**:1–12.
6. Léger L, Boucher R. An indirect continuous running multistage field test: The Université de Montréal track test. *Can J Appl Sport Sci* 1980;**5**:77–84.
7. Buchheit M. The 30−15 Intermittent Fitness Test: A new intermittent running field test for intermittent sport players: Part 1. *Approches Handball* 2005;**87**:27–34.
8. Buchheit M. The 30−15 intermittent fitness test: Reliability and implication for interval training of intermittent sport players. Paper presented at: *Europe College of Sport Science Proceedings*. Belgrade, Serbia; July 13, 2005.
9. Buchheit M. Illustration of interval-training prescription on the basis of an appropriate intermittent maximal running speed: The 30−15 intermittent fitness test, part 2. *Approches Handball* 2005;**88**:36–46.

10. Buchheit M. The 30−15 intermittent fitness test: 10-year review. *Myorobie J* 2010;**1**:1–9.
11. Buchheit M. The 30−15 intermittent fitness test: Accuracy for individualizing interval training of young intermittent sport players. *J Strength Cond Res* 2008;**22**:365–74.
12. Buchheit M, Lefebvre B, Laursen PB, Ahmaidi S. Reliability, usefulness, and validity of the 30−15 Intermittent Ice Test in young elite ice hockey players. *J Strength Cond Res* 2011;**25**:1457–64.
13. Scott BR, Hodson JA, Govus AD, Dascombe BJ. The 30−15 intermittent fitness test: Can it predict outcomes in field tests of anaerobic performance. *J Strength Cond Res* 2017;**31**:2825–31.
14. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle. Part II: Anaerobic energy, neuromuscular load and practical applications. *Sports Med* 2013;**43**:927–54.
15. Dellal A, Varliette C, Owen A, Chirico EN, Pialoux V. Small-sided games versus interval training in amateur soccer players: Effects on the aerobic capacity and the ability to perform intermittent exercises with changes of direction. *J Strength Cond Res* 2012;**26**:2712–20.
16. Viaño-Santasmarinas J, Rey E, Carballeira S, Padrón-Cabo A. Effects of high-intensity interval training with different interval durations on physical performance in handball players. *J Strength Cond Res* 2018;**32**:3389–97.
17. Atkinson G, Nevill AM. Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Med* 1998;**26**:217–38.
18. Currell K, Jeukendrup AE. Validity, reliability and sensitivity of measures of sporting performance. *Sports Med* 2008;**38**:297–316.
19. Thomas C, Dos'Santos T, Jones PA, Comfort P. Reliability of the 30−15 intermittent fitness test in semiprofessional soccer players. *Int J Sports Physiol Perform* 2016;**11**:172–5.
20. Kelly VG, Chen KK, Oyewale M. Reliability of the 30−15 intermittent fitness test for elite wheelchair rugby players. *Sci Med Football* 2018;**2**:191–5.
21. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med* 2016;**15**:155–63.
22. Mokkink LB, Terwee CB, Patrick DL, et al. The COSMIN checklist for assessing the methodological quality of studies on measurement properties of health status measurement instruments: An international Delphi study. *Qual Life Res* 2010;**19**:539–49.
23. Čović N, Jelešković E, Alić H, et al. Reliability, validity and usefulness of 30−15 Intermittent Fitness Test in female soccer players. *Front Physiol* 2016;**7**:510. doi:10.3389/fphys.2016.00510.
24. Jeličić M, Ivančev V, Čular D, et al. The 30−15 Intermittent Fitness Test: A reliable, valid, and useful tool to assess aerobic capacity in female basketball players. *Res Q Exerc Sport* 2020;**91**:83–91.
25. Scott TJ, Delaney JA, Duthie GM, et al. Reliability and usefulness of the 30−15 Intermittent Fitness Test in rugby league. *J Strength Cond Res* 2015;**29**:1985–90.
26. Valladares-Rodríguez S, Rey E, Mecías-Calvo M, Barcala-Furelos R, Bores-Cerezal AJ. Reliability and usefulness of the 30−15 Intermittent Fitness Test in male and female professional futsal players. *J Hum Kinet* 2017;**60**:191–8.
27. Grgic J, Oppici L, Mikulic P, Bangsbo J, Krustrup P, Pedisic Z. Test−retest reliability of the Yo−Yo test: A systematic review. *Sports Med* 2019;**49**:1547–57.
28. Drust B, Waterhouse J, Atkinson G, Edwards B, Reilly T. Circadian rhythms in sports performance−an update. *Chronobiol Int* 2005;**22**:21–44.
29. Grgic J, Lazinica B, Garofolini A, Schoenfeld BJ, Saner NJ, Mikulic P. The effects of time of day-specific resistance training on adaptations in skeletal muscle hypertrophy and muscle strength: A systematic review and meta-analysis. *Chronobiol Int* 2019;**36**:449–60.
30. Chtourou H, Hammouda O, Souissi H, Chamari K, Chaouachi A, Souissi N. Diurnal variations in physical performances related to football in young soccer players. *Asian J Sports Med* 2012;**3**:139–44.
31. Grgic J, Garofolini A, Pickering C, Duncan MJ, Tinsley GM, Del Coso J. Isolated effects of caffeine and sodium bicarbonate ingestion on performance in the Yo−Yo test: A systematic review and meta-analysis. *J Sci Med Sport* 2020;**23**:41–7.
32. Grgic J, Grgic I, Pickering C, Schoenfeld BJ, Bishop DJ, Pedisic Z. Wake up and smell the coffee: Caffeine supplementation and exercise performance—an umbrella review of 21 published meta-analyses. *Br J Sports Med* 2020;**54**:681–8.
33. Hunter SK. Sex differences in human fatigability: Mechanisms and insight to physiological responses. *Acta Physiol(Oxf)* 2014;**210**:768–89.
34. Bonett DG. Sample size requirements for estimating intraclass correlations with desired precision. *Stat Med* 2002;**21**:1331–5.