Original Research

Short Duration High-Intensity Interval Training Improves Aerobic Conditioning of Female College Soccer Players

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ABSTRACT

International Journal of Exercise Science 5(3) : 232-238, 2012. We hypothesized that High-intensity Interval Training (HIIT) is comparable to traditional endurance training for improving aerobic capacity over a 5-week training period. A VO_{2max} test and Yo-Yo Intermittent Recovery 1 test (Yo-Yo) were conducted by the HIIT group (Sprint Training (SPR); 5 maximal sprint efforts with 30 seconds of stimulus and 4.5 minutes of active recovery, twice weekly) and the endurance group (END; 40-min run at 80% of VO_{2max}, twice weekly) before and after intervention. Following initial testing, female NCAA D-III level soccer players were matched for VO_{2max} and randomly assigned to SPR (n=7) or END (n=6) groups. Between-group (END vs. SPR) and between-condition (pre- vs. post- training) comparisons were made using repeated measures ANOVA (α=0.05) with a Tukey post-hoc analysis. The Yo-Yo test revealed significant team pre- and post- training differences (1680±480 m vs. 1895±524 m respectively, p=0.002), also true for SPR (1857±423 m vs. 2131±436 m, p=0.001) and END groups (1473±494 m vs. 1613±510 m, p=0.042). There were no differences between groups for the pre-test (p=0.108) or the post-test (p=0.076). The training program resulted in significant improvements in team VO_{2max} values (50.66±3.52 ml·kg^{-1} ·min^{-1} vs. 52.71±3.24 ml·kg^{-1} ·min^{-1} respectively, p=0.002), with no differences between the two groups for the pre- (p=0.493) and post- tests (p=0.362). The mean VO_{2max} improved by 2.36 ml·kg^{-1}·min^{-1} (4.73%) for SPR and 1.66 ml·kg^{-1}·min^{-1} (3.42%) for END. Performing HIIT as little as twice per week offers an adequate aerobic training stimulus at considerable time savings.

KEY WORDS: Sprint training, female athletics, aerobic endurance

INTRODUCTION

Successful soccer players enhance their aptitude for the sport with exceptional technical skills and outstanding fitness. In recent years several investigators have documented the importance of endurance training for success in soccer performance (6,13). Krustrup et al. (2005) demonstrated that the players with the greatest aerobic capacity cover the largest distance during the game (10). In another study, Impellizzeri et al. concluded that improved aerobic fitness would prevent a decline in short passing accuracy (8). In addition, elite female soccer players reach near maximal heart rate levels during a game, further signifying the need for a high level of aerobic endurance (9). The need for players to meet these high intensity demands has brought renewed attention to the design of effective training protocols.

It is now widely accepted that High-Intensity Interval Training (HIIT) offers substantial benefits to soccer players, namely significant and timely improvements in VO_{2max}, recovery time, passing ability, and repeated sprint capacity (for a comprehensive review see 7). In one of the more influential reports, Helgerud et al. concluded that HIIT improved several measures relating to involvement in a match, including VO_{2max} levels (6). Bravo et al. compared sprint and interval training in order to identify the better way to improve aerobic endurance (1). Although both methods resulted in improvements in aerobic capacity, the sprint strategy showed greater improvements. The majority of such studies have incorporated elite athletes, disregarding the large population of non-professional athletes. One study that used high-intensity training with collegiate and youth female players showed similar results over an 8-week training period (4).

