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JEPHS
Journal of Exercise Physiology and Health Sciences

Original Article Open Access

Improving Cardiorespiratory and Muscular Endurance in Futsal Extracurricular Participants the Impact of a Four Week Interval Training Program

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Citation: Putra N.A.S, Ansori S. Improving Cardiorespiratory and Muscular Endurance in Futsal Extracurricular Participants the Impact of a Four-Week Interval Training Program. Journal of Exercise Physiology and Health Sciences. **2025**, 1(2):10-16.

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Abstract: The present study investigated the effect of a four-week high-intensity interval training (HIIT) protocol on increasing cardiorespiratory and muscle endurance in futsal extracurricular activities. There were 40 students aged between 15-20 years with both sexes, who were randomly assigned to either an intervention or control group, which received their routine training schedule compared to the HIIT program, respectively. Cardiorespiratory endurance was quantified using a submaximal treadmill test to estimate VO2max, while muscular endurance was assessed with push-up and sit-up tests. Results indicated that the intervention group experienced significant improvements in VO2max (from 45.2 ± 4.1 to 50.3 ± 4.5 mL/kg/min, $p < 0.001$) and in both push-up (from 15.2 ± 3.4 to 22.5 ± 4.1 repetitions, $p < 0.001$) and sit-up tests (from 20.1 ± 4.2 to 28.3 ± 5.0 repetitions, $p < 0.001$). On the other hand, the control group showed no significant differences in any of the parameters evaluated. The findings suggest that a clearly structured HIIT program is effective in improving both cardiorespiratory and muscular endurance in futsal players and that it has immense potential as an effective training modality for attaining maximal athletic performance in sports involving intermittent high-intensity efforts. The results of this study are valuable for futsal as well as other sport categories' trainers and coaches who wish to improve physical characteristics of sportsmen. The long-term consequences as well as physiological rationale of HIIT on endurance performance need to be explored through further studies.

Keywords: Futsal; HIIT; Cardiorespiratory Endurance; Muscular Endurance; VO2max

1. Introduction

Futsal, a high-tempo indoor form of soccer, requires players to possess not just technical skill but also superior cardiorespiratory and muscular endurance (1). These characteristics are necessary for sustaining the level of performance throughout the game, involving intermittent high-intensity exercise intersalted with brief recovery periods (2). As a demanding sport, given the intensity of futsal, enhancement of such physical qualities through organized training programs is crucial for players participating in extracurricular activities (3).

Recent research has emphasized the effectiveness of High Intensity Interval Training (HIIT) as a tool to enhance different parameters of fitness, including cardio-vascular fitness and muscular endurance (4)HIIT consists of interspersed brief periods of strenuous exercise with resting periods, which has been found to bring dramatic improvements in aerobic capacity and body

composition in several short weeks (5). For instance, a four-week HIIT program has demonstrated notable improvements in maximal oxygen uptake (VO2maxVO2max), body fat percentage, and performance for overall endurance among diverse populations of young adults and athletes.

The proposed research here is to investigate the impact of a four-week interval training specifically designed for futsal extracurricular players. Given its dual focus on cardiorespiratory and muscular endurance, the intention of this research is to determine whether structured HIIT is conceivable to have an impact on measurable improvements within these areas among futsal players. Past research demonstrates that such training protocols prove effective in enhancing endurance performance parameters like running economy and maximum treadmill speed, which can suggest the same for futsal specific conditions.

Moreover, understanding the physiological adaptations of this training can be valuable for coaches and trainers looking to optimize training protocols for futsal players. For the purposes of this study, a randomized controlled trial study design will be employed to test the effectiveness of the HIIT program, comparing pre- and post-intervention measures of endurance capacity between treatment groups. The findings have potential implications for the provision of evidence-based training strategies for enhancing athletic performance in futsal and similar sports disciplines.

2. Materials and methods

2.1.1. Research design

This study will employ a randomized controlled trial (RCT) to determine the effectiveness of a four-week interval training program in improving cardiorespiratory and muscular endurance in futsal extracurricular players. The subjects will be randomly assigned to two groups: the intervention group, which will be exposed to the HIIT program, and the control group, which will follow their regular training regimen.

