

THE EFFECTS OF HIGH-INTENSITY INTERVAL TRAINING AND GAME-BASED TRAINING ON JUNIOR HIGH SCHOOL SOCCER PLAYER

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Abstract: There was a lack of empirical comparison of the concurrent strength effects of High-Intensity Interval Training and Game-Based Training in the context of youth soccer players. **Objective:** The main purpose of this study was to examine the effects of those two types of training within six week-period of cardio activities performance characteristics of male junior high school soccer players in Kediri, East Java. **Methods:** By applying a quantitative approach and experimental research design, this study took 20 male junior high school soccer players with a mean age of 14.5-year-old to fulfill the requirement that the samples were in the youth stage and were accustomed to a training workload and involved in soccer training and matches for at least two years to meet the minimum criteria. The research instruments were the pre-test and post-test to measure the O_2 max of the research subjects. **Results:** For 6 weeks, the subjects performed HIIT at close to ~85% of maximal heart rate while the GBT intensity was set at 70-75% of maximal heart rate. The findings implied that students with HIIT were more likely to have a greater heart rate during the study and training to get into the local tournament. Also, sprinting performance increased significantly in both groups from pretest to post-test without any changes in running performance. **Conclusion:** These findings may become the reference to conduct further research on different characteristics of subjects or other areas of study.

Keywords: cardio, game-based training, heart rate, high-intensity interval training, oxygen uptake, soccer player.

INTRODUCTION

Being a skillful soccer player needs a lot of sacrifices and a big commitment in the process of training. Various cardio activities are required in soccer, such as jumping, kicking, tackling, turning, sprinting, and changing pace (Wang & Zhang, 2016). Improvement of these explosive performances has been reported after muscular strength training that increased the available force of muscular contraction in appropriate muscle groups (Maffiuletti et al., 2016). For soccer players, training aims to develop skills in technical, tactical, psychological, and physical qualities. The training emphasizes physical fitness improvements during the preseason, whereas during the in-season period the emphasis is mainly on making tactical and technical improvements while maintaining physical fitness (Miloski et al., 2016). Indeed, as competition matches require a high energy expenditure, the training load is not increased to avoid excessive fatigue or the beginning of an over-training syndrome (Halson, 2014).

The intensity and running periods can alternate at any time according to the demands of the match. In addition, goals or decisive actions are often preceded by accelerations, sprints, bursts, jumps, and shots (Faude et al., 2012). One of the aims of the training is to improve the ability to perform maximal and high-intensity exercise. Other references found that Danish first division players performed more high-speed, and sprint runs than Danish second division players, indicating that the number of sprints and high-speed running depends on the level of the competition (Andrzejewski et al., 2015).

Cardio activities and aerobic endurance are important for soccer performance, it is of practical interest for coaches to simultaneously improve these capacities in their players when the match has started (Dellal et al., 2012). In this context, previous studies of concurrent muscle strength and aerobic and cardio endurance training have produced contradictory results; some studies have reported complementary effects (Wong et al., 2010), whereas others showed interference effects (Cadore et al., 2011). Specifically, there is a contrast result from another finding that

stated strength training has been reported to cause muscle hypertrophy, increased contractile protein, and contractile force (Marston, 2011), which has the potential negative effect of reducing mitochondrial density and decreasing the activity of oxidative enzymes, thus inhibiting the improvement of aerobic endurance (Larsen et al., 2016). Unlike strength training, aerobic endurance training does not induce muscle hypertrophy but increases the mitochondrial content and oxidative capacity and converts muscle fiber characteristics from fast to slow twitch, which negatively affects explosive performances (Hoppeler et al., 2011).

High-intensity interval training (HIIT) is a high-intensity exercise in a short time. Some well-known methods include Crossfit and Tabata (Williams & Kraemer, 2015). Videos about the sport are circulating on Youtube, in almost the same way that is combining high-intensity sports with mild intensity and done in less than an hour. High-intensity sports can also be done for other types of sports as an effort to exercise cardio for soccer, basketball, and softball sports (Luti et al., 2020).

