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The Effects of Speed-Based High-Intensity Interval Training on The Physical Fitness of Elite Female Football Referees: A Pilot Study

Zhang Lingling[1,2], Kim Geok Soh[1], Salimah Japar[3], Suriyan Somphong[4], Komkrit Rattamanee[4], Siswantoyo[5], Erwin Setyo Kriswanto[5]

[1]Faculty of Educational Studies, Universiti Putra Malaysia, Serdang, 43400, Selangor, Malaysia, [2]The national football academy, Shandong Sport University, Jinan, China, [3]Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Malaysia, [4]Faculty of Science and Technology, Suan Sunandha Rajabhat University, Thailand, [5]Faculty of Sport Science, Universitas Negeri Yogyakarta, Sleman, Yogyakarta, Indonesia

Corresponding Auhor: kims@upm.edu.my

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Abstract

Speed-based high-intensity interval training (HIT) is used for team sports and has shown positive results. In comparison to the amount of literature that has used heart rate-based (HR-based) high-intensity interval training, there has been nothing to assess the impact of speed-based HIT on football referees. The primary objectives aimed to enhance comprehension regarding the influence of various exercise intensity settings, specifically focusing on high-intensity interval training, on the fitness levels of referees. This investigation scrutinized the physiological reactions resulting from diverse high-intensity training regimens and their effects on the referees' fitness. In order to gauge the physical demands of high-intensity interval training, both perceived exertion (RPE) and heart rates were documented throughout training sessions and assessments, while lactate acid levels were measured during the tests. The evaluation of referees' fitness levels employed the Dynamic Yo-Yo intermittent recovery test, along with assessments of repeat speed ability and agility. The comprehensive training workload for each training session was evaluated for both groups using the rate of perceived exertion (RPE) method. The training load of the two groups was similar and as they are expected. Within-group analysis showed that referees in the speed-based high-intensity interval training group (17.2) had a better improvement in distance covered in the DYY test than the HR-based group (8.4%) after the four-week training intervention. The lowest test result (level 15.8) in the two tests (pre-test and post-test) among the two groups was taken as the node, and the mean heart rate between the two groups at this node was compared respectively. The speed-based high-intensity interval training group had a similar

improvement of HRmean in the DYY test with the heart rate-based group after the four-week training intervention. A structured high-intensity training program can significantly improve the physical fitness level of football referees. Individualized high-intensity interval training using a percentage of VIFT as an exercise intensity reference is more likely to be an effective strategy for improving a referee's high-intensity running performance than high-intensity interval training based on HRmax percentages.
Keywords: High-Intensity Interval Training, Dynamic Yo-Yo Test, Football Refereeing

Introduction

With the development of football techniques and tactics, the game speed is getting faster. The physical demands on referees are getting higher. However, the research on the fitness training of referees is scarce. To increase football players' cardiorespiratory fitness, high-intensity interval training (HIT) is one of the most often used forms of exercise (Rabbani & Buchheit, 2015; Chamari et al., 2005). Krustrup and Bangsbo (2001) reported heart rate-based HIT had a positive effect on football referees' fitness levels.

The high-intensity training based on heart rate has been questioned to some extent. Heart rate cannot accurately indicate intensities beyond the minimum running speed that triggers maximal oxygen uptake (vVO2max) and maximum heart rate (HRmax) (Rabbani & Buchheit, 2015). The adoption of speed-based high-intensity interval training can objectively reflect the aerobic, change-direction, recovery, and other abilities of athletes. It can not only objectively reflect the real match demands fitness of football referees, but also effectively develop the fitness level.

The physical requirements of soccer referees are similar to those of soccer players, so high-intensity interval training based on speed may be effective in developing the physical requirements of soccer referees. This study was a pilot study with training over 4 weeks and pre - and post-tests. The influence of high-intensity interval training based on different exercise intensity references on the physical fitness of female elite referees was preliminarily identified.

Methods

Participants

The participants in this study were 16 football male and female referees from Sichuan China. They were randomly divided into two groups of 8. Inclusion criteria: (1) National and above level; (2) Can continuously complete the specified training; (3) Wear the requested brand heart rate watch during training; (4) Cooperate to submit the corresponding data. Exclusion criteria: (1) Got injury affecting implementation of the requested HIT. The study was approved by the Ethics Review Committee of Shandong Sport University.