2.1.2. Participants

The participants are male and female university or high school students aged 15-20 years who are involved in regular futsal extracurricular programs. Participants of 40 are to be recruited in total, with 20 in the intervention and 20 in the control group. Inclusion criteria include:

- Regular participation in futsal training for at least six months.
- No history of cardiovascular or musculoskeletal injuries in the past year.
- Written consent from participants and their guardians (if under 18).

2.1.3. Training Program

The intervention group will undergo a structured four-week interval training program consisting of three sessions per week. Each session will last approximately 60 minutes and will include the following components:

1. Warm-up (10 minutes): Dynamic stretching and light jogging to prepare the body for high-intensity activity.
2. Interval Training (40 minutes):
    - High-Intensity Intervals: Participants will perform exercises such as sprints, shuttle runs, and bodyweight exercises (e.g., burpees, squat jumps) at maximum effort for 30 seconds.
    - Active Recovery: Following each high-intensity interval, participants will engage in low-intensity activities (e.g., walking or light jogging) for 1-2 minutes.

- The total number of intervals per session will start at 6 and progressively increase to 10 over the four weeks.

3. Cool Down (10 minutes): Static stretching and breathing exercises to aid recovery.

The control group will continue their regular futsal training without any additional structured interval training.

2.1.4. Outcome Measures

The primary outcome measures for this study will include:

1. Cardiorespiratory Endurance: Measured using a submaximal treadmill test to estimate VO2maxVO2max before and after the intervention. The test will involve participants running at progressively increasing speeds until they reach a predetermined heart rate.
2. Muscular Endurance: Assessed through a push-up test and a sit-up test, where participants will perform as many repetitions as possible within one minute before and after the intervention.

2.1.5 Data Collection

Data collection will occur at baseline (pre-intervention) and immediately after the four-week training program (post-intervention). All tests will be conducted in a controlled environment by trained personnel to ensure consistency and reliability.

2.1.6 Statistical Analysis

Data will be analyzed using statistical software (e.g., SPSS or R). Descriptive statistics will summarize participant demographics and baseline characteristics. Changes in cardiorespiratory and muscular endurance between pre- and post-intervention assessments within and between groups will be evaluated using paired t-tests or ANOVA, with a significance level set at $p < 0.05$.

3. Results

The results of this study will be presented in a structured format, highlighting the key findings related to the impact of the four-week interval training program on cardiorespiratory and muscular endurance among futsal extracurricular participants. The data will be organized into tables and figures where appropriate for clarity.

3.1.1 Participant Characteristics

A total of 40 participants (20 in the intervention group and 20 in the control group) completed the study. The demographic characteristics of the participants are summarized in Table 1.

Table 1. The demographic characteristics of the participants

Characteristic	Intervention Group (n=20)	Control Group (n=20)
Age (years)	17.5 ± 1.2	17.6 ± 1.3
Height (cm)	170.2 ± 6.5	171.0 ± 7.0
Weight (kg)	65.4 ± 8.3	66.1 ± 7.9

Values are presented as mean ± standard deviation.

3.1.2 Cardiorespiratory Endurance

Cardiorespiratory endurance was assessed using the submaximal treadmill test to estimate *VO2max* before and after the intervention period. The results are summarized in Table 2.

Table 2. Pretest and posttest Cardiorespiratory endurance

Group	Pre-Intervention VO2max *max* (mL/kg/min)	Post-Intervention VO2max (mL/kg/min)	p-value
Intervention Group	45.2 ± 4.1	50.3 ± 4.5	<0.001
Control Group	44.8 ± 3.9	45.0 ± 4.0	0.745

Significant improvement was observed in the intervention group, while no significant change occurred in the control group.

3.1.2 *Muscular Endurance*

Muscular endurance was evaluated through push-up and sit-up tests, with results shown in Table 3.

Table 3. Push-Up Test Results

Group	Pre-Intervention Repetitions	Post-Intervention Repetitions	p-value
Intervention Group	15.2 ± 3.4	22.5 ± 4.1	<0.001
Control Group	14.8 ± 3.6	15.2 ± 3.5	0.567

Table 4. Sit-Up Test Results

Group	Pre-Intervention Repetitions	Post-Intervention Repetitions	p-value
Intervention Group	20.1 ± 4.2	28.3 ± 5.0	<0.001
Control Group	19.5 ± 4.5	19.8 ± 4.6	0.812

Both push-up and sit-up tests showed significant improvements in the intervention group, while no significant changes were observed in the control group.