The tabata method, for example, combines push-ups, jump squats, chin-ups, or other movements into one unified exercise (Viana et al., 2019). HIIT is a cardio exercise that uses a combination of high-intensity exercise with moderate or low intensity within a certain time interval. An example is to run a sprint for about 20-30 seconds followed by overnight or jogging for 60-90 seconds depending on the fitness conditions of each (Fragala-Pinkham et al., 2014). Regarding the benefit of HIIT implementation, previous research on HIIT-styled training indicates improvements in markers of cardiovascular health, and metabolic capacity, and often superior compared to the more traditional continuous moderate-intensity exercise (Kilpatrick et al., 2014).

Game-based training (GBT) transforms training content into a game, and employees learn as they play. Learning becomes active, and game mechanics challenges users to engage frequently to master the content and “level up.” This approach not only increases engagement with training but helps improve retention. The game-based approaches (GBAs) have been advocated as a pedagogy to improve decision-making, skill execution, and physical fitness in physical education teaching and sports coaching (Kinnerk et al., 2018). For high school football players, adopting GBT as a form of practice before the actual game on the field is a very good to do. This exercise can make young players feel the real euphoria of cardio exercises and train their minds to carry out activities in real football games such as running fast, running mid-range, sprinting, jumping, kicking, and dribbling (Vagheti et al., 2018). Soccer games for teenagers in junior high school need training that is adjusted to their energy, calorie, and breathing capacity, so that they will not experience overpowering due to fatigue or too heavy training (Kunz et al., 2019). Furthermore, previous research reported that the implementation of game-based training showed significant improvements in various aspects of decision-making and tactical awareness (Miller et al., 2017).

However, it is highly recommended that the application of HIIT should follow the safety guideline to minimize any injury risk. HIIT may be potent for health and generally well tolerated, participation in this exercise requires practitioners to consider established guidelines related to risk (Campbell et al., 2019). In addition, this form of training fits somewhat loosely within the range of vigorous exercise. Therefore, is only appropriate for low-risk individuals, moderate-risk individuals who have been cleared for vigorous intensities by a medical professional, and high-risk individuals who are under direct medical supervision during exercise training (Goodman et al., 2011). Previous studies on Game-Based training suggest that the type of exercise may not always meet the high-intensity, repeated-sprint demands of competition (Delextrat et al., 2018). Even though the reference on GBT implementation in a competitive context was still only a few, reviews of the literature on GBAs have discovered the emergence of studies investigating game-based approach in competitive training settings (Misurell et al., 2011). There are concerns from previous studies that high volumes of training may increase the risk of early specialization in youth athletes (Jayanthi et al., 2013) and can potentially have many negative consequences, such as an increased risk of injury (Fischer et al., 2011), overtraining and early dropout (Myer et al., 2015), reducing the individual's all-around motor skill development (Girard et al., 2013), and reduced performance later in their athletic career (Franchini et al., 2012). Therefore, this study intended to fill the gap between the two types of training to find out the best alternative to train young soccer players.

To the best of our knowledge, there is no previous study examining the effects of concurrent muscular strength due to HIIT and GBT and the difference between them in youth soccer players with ages ranging from 14 to 16-year-old. The present study aimed to compare the effects of high-intensity interval training (HIIT) and game-based training (GBT) on the cardio activity's performance characteristics of male junior high school soccer players in Kediri, East Java, Indonesia. As the tight control of exercise training intensity using individualized high-intensity interval training

is known to be a successful stimulus for enhancing aerobic performance, and because high-intensity interval training will also stress anaerobic pathways, we hypothesized that it would be more efficient than game-based handball training at improving indices of (supra) maximal cardio power. Thus, the researcher determined the research objective as discovering the effects of both high-intensity interval training and game-based training on a junior high school soccer player.