In the United States, college athletics are divided into different levels of play based on a variety of demographic factors. Within the National Collegiate Athletic Association (NCAA) there are three levels of competition, Division I, Division II, and Division III, which vary in financial support and length of season, among other things. Division III collegiate soccer is a fall sport, signifying the main season of competition taking place in the fall while off-season training is completed in the spring. The fall season begins with two weeks of preseason training preceding a 14-week schedule of games. Following the last competition players do not engage in organized activities until a 5-week training period in the spring. In the interim, players may engage in minimal training activities or remain physically inactive resulting in decreased aerobic performance. Christensen et al. specifically demonstrated the negative effects of a short 2-week period of inactivity after a competitive season through VO_2 kinetics (3). However, rules exist at the NCAA Division III level limiting the number of practice hours per season. Thus, it is imperative that aerobic endurance and skill development are both incorporated into each practice to ensure that maximal skill development and aerobic endurance levels are reached and maintained.

Given the limited amount of practice time for a team at this level and the proven negative effects on aerobic capacity due to cessation of training, it is obvious that collegiate soccer players must make quick and lasting gains in aerobic capacity. Therefore, in this study we compare the results of HIIT to traditional endurance training over a short 5-week training period during the spring off-season conditioning period in Division III female soccer players.

METHODS

Participants

Thirteen of the sixteen women on the Willamette University Division III women's soccer team (age 19.4 ± 0.87 years, height 170.5 ± 5.6 cm, weight 63.2 ± 6.9 kg) participated in this study during the team's 5-week spring training season. Due to unrelated illness and injury two of the original participants did not complete the VO_{2max} testing portion of the study (n=11, age 19.5 ± 0.93 years, height 172.1 ± 5.7 cm, weight 61.9 ± 6.6 kg).

Protocol

The study included pre- and post- test measurements on either side of the team's 5-week training schedule. The tests included an individual VO_{2max} test and a team Yo-Yo test conducted at the same time of the day so as to avoid diurnal variations in performance. All team participants completed the Yo-Yo testing as a team under the same conditions. Following the initial test participants were matched for VO_{2max} and randomly assigned to the endurance (END, n=6) or sprint training (SPR, n=7) group. During the 5-week training period the SPR group completed two training sessions per week consisting of five repetitions of 30-sec maximum effort sprints with 4.5 min active recovery (jogging) for a total of 25 minutes. The recovery interval was reduced to 3.5 min on the 4th week of training for a total of 20 minutes. This change was made because as the participants' aerobic capacity improved, they were considered to have fully recovered after 3.5 minutes, and no longer needed the full 4.5 minutes. During the same time the END group completed a 40-min run at 80% of VO_{2max}; exercise intensity was maintained using personal heart rate monitors (Polar, USA). The endurance group protocol was not adjusted because the protocol did not include a recovery interval and the perceived intensity was no lower than at the start of the training period. There were no other differences in training volume or intensity between the two groups.

VO_{2max} Test: The VO_{2max} test was conducted using a calibrated metabolic system (Parvomedics, Sandy, UT) and associated treadmill (Trackmaster, Newton, KS). Participants first completed an individual warm-up, also used to establish speed settings for the customized testing protocol. The warm up consisted of a 5 to 10 minute jog on a treadmill at a pace of the individual's choosing during which the participant was asked to identify a pace that they would be comfortable running at for 20 minutes. This speed was used to accurately select the speed of the testing protocol. The participants were given time to stretch and informed the researchers when they were ready to begin. After being fitted with the monitoring equipment, baseline data were recorded for 1-min as the participant was standing on the treadmill. Participants completed three 1-min stages of increasing speed (in increments of 0.5 mph) starting at a speed 1 mph lower than reported comfortable during the warm up. Thereafter, the speed remained constant and the grade increased by 2% at 1-min intervals. The participants were encouraged to continue until complete exhaustion or until there was no further increase in VO_2 despite the rise in grade. Participants were then asked to remain walking on the treadmill in order to record proper recovery data.

Yo-Yo Intermittent Endurance Test 1: In order to avoid temperature variations between the pre- and post- testing conditions, the Yo-Yo Intermittent Endurance Test 1 was conducted in a gymnasium in accordance with the procedures described previously (9). Briefly, the participants ran shuttles between cones positioned 20m apart; the runs started with a beep sound and the interval between beeps decreased progressively. Participants were considered to have completed the test when they failed to complete two shuttles in time.

