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*Original Research*

# In-Season High-Intensity Interval Training Improves Conditioning In High School Soccer Players

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ABSTRACT

***International Journal of Exercise Science 10(5): 713-720, 2017.*** Soccer is characterized by high aerobic demands interspersed with frequent bursts of anaerobic activity. High-intensity interval training (HIIT) is considered a viable alternative to traditional endurance conditioning and offers the additional time-saving benefits of anaerobic training. We hypothesized that HIIT will compare favorably to traditional (aerobic-based) soccer conditioning over the course of a high school soccer season. Junior varsity soccer players were split into control (CON, n=16) and experimental (HIIT, n=16) groups for the 10-week study. The HIIT group performed 4-6 "all-out" sprints lasting 30s each, with 4.5 minute recovery, 3 times a week. The CON group performed endurance running for the same duration. The groups did not differ in any other aspect of their training. Participants completed the Yo-Yo intermittent recovery test level 1 (IR1), a 40-yard dash, vertical jump, Illinois agility test, and a sit-and-reach test, in two different testing sessions (pre/post season). Both HIIT and CON groups exhibited significant increase in IR1 test performance with time (741.6±307.6m vs. 1067.6±356.8m, $p$<.001 and 733.2±318.8m vs. 1165.2±252.8m, $p$<0.001 respectively), with no difference between groups. The CON group demonstrated a significant difference in the 40-yard dash over time (5.48±0.36s vs. 5.21±0.16s, $p$<0.004). While there was a difference in vertical jump between the pre and post tests for the HIIT group (42.20±7.04cm vs. 47.87±750cm respectively, $p$<0.019), no such effect was observed in the CON group. In contrast, there were differences in the agility test only for the CON group over time (16.67±0.76s vs. 16.15±0.49s, $p$<0.001). There were no differences in the flexibility test between groups. Our results indicate that HIIT offers similar endurance improvements to more traditional soccer training.

KEY WORDS: Soccer, high school, conditioning, High-intensity interval training, Yo-Yo test

## INTRODUCTION

Physical fitness has been shown to have a key role in success during a soccer match. Over a 90-minute match, elite youth (ages 13-18) soccer players engaging in intermittent activity will often cover distances greater than six kilometers, placing an importance on the aerobic metabolic pathway (1). Improvements in aerobic power have been shown to affect the number

of sprints, involvements with the ball, and distance covered during a soccer match (8). The same study demonstrated that players' heart rate during a soccer match can reach values approximating 80-90% of an age-predicted heart rate max, further highlighting the demands placed on the anaerobic metabolic pathway on top of aerobic fitness (8). At the same time, observations of specific player movements throughout a match suggest that high-intensity activity is an important factor for performance and success in professional soccer (2, 8, 12, 15). Studies in young players indicate that soccer specific tasks such as passing accuracy and involvement with the ball decline after short bouts of high-intensity exercise (14). Others have also demonstrated the detrimental effects of the game on sprint performance (10). These findings suggest that training programs should place emphasis on repeated bouts of high intensity work, with and without the ball. Indeed, most teams focus on both aerobic and anaerobic conditioning during pre-season workouts.

The problem is that despite existing knowledge that improved physical conditioning positively influences soccer performance, this aspect of training is largely ignored as the competitive season progresses and practice time is allocated to other important activities (11). This phenomenon is most prevalent in high school and collegiate soccer, where the time available for practice is a limiting factor during the season. The need to revisit training practices in soccer during a competitive season was recently highlighted (17). Thus, the potential for a team coach to maintain and/or increase aerobic power and anaerobic capacity throughout the competitive season within a limited amount of time dedicated to conditioning may provide a solution to this time constraint.

In recent years, High-intensity interval training (HIIT) has been proposed as a preferred method of exercise when time is limited. A HIIT protocol using repeated maximal effort on a cycle ergometer in a laboratory setting at a reduced time commitment (one third) of traditional endurance training proved to be equally effective at enhancing anaerobic power and providing similar skeletal muscle adaptations as aerobic training (4, 5). Previous work in our laboratory demonstrates that a four-week HIIT period yielded similar results to traditional aerobic conditioning ($\dot{V}O_{2max}$) in female collegiate soccer players (16). Yet, these studies were conducted in a laboratory/field setting using methodology and equipment not always available to a soccer coach. It is therefore of interest to demonstrate the effectiveness of HIIT to maintain and/or improve both aerobic and anaerobic conditioning using field tests commonly available and easy to administer. In addition, there is no research exploring this HIIT method for a period longer than six weeks, so we elected to compare HIIT to traditional soccer conditioning with high school soccer players over a ten-week competitive season. It was hypothesized that HIIT would compare favorably to the traditional conditioning program.