METHOD

Research Approach and Design

This study applied a quantitative approach and experimental design. To measure the effects of the two types of training, quantitative data were needed to present an accurate measurement of the indicators. This research consisted of 1 pretest and 1 post-test diagnostic phase and 1 training period with 2 intervention groups to test whether HIIT has a greater effect on maximal oxygen uptake, 1,000-m running time, sprint, and jumping abilities compared to GBT. In both diagnostic phases, all participants completed an $\dot{V}O_{2\max}$ test on a treadmill, a sprint and jump test, and a 1,000-m run. During the intervention, the participants exercised either according to the HIIT or GBT program. During this period, the energy expenditure of all junior high school students was recorded via lightweight multisensory devices.

The participants were followed over a 6-week period that was divided into two groups of treatment which are HIIT in the 6 weeks as the experiment group and GBT in the 6 weeks as a control group. Before beginning the protocol, anthropometric measurements (height, mass, and percentage of body fat) were made, and a maximal graded test was performed. Field tests (maximal graded field test and 40-m sprint field test) and anthropometric measurements were carried out before the control period, after the control period (which corresponded to the beginning of the HIIT and GBT period), and at the end of the training period. Both groups have been measured by the cardio parameter.

Subjects

A total of 20 children took part in this study (mean \pm SD: 14.5 \pm 0.5-year-old, weight: 48.4 \pm 9.1 kilograms, height: 158.1 \pm 8.0 cm). The subjects of this study were in the age range of youth and met the criteria to get exposure to intensive training. All junior high school students were accustomed to a training workload of >6 training units per week and have been involved in soccer training and matches for at least 2 years. All junior high school students were members of a team (<14 years) in the local junior high school club. Five players were members of a federal junior all-star team. The sampling technique used was simple random sampling because the population was homogeneous. The junior high school students were divided into a training group that mainly performed high-intensity intervals (HIIT, $n = 7$, $\dot{V}O_{2\max}$: 50.1 \pm 4.3 ml \cdot min $^{-1}\cdot$ kg $^{-1}$) and one training group with continuous loads of endurance training (GBT, $n = 13$, $\dot{V}O_{2\max}$: 49.3 \pm 6.5 ml \cdot min $^{-1}\cdot$ kg $^{-1}$) according to their maximal oxygen uptake.

Procedure

The research instruments were the pre-test and post-test to measure the $\dot{V}O_{2\max}$ of the research subjects. The treatment of both groups focused merely on the endurance cardio part of the training session. The training session for both HIIT and GBT was administered as an extension of the regular soccer-specific training. The study period was conducted directly before the beginning of the second half of the junior soccer season in the first semester of a junior high school class in Kediri. Usually, the tournament is held between January to March at the beginning of the year. As the tournament began, this study was conducted with 3-4 sessions per week over the 6-week winter tournament preparation period. The training week consisted of 4 times 1-1.5 hours of practice and 1 game. During the study, all training sessions were designed in the same manner for both HIIT and GBT.

The training sessions started with a warm-up phase of 5-10 minutes, containing flexibility exercises, short sub-maximum sprints, and integrating game-specific actions. Thereafter, a phase of soccer-specific drills followed. Within the soccer-specific drills, either single skill practice or team tactics in small-sided games took place. Further, the focus in this phase was set on agility (twists, turns, and jumps) and on core strength training (sit-ups and push-ups). No additional apparatus-based strength training or weightlifting was performed. Because of this training design, soccer-specific training was equal for both groups. After the soccer-specific part, endurance training followed. Heart rate and energy expenditure were monitored during the entire session.

The high-intensity interval intervention consisted of various types of interval training without a soccer ball and did not exceed a total exercise time of 30 minutes, including rest. During HIIT, all junior high school should achieve or maintain 90-95% of their maximal heart rate, separated by periods of 1-3 minutes jogging at approximately 60-70% of maximal heart rate according to the training program Arterial lactate concentration and ratings of perceived exertion were obtained from every player in each session of this study.

