

# The Reliability and Sensitivity of the Sub-maximal Yo-Yo Intermittent Recovery test during a 6-week Pre-season

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## Headline

The Yo-Yo Intermittent Recovery – Level 1 (IR1) test is frequently used within professional soccer for the evaluation of a player's physical performance; however, its exhaustive nature often limits the frequency of testing and the implementation of test results to coaching sessions. In replacement, it is suggested the sub-maximal 6-min Yo-Yo IR1 (Yo-Yo IR1<sub>sub</sub>) is more appropriate for routine testing, with much less impact on coaching planning and delivery. Previous research has demonstrated that the heart rate (HR) responses in the final minute of the Yo-Yo IR1<sub>sub</sub> are strongly correlated ( $r = -0.74$ ) to a player's relative maximum HR (%HR<sub>max</sub>) (1). More recently, Owen et al. (2) and Doncaster et al. (3), concluded absolute HR taken in the final minute of the Yo-Yo IR1<sub>sub</sub> provides a practical alternative to the Yo-Yo IR1, due to good levels of reliability (CV = 1.1–1.6%). There is, however, a lack of research focused on the sensitivity of the Yo-Yo IR1<sub>sub</sub> to detect change across a soccer mesocycle (e.g., pre-season).

## Aim

This study aimed to establish the reliability of Yo-Yo IR1<sub>sub</sub>, and the sensitivity of percentage average heart rate (%Avg. HR) and percentage heart rate max (%HR<sub>max</sub>) during a full 6-week pre-season with professional soccer players.

## Design

Longitudinal.

## Methods

**Athletes.** Fifteen professional soccer players (mass  $79 \pm 8$  kg, stature  $183 \pm 8$  cm, age  $20 \pm 2$  years, professionally contracted  $2.8 \pm 2.9$  years) were recruited to participate within the study. All participants were recruited from the same team and played in an elite development/under-21 league, representing an English Premier League club (1<sup>st</sup> tier). The study was completed in alignment with the declaration of Helsinki and was approved by the host university ethics committee. Each participant completed a Yo-Yo IR1 at the beginning and end of a 6-week pre-season, and a Yo-Yo IR1<sub>sub</sub> at the beginning of each training week.

**Yo-Yo IR1 and Yo-Yo IR1<sub>sub</sub> Protocols.** The Yo-Yo IR1 test consisted of 20 m shuttles separated by a 10-s active rest, consisting of 2 x 5 m walking. Each participant completed this protocol until volitional exhaustion, or until they twice failed to complete the shuttle in time with the audio beep after one

warning. The Yo-Yo IR1<sub>sub</sub> was completed following the same protocol outlined above, but all participants were stopped at the start of the 6<sup>th</sup> minute. Testing was performed on an artificial grass pitch surface, with players wearing soccer boots at the same time of day (10:45 h). Weather conditions were similar during all Yo-Yo IR1<sub>sub</sub> tests (temperature  $20.0 \pm 0.9^\circ\text{C}$ ).

During all testing sessions, physiological responses were monitored through a global positioning system (GPS) (Viper Pod, 10-Hz, Statsports, NI) and heart rate belt recording at 5-s intervals (FS1, Polar Electro, Finland). To prevent inter-unit and belt error, each player was assigned the same device and belt for each session (4). The %Avg. HR and %HR<sub>max</sub> during the Yo-Yo IR1<sub>sub</sub> were calculated from the average HR observed during the entire duration of the 6-min test, and relative to the maximum HR observed during the Yo-Yo IR1.

**Statistical Analyses.** To examine the sensitivity of the Yo-Yo IR1<sub>sub</sub> during pre-season, participants who had completed one test per week for the duration of the 6-week period were included for analysis ( $n = 8$ ). To establish the reliability of the Yo-Yo IR1<sub>sub</sub>, participants who had completed two trials within 1-week of each other were included for analysis ( $n = 15$ ). Finally, to compare the difference between the pre pre-season and post pre-season, participants who had completed the Yo-Yo IR1 in weeks 1 and 6 were included for analysis ( $n = 10$ ). Comparisons of HR data between weeks were analysed through a one-way repeated measures ANOVA, with a simple contrast to compare weekly changes in %Avg. HR and %HR<sub>max</sub>. A paired-samples t-test was used to compare the total distance covered during the full Yo-Yo test between week 1 and week 6 of pre-season. The reliability of the Yo-Yo IR1<sub>sub</sub> was measured using intraclass correlation coefficient (ICC) and CV, with a value of  $<5\%$  deemed acceptable (5). The smallest worthwhile change (SWC) was calculated for %Avg. HR and %HR<sub>max</sub> following guidelines by Hopkins (5). The substantial change (6) was calculated as the SWC + CV. All data are presented as mean  $\pm$  SD, with statistical analyses completed using SPSS (v26, IBM) and statistical significance set at  $P < 0.05$ .