## METHODS

*Participants*

Participants who were free of underlying medical conditions via a physical activity readiness questionnaire and were medically cleared to participate in high school athletics were allowed to participate. In addition participants were required to provide written assent along with their

guardians' written consent before they were allowed to participate in the study. High school junior varsity soccer players volunteered to participate in the study over the course of a 10-week fall competitive season. Of the initial n=38 participants, only n=32 (HIIT, n=16, and CON, n=16) completed both pre- and post-training testing and were included in this study (age HIIT: 15.06 ± 0.77 years, CON: 14.81 ± 1.22 years). The remaining players (n=6) were dropped from the study due to injury, missing testing sessions, or declined to participate after the first testing session.

*Protocol*

During the pre- and post-intervention sessions, age, weight, and height, were recorded for all participants. In order to compare the effects of HIIT in all the physical aspects of the game, time for the 40-yard dash, time for the Illinois agility test, vertical jump ability, and sit-and-reach flexibility were measured and recorded. For consistency, the same technician performed each of the measurements. After this testing was completed participants performed the Yo-Yo IR1 test, previously shown to be a reliable and valid test of aerobic capacity in soccer players (10). All testing sessions were conducted indoors at similar times of day with a total time commitment of 1.5-2 hours. After the baseline Yo-Yo IR1 test, participants were randomly placed into two groups (HIIT vs. CON) using a stratification randomization protocol, placing the highest score into one group the next highest into the other group and repeating the process for all participants.

For the first two weeks of the 10-week study the experimental group (HIIT) performed a HIIT protocol of a 30 second all-out sprint with 4.5 min active recovery, for four repetitions, three times a week. At week 3 the repetitions increased to five, and from week 5 onward it was increased to six, keeping HIIT training at 3 times a week. Meanwhile the control group (CON) underwent normal team conditioning, consisting primarily of endurance training (i.e. long runs), for the same time duration as the HIIT group. All aspects of this project were approved by the Institutional Review Board.

40-yard Sprint Test: Participants ran twice at maximum speed across a 40-yard distance, with a 2-minute walking rest between trials. The participants stood behind the starting line and the test was terminated when any part of their body crossed the finish line. The test began at the movement of the participant. A practitioner recorded the time after each trial, and the fastest score was used for all further analyses.

Sit-and Reach Flexibility Test: Participants performed two trials of the sit-and-reach. Participants placed their feet against a sit-and-reach apparatus while sitting on the floor with knees touching the floor. The participant reached as far as possible across the apparatus while the practitioner gently held the knees to the ground. Once the farthest distance was reached, the participant held the position for 2 seconds. After this was repeated for the second trial the practitioner recorded the distances, and the highest score was recorded for the test.

Illinois Agility Test: Participants performed a timed Illinois agility test; this was performed running a specific pattern around cones as previously described (6) and shown to be both

reliable and valid (19). The test began on the movement of the participant and finished as the participant crossed the finish. A practitioner recorded the time after the trial.

Vertical Jump Test: Participants used a calibrated, commercially available vertical jump test apparatus (Vertec). After their standing height was recorded using the fully outstretched arm, they performed a vertical jump and touched the highest possible vane on the apparatus. The difference between the standing reach height and highest point reached was recorded by the practitioner.

Yo-Yo IR1 test: The Yo-Yo IR1 protocol followed the specific procedure described by Krustrup et al. (2003) and further validated (3). Briefly, participants performed shuttle runs of 2x20 m initiated by a beep. After each set of shuttles, a beep initiated a 10-second 2x5 m recovery jog. After the 10 seconds another beep signaled the next 2x20 m shuttle. As the process repeated, the length of time to cover the 2x20 m shuttle slowly decreased while the 10-sec interval remained constant. Failure to complete the shuttles before the recovery beep on two consecutive occasions ended the test for a participant, and the total number of shuttles was recorded.