Statistical Analysis
All within group (pre- to post-) and between group (END to SPR) comparisons were made using a repeated measures ANOVA (α=0.05) with a Tukey post-hoc analysis. A medium effect size was found for both SPR (Cohen's *d* = -0.67) and END (Cohen's *d* = -0.42).

RESULTS

Eleven of thirteen participants completed the study; one participant from each group withdrew due to unrelated injury or illness. In addition three members of the END group substituted a maximum of three separate runs with alternate workouts on the elliptical trainer due to injury, although they continued using the heart rate monitors to maintain their individual target heart rate and participated in the technical and tactical team training.

Yo-Yo Intermittent Endurance Test 1
The distance covered during the Yo-Yo test was significantly different between the pre- and post- tests (1680±480 m vs. 1895±524 m respectively, p=0.002). The differences could be further observed by separating the SPR group (pre-test: 1857±423 m vs. post-test: 2131±436 m, p=0.001) and END group (pre-test: 1473±494 m vs. post-test: 1613±510 m, p=0.042). There were no differences between the SPR and END groups for the pre-test (p=0.108) or the post-test (p=0.076).

VO_{2max} test
All participants completed valid VO_{2max} tests on both occasions. The 5-week training program resulted in significant improvements in team VO_{2max} values between the pre- and post- training tests (50.66±3.52 ml·kg^{-1}·min^{-1} vs. 52.71±3.24 ml·kg^{-1}·min^{-1} respectively, p=0.002). The pre- post- differences in VO_{2max} tests for the SPR and the END groups are represented in figure 1.

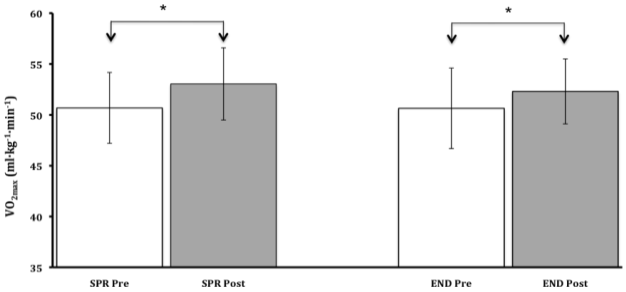

Figure 1. The mean values of VO_{2max} for SPR for pre- and post- testing were 50.68 ml·kg^{-1}·min^{-1} and 53.04 ml·kg^{-1}·min^{-1}, respectively whereas the mean values for VO_{2max} for END pre- and post- testing were 50.64 ml·kg^{-1}·min^{-1} and 52.31 ml·kg^{-1}·min^{-1}, respectively. Improvements in VO_{2max} between the pre- and post-tests were 2.36 ml·kg^{-1}·min^{-1} (4.73%) for the SPR group and 1.66 ml·kg^{-1}·min^{-1} (3.42%) for the END group. Following randomized assignment there were no differences in VO_{2max} between the SPR and END groups for the pre-test (p=0.493) and the post-test (p=0.362). A significant increase in team VO_{2max} was observed (p=.002), no significant differences were found between groups.

Finally, we report small correlations between improvements in VO_{2max} and the Yo-Yo test of Pearson's r=0.39 in absolute values and r=0.29 in % increase from baseline. These results hint at a possible dissociation between performance in the Yo-Yo test and oxygen consumption.

DISCUSSION

The existing literature is replete with information regarding the significant contributions of high-intensity training for performance in prolonged events such as soccer. Our purpose was to compare improvements in aerobic fitness if only HIIT was used, and only twice per week, to

a more traditional protocol that involved longer runs (>40 min) at moderate intensity. In planning our training protocol we were mindful of the limited time available for soccer-specific training during the short spring-training window allowed by DIII collegiate rules. We also explored whether the intriguing findings regarding the effect of HIIT on the oxidative capacity of muscle presented by Burgomaster et al. could be applicable to a team setting outside the laboratory (2). We report that this was the case, as SPR training was just as efficacious as END training in improving aerobic capacity, and at a greater time savings as previously shown (2). An additional consideration was that these findings were demonstrated in a traditionally understudied athletic population, Division III female soccer players.