Statistical Analysis

All results are documented as mean ± SD. A Student’s test was performed to analyze the differences in heart rate and lactate concentration between HIIT and HVT during the intervention. The significance of within and between-condition mean differences were assessed by analysis of variance, with repeated measures followed by post hoc analyses using the Least Significant Difference test. An alpha level of $p \leq 0.05$ was considered statistically significant and marked as $*p \leq 0.05$. Standardized difference (d) was calculated to standardize comparisons between the pre- and post-measurements. This effect size was considered small when $d < 0.2$, moderate when $d < 0.4$ and high when $d = 0.6$ or greater. Analysis in this study was done using SPSS and software package for Windows which is statistical analysis in Excel.

RESULTS

Intervention, Pre-Test, and Post-Test Diagnostic

The junior high school student soccer players completed the session of training in both experiment classes using HIIT and control class using GBT of all training sessions were completed in both groups. Table 2 and Figure 1 show the percentage amount of training performed at different heart rate intervals. The HIIT showed a significantly greater amount of time spent at intensities of 80-100% of maximal heart rate compared to HVT ($p < 0.05$). HVT, on the other hand, revealed a higher percentage in the lower heart rate zones (60-80% of maximal heart rate) compared to HIIT ($p < 0.05$). Relative oxygen uptake increased significantly by 8.2% from pretest to post-test in HIIT but not in GBT (+1.9%). Running time over 1,000 m decreased significantly in HIIT but not in GBT. The mean decrease in HIIT was 10 vs. 5 seconds in GBT. Sprint performance increased significantly in both groups from pretest to post-test without any change in jump performance of each student. Table 1 shows the results of training for the pretest statistically while Table 2 shows the results of training for the post-test statistically.

Table 1. The result of training for pretest

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	337.573	1	337.573	5.311	.024
Within Groups	4894.231	77	63.561		
Total	5231.804	78			

Table 1 shows the results of the t-test analysis to compare the pretest mean of two class groups namely the experiment class and the control class to measure cardio parameter and heart rate. The significance value obtained is 0.024, which means lower than the alpha value of 0.05. While the F value obtained is 5.311. It means that there is a difference between students who were trained using HIIT and students who were trained using GBT in the pretest.

Table 2. The result of training for post-test

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	5333.865	1	5333.865	165.135	.000
Within Groups	2487.100	77	32.300		
Total	7820.965	78			

Table 2 shows the results of the t-test analysis to compare the post-test mean of two class groups namely the experiment class and the control class to measure cardio parameter and heart rate. The significance value obtained is 0.000, which means lower than the alpha value of 0.05. While the F value obtained is 165.135. It means that there is a difference between students who were trained using HIIT and students who were trained using GBT post-test.

DISCUSSION

the purpose of this study was to compare the effects of a specific training protocol based on sprint repetitions and high-intensity intermittent runs in comparison with a control period. The present study is the first to investigate, using specific field tests and a controlled study design, a comparison of the effectiveness of HIIT and GBT to junior high school soccer players on the physical performance capacities in Kediri before the tournament. This is significant to select the best type of training as soccer players need to recover fast even after a mild injury during their training or match. The players can perform high-intensity activities such as running and sprinting and still can recover in time for the next action (Carling et al., 2012). Due to the different responses inherent with specific HIIT and GBT, we hypothesized that HIIT as the experiment group would obtain greater improvements in indices of (supra)maximal cardio power than the GBT group, yet GBT would be more efficient at enhancing repeated sprint ability and intermittent endurance than HIIT. Despite the effectiveness of high-intensity training such as HIIT and GBT, there was a lack of empirical research to provide accurate and valid evidence, especially on soccer players.