## Results

The mean distance performed during the Yo-Yo IR1 significantly increased following the 6-week pre-season training,  $P = 0.002$  (pre =  $2384 \pm 239$  m vs. post =  $2732 \pm 278$  m) (Figure 1). A one-way repeated measures ANOVA showed a significant difference between the weekly %Avg. HR during the Yo-Yo IR1<sub>sub</sub> test ( $P = 0.001$ ). Additionally, there was a

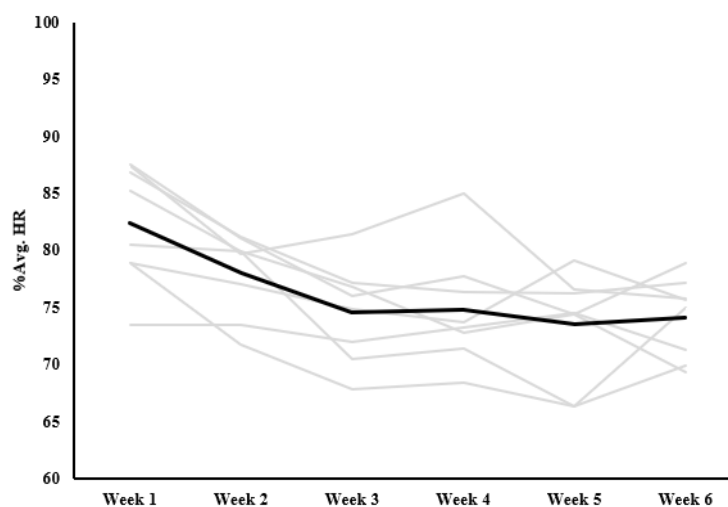
significant difference between weeks for %HR<sub>max</sub> ( $P < 0.001$ ), demonstrating that the Yo-Yo IR1<sub>sub</sub> test is sensitive to the physiological changes observed during pre-season (Table 1).

Following repeat testing of the Yo-Yo IR1<sub>sub</sub>, a CV for %Avg. HR and %HR<sub>max</sub> of 3.6% and 1.6%, respectively were observed. The SWC for %Avg. HR and %HR<sub>max</sub> was 2.1% and 1.6%, respectively, resulting in a substantial change of

5.7% and 3.2%, respectively. Additionally, an ICC of 0.66 was observed for %Avg. HR and 0.76 for %HR<sub>max</sub>. Given the reported changes in %Avg. HR and %HR<sub>max</sub> were 9.8% and 8.8%, respectively (Table 1), it is suggested that the Yo-Yo IR1<sub>sub</sub> is sensitive to monitor meaningful physiological changes.

**Table 1.** Mean of %Avg. HR and %HR<sub>max</sub> during each week of pre-season

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	% Change (Week 1-6)
%Avg. HR	82 ± 3	78 ± 4*	75 ± 4*	75 ± 5*	73 ± 5*	74 ± 4*	9.8
%HR <sub>max</sub>	91 ± 4	86 ± 4*	83 ± 4*	84 ± 4*	83 ± 5*	83 ± 3*	8.8



**Fig. 1.** Yo-Yo IR Test Performance (distance in m), pre- and post- pre-season

**Discussion**

This study aimed to ascertain the reliability of the Yo-Yo IR1<sub>sub</sub> and its sensitivity during a soccer 6-week pre-season. The results suggest that the non-exhaustive Yo-Yo IR1<sub>sub</sub> demonstrates acceptable between-day reliability, together with the sensitivity to detect physiological changes over a 6-week pre-season. These findings suggest that the Yo-Yo IR1<sub>sub</sub> could potentially provide valuable information for sports scientists and coaches from non-exhaustive methods concerning the evaluation of physical performance and how individuals respond differently during pre-season (Figure 2 and 3).

The results of this study suggested that the Yo-Yo IR1<sub>sub</sub> is reliable with a CV of 3.6% for %Avg. HR and 1.6% for %HR<sub>max</sub>. These results are in line with previous research by Krstrup et al.(7), Fanchini et al.(8) and Owen et al. (4), who all reported that the Yo-Yo IR1<sub>sub</sub> is a reliable testing protocol, with a CV of 4.9%, 2.2% and 1.6% reported, respectively, when measuring HR in the 6<sup>th</sup> minute of the testing protocol. It is essential in applied sports science research for testing methods to demonstrate reliability between testing days, especially when used to monitor changes in performance.

Following a 6-week pre-season, the participant’s Yo-Yo IR1 performances significantly improved by approximately 12% (Figure 1), which is in line with the results of a study by Krus-

trup et al.(8), but less than the 25% improvement observed by Fanchini et al. (8). It is noted, however, that Fanchini et al. (8) completed post-training block testing following a period of 3 weeks of training and 8 weeks of soccer-specific training and matches. The participants in their study would therefore have had a longer time to gain cardiorespiratory fitness. In addition to the greater period of training exposure, Fanchini et al. (8) completed their study using youth soccer player (age = 17 ± 1 years) from a 4th division Italian professional club, and it is widely documented that greater Yo-Yo IR1 performance occurs for amateur/semi-professional soccer players when compared to professional players (9,10).