Both the Yo-Yo test and VO2 max test allowed for comparisons between (SPR vs. END) and within (pre- vs. post- training) groups. The Yo-Yo test however provided a measure more applicable to game-like aerobic and anaerobic movements with the use of short duration, high intensity sprints (1, 6, 9). The test has been previously validated against high-intensity running, but was only moderately correlated to oxygen consumption (9). We confirm the low to moderate correlation in this population of female soccer players, perhaps emphasizing the dissociation between the Yo-Yo test and VO_{2max}, previously reported by Krustrup et al. (10). Alternatively, Wisløff et al. reported a positive correlation between VO_{2max} values and soccer performance. As there is no measure that is perfectly correlated with aerobic ability and soccer performance, both the Yo-Yo and VO_{2max} test results must be taken into account to properly examine overall soccer performance (13). Although the applicability of both tests should be recognized, the Yo-Yo test is a more realistic tool for the majority of nonprofessional teams to measure soccer performance due to the inexpensive nature and ease of administration (9).

The use of VO_{2max} testing as a measure of improvement in aerobic capacity between the pre- and post- tests provided quantitative evidence for the effectiveness of the training program. Our findings provide unequivocal support to our hypothesis that as little as 25 minutes of HIIT twice per week is a complement to the traditional soccer training drills and provides an adequate stimulus for aerobic improvements. Between-group changes were indistinguishable for VO_{2max} values, however the increase in aerobic capacity for SPR was made using just over half the time as the END group (25 min for SPR vs. 40 min for END) leaving more time for skill development, mechanics of play, or academic pursuits. Furthermore, the SPR protocol allows for additional opportunities to engage in ball-handling drills between the intermittent sprints, an aspect very pleasing to the coaching staff.

We must note that the SPR group anecdotally reported considerably greater satisfaction from their training than the END group. Given the inherent competitiveness of these athletes it was not difficult to motivate them to perform at maximal effort during the repeated sprints. Each member of the END group was required to run at 80% of their personal VO_{2max} level and therefore was not exposed

to the same level of competition, a characteristic that is less favorable to the members of a team sport.

A number of injuries reduced the number of able participants, so further validation of these results in this population would require increased number of participants in each testing group. The NCAA's limited 5-week spring season also restricted the length of the study. Due to the fact that the recovery period of the SPR protocol shortened during the training period, a modification that was made as an effort to keep the intensity levels of the groups comparable, we cannot deduce that 25 minutes of SPR or 20 minutes of SPR for the entire 5-week period would produce the same results. Although this modification was incongruent between groups, this small adjustment is not perceived to have had a large impact on the physiological response of the SPR individuals since they were already considered to be at rest after 3.5 minutes, and should therefore be viewed only as a greater time savings. Although we present definitive conclusions regarding the efficacy of HIIT during this short training period, we cannot assume that proportional results would have been found after a longer training period. One final consideration for our results is that the improvements in END reached significance despite the relatively small sample size of the Willamette University Women's Soccer team. A future study could follow the methodology of the current study while using a larger number of participants (male and female) and a longer training period.

In conclusion, although the two testing groups demonstrated similar improvements in aerobic endurance, the SPR group accomplished this while training for a shorter duration and with greater enjoyment due to the competitive team atmosphere. Our work could allow coaches more time to focus on skills and teamwork and as an added bonus, the players may experience more free time for non-soccer related activities, allowing these student-athletes more time to apply to their studies. Overall, this study provides measurable evidence of a time-efficient method to increase aerobic endurance in non-elite female soccer players.

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