*Statistical Analysis*

Paired t-tests examined within group differences in height and weight between the start (PRE) and the end of the study (POST). A two-tailed 2x2 repeated measures ANOVA test (group X time) was performed to find mean differences in the 40-yard dash, sit-and-reach, Illinois Agility test, vertical jump test, and the Yo-Yo IR1 test between the two groups and between the start and end of the season. Cohen's $d$[2] was used to calculate effect size and the G-Power software was used to calculate power for all statistically significant findings. Significance was set at $\alpha$=0.05 for all analyses.

## RESULTS

Throughout the 10-week period of the study, the average weight remained the same for the CON group (PRE: 64.87±6.26 Kg vs. POST: 64.85±5.54 Kg, $p$=0.969) and the HIIT group (PRE: 65.15±10.50 Kg vs. POST: 67.29±10.02 Kg, $p$=0.139). The same was true for the average height for the CON group (PRE: 172.99±5.70 cm vs. POST: 173.56±5.97 cm, $p$=0.082) and the HIIT group (PRE: 173.87±8.48 cm vs. POST: 174.62±7.79 cm, $p$=0.546).

There was no effect of time on the sit-and-reach test for the CON group ($p$=0.61) or for the HIIT group ($p$=0.211) and no difference between the two experimental groups at PRE ($p$=0.249) or POST ($p$=0.749).

There was a statistically significant effect of time on the Illinois Agility Test for the CON group ($p$=0.001), with a moderate effect size = 0.53, and high statistical power= 0.81. No differences were noted for the HIIT group ($p$=0.911). There were no differences between the two experimental groups at PRE ($p$=0.262) or POST ($p$=0.627).

There were no improvements in the vertical jump test score for the CON group ($p$=0.078), but there was a statistically significant effect of training for the HIIT group ($p$=0.019) with a moderate effect size = 0.46 and moderately high power = 0.59. There were no differences between the two experimental groups at PRE ($p$=0.284) or POST ($p$=0.061).

There were statistically significant effect of time on the 40-yard sprint test for the CON group ($p$=0.004, high effect size = 0.84 and high power = 0.99). There was no significant effect of time for the HIIT group ($p$=0.132). There were no differences between the two experimental groups at PRE ($p$=0.338) or POST ($p$=0.794).

Finally, there was a statistically significant effect of time on the Yo-Yo IR1 test for the CON group ($p$<0.001, high effect size = 0.85 and high power = 0.99) and the HIIT group ($p$=0.001, moderate effect size = 0.65 and moderate power = 0.65), and there were no differences between the two experimental groups at PRE ($p$=0.945) or at POST ($p$=0.406).

**Table 1.** Summary results for the fitness tests associated with performance in soccer.

| | Pre | Post |
|---|---|---|
| **40 yard dash (s)** | | |
| CON | 5.48 ± 0.36 | 5.21 ± 0.16† |
| HIIT | 5.36 ± 0.27 | 5.18 ± 0.33 |
| **Sit-and-Reach (cm)** | | |
| CON | 30.50 ± 5.69 | 30.07 ± 6.99 |
| HIIT | 27.66 ± 6.79 | 29.15 ± 7.77 |
| **Agility test (s)** | | |
| CON | 16.67 ± 0.76 | 16.15 ± 0.49 † |
| HIIT | 16.26 ± 1.02 | 16.29 ± 0.92 |
| **Vertical Jump (cm)** | | |
| CON | 39.37 ± 6.42 | 42.59 ± 6.45 |
| HIIT | 42.20 ± 7.04 | 47.87 ± 7.50 † |
| **Yo-Yo IR1 (m)** | | |
| CON | 733.2 ± 318.8 | 1165.2 ± 252.8 † |
| HIIT | 741.6 ± 307.6 | 1067.6 ± 356.8 † |

Values are represented as means ± SD, † = differences between PRE and POST, $p$<0.05

## DISCUSSION

Previous literature suggests high-intensity training provides adaptations that can positively influence soccer performance while providing aerobic conditioning similar to endurance training (7, 9). We compared a HIIT protocol to traditional endurance training in high school soccer players over a 10-week season. Our results suggest that both groups demonstrated significant change in aerobic conditioning as measured by the Yo-Yo IR1 test performance (CON: $p$<0.001, HIIT: $p$=0.001), though there was no difference between groups before ($p$=0.945) and after ($p$=0.406) the 10-week training period. These findings support our hypothesis that HIIT is a viable alternative to traditional soccer conditioning for increasing aerobic power.