Findings on the results showed that both in the pretest and post-test the results between groups were different. The experiment group performed HIIT at close to ~85% of maximal heart rate. It showed that students who had done exercising with HIIT would have a greater heart rate. This is in line with the findings from previous research (Currie et al., 2013), it was showed that high-intensity training affects heart rate during rest and exercise. Furthermore, HIIT is an alternative exercise with time efficiency that is as effective as moderate-intensity continuous training with increased capacity in young individuals (Wewege et al., 2017). Meanwhile, in the GBT, heart rate intensity was set at 70-75% of the maximal amount of measurement. It showed that GBT had not reached the same results as HIIT. Students with HIIT were more likely to have greater heart rates during the study and training to get into the local tournament. The somewhat greater efficiency of our treatment or intervention may be because of the longer intervention phase of 7-10 weeks compared to 6 weeks in this study for students to take.

Other findings also show that the O_2 max increased significantly from pretest to post-test. The value of increment between pretest and post-test was 8.2%. It happened from pretest to post-test in HIIT but not after GBT. Meanwhile, T_{1000} decreased significantly after HIIT. The T_{1000} in HIIT decreased ~-10 while T_{1000} in GBT decreased ~-5 seconds. It shows that from a practical point of view, to avoid cost-worthy and complex laboratory procedures, the simple assessment of T1000m reflects a feasible and uncomplicated method to detect improvements in endurance performance. Further, the frequent measurement of 1,000-m time provoked a positive competition mentality among the players wanting to beat their personal best and their teammates' times. In this study, sprinting performance increased significantly in both groups from pretest to post-test without any changes in running performance.

During the preseason period of this study, strength and conditioning specialists can use muscular strength training and high-intensity interval running when dribbling balls conducted as cardio exercise. Stakeholders from various fields have called for new concepts for attractive and effective training alternatives to reduce entry barriers and help to maintain training adherence for a wide range of people over several years (Moynihan et al., 2015). Junior high school students who were soccer players intended to join this study until the end. The practical application can be seen in the soccer player's stamina and health when practicing after the study has ended. They stated that this study affects so much on their performance during match exercises. Specifically, to minimize the interference effect of the concurrent training modes, high load, and less repetition (6RM for 4 sets, with 3 minutes of rest between sets) are recommended in muscular strength training to stress the neural adaptation and to avoid muscle hypertrophy for soccer players who already have sufficient muscle mass. Both HIIT and GBT can be properly implemented to become alternatives to train junior high school soccer players and improve their performance effectively.

CONCLUSION

based on the findings, in 6 weeks, 20 male junior high school soccer players with a mean (SD) age of 14.5 ± 0.5 years performed HIIT at close to ~85% of maximal heart rate. The GBT intensity was set at 70-75% of maximal

heart rate. The O_2 max increased significantly (8.2%) from pretest to post-test in HIIT but not after GBT. The T_{1000} decreased significantly after HIIT (~-10 vs. ~-5 seconds in GBT). Sprinting performance increased significantly in both groups from pretest to post-test without any changes in running performance. Therefore, it can be concluded that there was a slight difference in the heart rate performance between HIIT and GBT implementation. HIIT was slightly better in maximizing the heart rate performance. In addition, the oxygen uptake in the implementation of HIIT increased quite a lot from the pre-test session to the post-test. Meanwhile, such improvement did not show when GBA was implemented. Thus, the findings of this research were significant in the selection of appropriate training for youth soccer players. As the HIIT showed slightly better performance, it could be prioritized to be implemented as the training alternative. Since GBA also prove that it was also beneficial in cardio training, it can be the next alternative to vary the types of training.

RESEARCH LIMITATION AND RECOMMENDATION

this research was conducted to measure the effects of two types of training; they were High-Intensity Interval Training and Game-Based Training on youth soccer players. To enrich the empirical findings, the further researcher may take other types of training to make comparisons. Also, since this study only focused on the performance of young soccer players, future researchers may try to highlight the performance of younger players or adult players. Moreover, other research should also challenge finding other elements to measure as indicators other than heart rate and oxygen intake that have been discussed in this study.

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