Baseline feature

Training history and injury information, including age, sex, height, weight, training types, frequency, carry injuries, and injury location and extent. A self-made questionnaire was used to collect the demographic characteristics and basis of the subject's implementation of training. The mean age of the control group is 32.8+ 4.2 years, it's 31.5+ 5.1 for the experimental group. The referees have 2-18 years of national and above refereeing experience. These referees had all registered with the Chinese Football Association (CFA). All the participants are notified orally and sign an informed

Training

Training Sessions

Four week-long training program for the referees was introduced two weeks before the intervention. The participating referees were provided with a weekly training schedule via the WeChat group. The plan outlined two high-intensity interval training (HIT) sessions per week and recommended incorporating strength and speed sessions. This study is only focused on the HIT sessions. One group takes heart rate-based high-intensity interval training, the expected heart rate zone is >90%HRmax. Another group took speed-based high-intensity interval training, the participants took 30-15 intermittent fitness tests (IFT) before they started this 4-week training program. The ending velocity of the IFT (VIFT) is used to set the exercise intensity. The intensity is considered 75% VIFT equal to 90 %HRmax (Rabbani & Buchheit, 2015).

Heart rates of the referees during training sessions were captured through short-range telemetry utilizing Polar Vantage M2 watches (Polar, Kempele, Finland), with data recorded every 5 seconds. Subsequent to each group training session, the recorded data were uploaded to Polar Flow. The coach then selected the data from the relevant period and stored it in an Excel table for subsequent analysis.

Training Monitoring

Referees receive training plans for the coming week every Sunday, which are sent to them via public social media. The intensity, frequency, and duration of training varied over the four weeks. Except for high-intensity training, the rest of the week advises on the type of training, with no specific schedule. All participants were asked to upload heart rate meter data to pola flow immediately after each training session. Fill in the training diary, including the type and length of each training session, and the experience of the two high-intensity training sessions (RPE). Record average and maximum heart rate during training. After analyzing individual heart rate data, coaches retain plans for the following week or fine-tune them and make requests or instructions to individual referees. The authors of this study developed and rigorously oversaw all training procedures.

Tests

Dynamic Yo-Yo (DYY) Intermittent Recovery Test

Two times fitness tests were conducted before and after the 4 weeks training program. The test was a dynamic YO-YO test (DYY). The DYY test is one of the FIFA referee's optional fitness tests. This test is modified through the Yo-Yo Intermittent Recovery Test. It is similar to the classic Yo-Yo Intermittent Recovery Test. Only the location is all around the football field according to the referees' position during the actual game. To gain the reliability of this test, we confirmed all the locations of the marks (Figure 1).

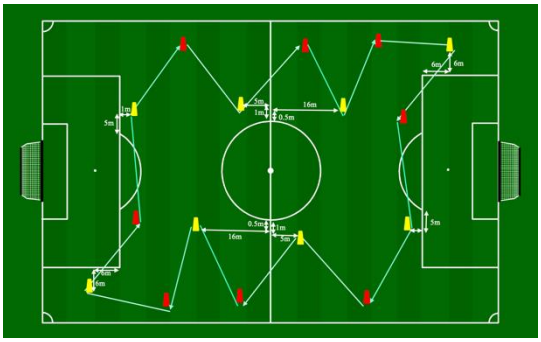

Figure 1: The field setting-up of the DYY test.

A 30-to-15-second intermittent fitness test involves covering a specific distance while actively recovering for 15 seconds. It progresses in levels, with a 0.5 km/h rise per 45-second level, and begins at a relatively easy speed of 8 km/h. The start, middle, and end lines have safe zones of three meters on the side. Failure is deemed to have occurred if an athlete does not enter the safe zone by the beep. Before the exam is over, athletes are permitted three failures. The previous speed of failure is recorded. This study uses the speed obtained in 30-15 intermittent fitness test (IFT) (Figure 2).

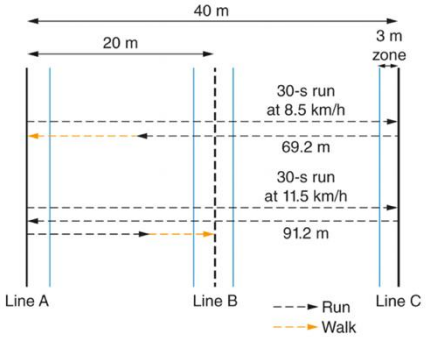

Figure 2: The field setting-up of 30-15 intermittent fitness test (IFT)

Data Analysis

The referees' maximum heart rate (HRmax) was determined during matches, high-intensity speed endurance training sessions, or through the Yo-Yo intermittent recovery test or the dynamic Yo-Yo intermittent recovery test. To establish various heart rate zones relative to the referees' HRmax, activity categories were differentiated based on existing literature (Catterall et al., 1993; Helsen & Bultynck, 2004). High intensity was defined as the zone >86% HRmax. Differences in the referees' mean and peak heart rates (expressed as a percentage of HRmax) between the pre-test and post-test were assessed using a paired t-test. The analysis of the distance covered in the dynamic Yo-Yo test employed a two-way ANOVA with a 2 (group) (heart rate-based, VIFT-based) by 2 (testing period) repeated measures design. In case of a significant interaction, the data were further examined using a Scheffe test. The threshold for significance was set at $P < 0.05$.