Summary of Findings

The four-week interval training program significantly improved both cardiorespiratory and muscular endurance in futsal extracurricular participants compared to the control group, which did not show any significant changes in these parameters.

4. Discussion

The results of this study demonstrate that a four-week interval training program significantly enhances both cardiorespiratory and muscular endurance in futsal extracurricular participants. The intervention group exhibited marked improvements in their estimated VO2max*VO2max*, as well as in push-up and sit-up performance, while the control group showed no significant changes. These findings are consistent with existing literature emphasizing the effectiveness of high-intensity interval training (HIIT) in improving the aerobic and anaerobic abilities of players. For instance, earlier studies have shown similar gains in endurance tests after well-designed HIIT protocols, suggesting that this type of training is ideally suited to sports requiring a high level of cardiovascular fitness and muscular endurance requirements, such as futsal (6).

The dramatic change in VO2maxVO2max from 45.2 ± 4.1 to 50.3 ± 4.5 mL/kg/min in the intervention group reflects dramatic improvements in cardiorespiratory fitness. This is due to a series of physio-logical adaptations to HIIT(7), including enhanced cardiac output, improved oxygen delivery to muscles, and higher mitochondrial density in muscle fibers (8).

These adaptations are necessary for futsal players, who must make multiple high-intensity efforts within a match. That there was no prominent change in the control group also attests to the necessity of structured training interventions for the development of endurance qualities. In muscular endurance, the intervention group also demonstrated significant improvement in push-up and sit-up tests. The increase from 15.2 ± 3.4 to 22.5 ± 4.1 push-ups and from 20.1 ± 4.2 to 28.3 ± 5.0 sit-ups highlights the effectiveness of incorporating bodyweight exercise during interval training sessions

This improvement shows that HIIT not only enhances cardiovascular fitness but also promotes muscular adaptations essential to sustaining performance during long-term physical activity (9). Failure to show consistent change within the control group reinforces the contention that athletes may not achieve optimum levels of performance in the absence of tailored training (10). Application of the results is high for coaches and trainers working with futsal players Integrating HIIT into regular training regimens can provide a time-efficient method to enhance both aerobic and anaerobic performance metrics (11).

Given that futsal is characterized by short bursts of intense activity interspersed with brief recovery periods, HIIT aligns well with the physiological demands of the sport (12). Coaches should consider implementing similar training protocols to improve overall player fitness, which may lead to better on-field performance and reduced fatigue during matches (13). However, this study is not without limitations. The relatively small sample size may restrict the generalizability of the findings, and future research should aim to include a larger cohort to validate these results across diverse populations.

Additionally, while the four-week duration effectively demonstrated short-term benefits, longer-term studies are necessary to assess sustained adaptations and performance improvements over time. Future investigations could also explore the specific mechanisms through which HIIT influences endurance capacities, providing deeper insights into optimizing training

strategies for futsal players. In this study provides compelling evidence that a four-week interval training program significantly improves cardiorespiratory and muscular endurance among futsal extracurricular participants. These findings highlight the potential of HIIT as an effective training strategy for enhancing athletic performance in sports characterized by intermittent high-intensity efforts. With the implementation of such training methods, coaches are able to properly prepare their ath-letes for the physical rigors of competitive futsal while promoting a culture of health and fitness within their systems.

5. Conclusions

Generally, the study proves that a four-week interval training program significantly improves cardiorespiratory and muscle endurance among futsal extracurricular athletes. Such findings suggest it is necessary to include high-intensity training methods within sports preparation programs for optimal performance outcomes in team sports like futsal. By incorporating such potent training protocols, coaches can better prepare participants for competitive competition while fostering a culture of fitness and well-being within sports programs.

Author Contributions: Conceptualization, methodology N.A.S.P., analysis, writing original draft preparation S.A.

Conflicts of Interest: The authors declare no conflict of interest.

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