The Yo-Yo IR1 can be used to estimate aerobic performance in soccer players and provides a strong correlation to $\dot{V}O_{2max}$ (r=0.70, $p$<0.05), however due to the intermittent nature of the Yo-Yo IR1 likely impacting the correlation to $\dot{V}O_{2max}$. The Yo-Yo IR1 has also shown to be a repeatable field test with high reliability (r=0.95, $p$<0.01) for individuals of varying levels of fitness (10, 20). Others argue that due to the intermittent nature of soccer, a $\dot{V}O_{2max}$ test may not be sensitive enough to measure intermittent sport fitness levels (14). The authors tested professional (n=12) and amateur (n=11) soccer players and noted no significant difference in $\dot{V}O_{2max}$ ($p$>0.05, 58.5 ± 4.0 $mL \bullet Kg^{-1} \bullet min^{-1}$ vs. 56.3 ± 4.5 $mL \bullet Kg^{-1} \bullet min^{-1}$, professional and amateur, respectively). The authors noted a difference in mean repeated sprint ability ($p$<0.05, 7.17 ± 0.09 seconds vs. 7.41 ± 0.19 seconds, professional and amateurs, respectively), suggesting that the $\dot{V}O_{2max}$ test alone is not sensitive enough to measure fitness levels in intermittent sports. For these reasons the Yo-Yo R1 test is considered most appropriate measure of aerobic conditioning for sports such as soccer, with the added advantage that administration of the test requires minimal equipment and no sophisticated laboratory technology.

Our main finding of similar results from traditional endurance training versus HIIT mirrors previous research implementing this training protocol. Repeated Wingate tests for a two week period and reported a significant decrease in time trial performance compared to a control group without training (4). The same research group compared HIIT with an endurance control for a 6-week study, noting no difference in $\dot{V}O_{2max}$ between groups post-intervention (5), a similar result to the present study.

While we did not identify any increases from baseline in anaerobic power through the 40-yard dash for the HIIT group ($p$=0.132), the HIIT group did improve in the vertical jump test ($p$=0.019). The CON group improved from baseline in the 40-yard dash significantly, but not the vertical jump test ($p$=0.004 and $p$=0.078, 40-yard dash and vertical jump test, respectively). There were no differences between the 40-yard dash and the vertical jump test between groups post-intervention ($p$=0.794 and $p$=0.061, 40-yard dash and vertical jump test, respectively). Previous research implementing a similar high-intensity protocol via the Wingate test on a cycle ergometer noted an increase in anaerobic power, possibly improving the vertical jump test for the HIIT group (4, 5). Since aerobic training alone has not been shown to improve vertical jump in soccer players, previous research work supports the idea that high-intensity training may improve anaerobic power as measured by vertical jump height (8). However, the same authors also noted no change in sprint time for the 40 meter dash after soccer players were aerobically trained. Thus, it is hard to determine what influenced the change in the 40-yard dash time in the CON group of the present study other than normal soccer training independent of the conditioning protocol. This interpretation is supported by the lack of difference between the CON and HIIT groups at the end of the intervention ($p$=0.794). Our experimental design did not account for differences in training or player position on the field, so we cannot offer an explanation for these data.

The only fitness test to find a difference between groups in our study was the Illinois agility test. Previous research suggests regular soccer practice over the course of the season without any intervention will not result in an increase in performance for the Illinois agility test (13). There are a couple possible explanations for this difference, 1) traditional endurance training may influence agility testing or ability more so than HIIT, 2) foot apparel may not have been consistent between tests or participants occasionally slid on the floor but only during the agility test, or 3) the agility test requires memorization of a specific pattern, thus there may be cognitive load considerations of the athletes performing the test. It has also been reported there is a low-to-moderate correlation between a 20 meter sprint and the Illinois agility test thus the improved agility test performance in the CON group ($p$=0.001) may be reflective of improved sprinting ability as evidenced by the change in the 40-yard dash performance (18).

In conclusion both the endurance training group and the high-intensity interval training group demonstrated significant improvements in aerobic ability as measured by the Yo-Yo intermittent recovery test level 1. Future research examining high-intensity interval training should investigate whether this training protocol has an influence on other measures sensitive to intermittent sports, such as the repeated sprint test. Our study supports high-intensity interval training as a beneficial fitness adaptation alternative to traditional endurance training in high school soccer players over a 10-week intervention.

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