Results

The comprehensive training workload for each group was evaluated during every training session utilizing the rate of perceived exertion (RPE) method (Impellizzeri et al., 2004) (Table 1). The training load of the two groups was similar as they are expected. Within-group analysis showed that referees in the VIFT-based HIT group (17.2) had a better improvement of distance covered in the DYY test than the HR-based group (8.4%) after the four-week

training intervention (Table 2) . The lowest test result (level 15.8) in the two tests (pre-test and post-test) among the two groups was taken as the node, and the mean heart rate between the two groups at this node was compared respectively. The VIFT-based HIT group had a similar improvement of HRmean in the DYY test with the HR-based group after the four-week training intervention (Table 3).

Table 1

Four weeks training load (mean ± sd) for the vift-based and hr-based high-intensity interval training group.

Types of HIT	VIFT-based Group	HR-based Group
Four Weeks Training Load	7516 ± 169	7488 ± 289

Note: HIT: High-intensity Interval Training, VIFT: the maximum speed reached at 30– 15 Intermittent Fitness Test, HR: Heart rate, SD: standard deviation.

Table 2

Average values and standard deviations of the distance covered in the Dynamic Yo-Yo Intermittent Recovery Test are provided for both the Heart Rate-Based High-Intensity Interval Training (HIT) group (n=8) and the Speed-Based HIT group (n=8) in meters.

	Pre-test		Post test
Heart rate-based group Mean SD	1520 400		1648 520
		1560	1828
Speed based group Mean SD	480		279

Note. *Significant difference between heart rate-based and speed-based referees (P <0.05).

Table 3:
Mean Values and Standard Deviations of heart rate on the Dynamic Yo-Yo Intermittent Recovery Test for Both Heart Rate Based HIT (n=8) and Speed Based Groups (n = 8) (in meters).

	Pre-test	Post test
Heart-based Group		
Mean	168[a]	166
SD	25	24
Speed based Group	170	167
Mean	26	23
SD		

Note: [*]Significant difference between heart rate-based and speed-based referees (P <0.05).

Table 2 presents a summary of the means ± SD for the distances covered by the referees in the Dynamic Yo-Yo (DYY) test. The outcomes of the statistical analysis revealed a significant impact for both the speed-based and HR-based High-Intensity Interval Training (HIT) groups. In Table 3, a comparison is provided between a referee's heart rate response in test 1 and test 2. The table illustrates performance improvement in both groups, as anticipated, alongside a reduction in submaximal heart rates observed throughout the test.

Discussion

This study investigated the immediate impact of targeted high-intensity interval training sessions on the fitness levels of football referees. To assess the influence of these training sessions, we employed the Dynamic Yo-Yo intermittent recovery test, recognized as one of the FIFA optional fitness tests for referees.

Although heart rate stands as the prevailing method for evaluating exercise intensity during High-Intensity Interval Training (HIT), this approach has various limitations, such as the challenge for practitioners in regulating running intensity. To address these constraints, several studies have adopted the speed achieved at the conclusion of the 30–15 Intermittent Fitness Test as a benchmark for exercise intensity.

The primary aim of this study was to, for the first time, evaluate the impacts of two methods for determining exercise intensity in High-Intensity Interval Training (HIT) on the high-intensity intermittent running performance of football referees. The exercise intensity was set based on either the maximum speed attained during the 30-15 Intermittent Fitness Test (IFT) or the maximum heart rate (HRmax). The key finding is that both groups, utilizing different approaches, demonstrated significant enhancements in high-intensity intermittent running performance after four weeks. Notably, the Velocity at Intermittent Fitness Test (VIFT)-based group exhibited greater improvement in the Dynamic Yo-Yo (DYY) test compared to the Heart Rate (HR)-based group.

Typical comparisons of training interventions generally require equated training doses or durations. Using heart rate as the basis of exercise intensity is often convenient for post-training evaluation. It is very inconvenient to grasp the target heart rate zone during the training process, the actual training results are often higher or lower than the target heart rate zone. As shown by the RPE in this study, the HR-based HIT group had a higher variance.

Such unstable results somehow reveal the instability of actual training intensity, and it is difficult to follow the principle of Super compensation. The body can't adapt as expected, and it's especially difficult to achieve periodic goals. This may be the main reason the heart rate-based group did not perform as well as the VIFT group during the DYY test.

Conclusion

The data from this study suggest that a structured high-intensity training program can significantly improve the physical fitness level of football referees, as demonstrated in the DYY test. Individualized HIT using a percentage of VIFT as an exercise intensity reference is more likely to be an effective strategy for improving a referee's high-intensity running performance than HIT based on HRmax percentages in the dynamic YO-YO test.

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