Directly comparing week 1 to week 6, an improvement of 9.8% and 8.8% was observed for %Avg. HR and %HR<sub>max</sub>. Therefore, with %Avg HR and %HR<sub>max</sub> demonstrating a CV of 3.6% and 1.6%, a SWC of 2.1% and 1.56%, alongside a substantial change of 5.4% and 3.2%, respectively, the actual change in performance of -8 and -9% (Table 1) observed during pre-season can be interpreted as a worthwhile and detectable change. This study has suggested that the Yo-Yo IR1<sub>sub</sub> is sensitive to detect physiological changes within professional soccer players, with significant differences observed for all HR measures between each week when compared to week 1 (Table 1).

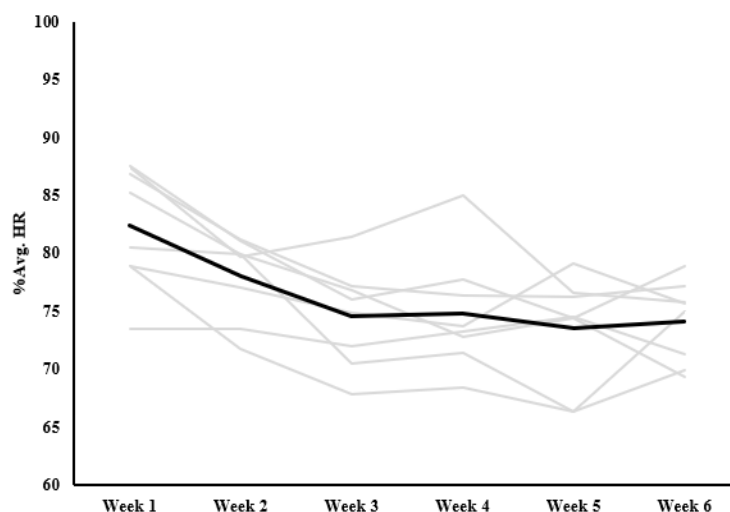


Fig. 2. Individual weekly %Avg. HR responses during the Yo-Yo<sub>sub</sub>. The solid black line represents the group mean

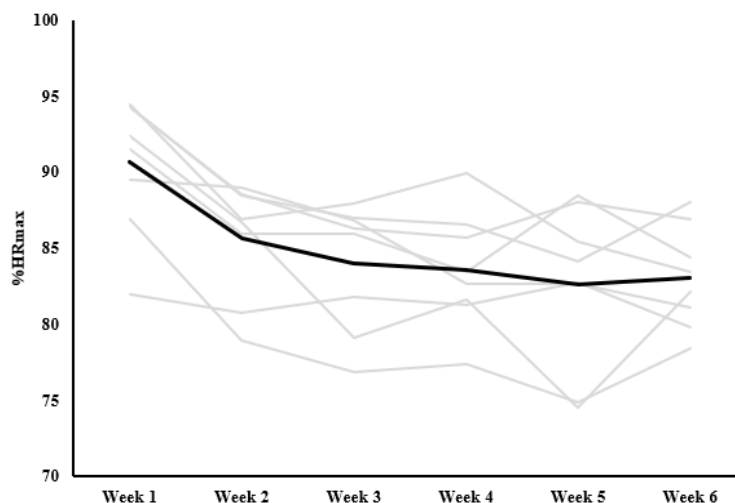


Fig. 3. Individual weekly %HR<sub>max</sub> responses during the Yo-Yo<sub>sub</sub>. The solid black line represents the group mean.

**Practical Applications**

- The results demonstrate that the Yo-Yo IR1<sub>sub</sub> can provide valuable information about soccer fitness during a pre-season training period, without the requirement for maximal testing.
- It is suggested that the Yo-Yo IR1<sub>sub</sub> reduces the impact on the coaching programme, on the strength of being undertaken at the start of a session, allowing for all practitioners to work symbiotically, rather than having to compete for additional time within a typical coaching plan.
- It suggested that sub-maximal testing is utilised throughout the season to monitor the performance of professional soccer players.

**Limitations**

- All participants within this study were part of the same soccer team, and whilst this is essential for controlling ex-

ternal variables, it is unclear if the results of this study could be generalized to other teams, with a different pre-season training plan.

- It is noted that the sample size of this study is relatively small (n = 8–15), and the use of professional soccer players from a development/under 21 squad, meant that some players had to be excluded from the study, or sections of the analyses, due to being on loan, or being recruited to represent the senior team.

**Conflicts of Interest**

The authors confirm there are no conflicts of interest.

**Dataset**

Dataset available on request to the authors.

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