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THE EFFECT OF SKILL-BASED MAXIMAL INTENSITY INTERVAL TRAINING ON AEROBIC AND ANAEROBIC PERFORMANCE OF FEMALE FUTSAL PLAYERS

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ABSTRACT: This study examined the effects of skill-based maximal intensity interval training on aerobic and anaerobic performance variables among female futsal players. The study included 12 elite female futsal players (training group, TG) from university league division I and 12 physically active female sports-school students (control group, CG). The CG completed volleyball and basketball courses (each 2 hours per week) as part of their school programs; the TG completed an 8-week training program (non-sequential, 4 days per week). Aerobic and anaerobic performance variables were measured before and after the training program via a 20m shuttle run and running anaerobic sprint tests (RAST). Average anaerobic power, fatigue index and VO_2max of TG improved by 10.7%, 22.1% and 9.6% ($p<0.05$), respectively. These findings demonstrate that skill-based maximal intensity interval training had significant effects on both aerobic and anaerobic performance variables of female futsal players. The results suggest that this training model may be useful as a training efficiency tool among futsal coaches.

KEY WORDS: VO_2max., training efficiency, training modality

INTRODUCTION

Futsal is an indoor variant of soccer that has shown a widespread increase in popularity. However, there are a number of distinctions between the two forms: soccer is played on a large outdoor area and over a longer duration, which requires running greater distances and energy release [20]. In comparison, futsal is played on a smaller playing area (20 × 40m), over a shorter duration (2 × 20 min) and at higher intensity. There are a number of possible reasons for the increased popularity of futsal including its similar technical characteristics to soccer, the more compact playing area, and (particularly among female athletes) the exclusion of unpleasant weather conditions.

Barbero-Alvarez et al. [2] demonstrated that futsal involves high-intensity sprint activities for a large proportion of the game, as in basketball and handball. In previous studies, heart rates of futsal players were recorded in the range 170 to 190 beats$\cdot$min^{-1} [4] or at the maximum during 85–90% of the match [2]. However, mean heart rate during soccer match with the work rate and differ between playing position and between first and second half were reported as between 155 and 171 beats$\cdot$min^{-1} [20, 24]. This intensity may be an indication of higher anaerobic metabolism in futsal compared to soccer [4]. Therefore, movements in a restricted area that require highly and maximally intense motor skills and technical characteristics are also important in futsal as well as in soccer. Although anaerobic metabolism is the major energy source for highly and maximally intense exercise with repeated bouts over short durations, aerobic capacity is important for short-term recovery intervals during the actual play (when the ball is out of play or the player is passive) [27]. Therefore, the aerobic capacity and anaerobic power required for higher physical performance have been a main focus among researchers investigating methods to enhance the physical performance of athletes. Many previous studies reported that aerobic capacity and anaerobic power could be improved by training programs designed in accordance with the pace. These athletes were traditionally trained using various running drills without a ball [19]. When training programs are designed specifically to improve technical, aerobic and anaerobic characteristics, the training efficiency may be reduced and the improvement process may be prolonged. If these characteristics are enhanced simultaneously with the use of a ball at maximal intensity it can be an extremely effective use of training time and physical load.

Skill-based variations are a common strategy used by coaches to direct players to physical, physiological and technical targets. Recently, skill-based training programs have been widely applied to improve both technical skills and physical performance, particularly for team sports. However, the efficiency of these training programs, unlike traditional training, has not been conclusively demonstrated through research. Gabbett [7] and Buchheit et al. [3] stated that there were no significant differences between skill-based and traditional training models in terms of developing speed and aerobic capacity. In other studies, skill-based condition training was recommended to develop both technical skills and physical performance [8,9]. A players' performance in exercising at maximal intensity when interacting with the ball may be an important determinant for success; however, the scientific basis for how these variations influence a player's physical performance is unclear. None of the previous studies in the literature have directly investigated the physical performance variables of female futsal players or the effects of training programs on aerobic and anaerobic factors. In this study, it was assumed that if maximal intensity training could be incorporated into training programs using ball-specific drills and small-sided games, aerobic and anaerobic performances would be enhanced in addition to technical capacity. Therefore, the present study aimed to determine the effects of skill-based maximal intensity interval training on the aerobic and anaerobic performance of female futsal players. The results of this study could provide clear directions for coaches and players in the development of training programs.

MATERIALS AND METHODS

Participants. Twenty-four healthy female athletes voluntarily participated in this study. The training group (TG) consisted of 12 female futsal athletes competing in Division I of the Turkish University League and the control group (CG) consisted of 12 female students attending core modules of the School of Physical Education and Sport at Aksaray University. The demographic characteristics of the groups are listed in Table 1. All study and test procedures were approved by Erciyes University Faculty of Medicine (Turkey) and by the local Ethics Committee (approval no: 2010/142). The groups were informed about the study and their consent was obtained prior to the program.

TABLE 1. DEMOGRAPHIC CHARACTERISTIC OF GROUPS

Groups	Age (yr)	Body height (cm)	Body mass (kg)
TG (n=12)	20.2 ± 2.4	166 ± 6.2	59.7 ± 7.3
CG (n=12)	20.7 ± 2.1	166 ± 4.1	54.3 ± 6.4

Note: The values are mean ±SD

Procedures

Participants were interviewed about whether they had prior experience of the proposed test procedures. Therefore, the participants were carefully familiarized with the testing protocol as they had not been previously on several occasions in previous seasons for training prescription purposes. All of the participants were assessed on the same day and tests were performed in the same sequence. Performance tests were administered over two consecutive days, both at the beginning and the end of the training program.

Measurements

Demographic characteristics:

The body mass of the athletes was measured to the nearest 0.1 kg using a balance beam scale and their height was measured using a stadiometer to the nearest 0.5 cm

Anaerobic power

The Running-based Anaerobic Sprint Test (RAST) was used to determine anaerobic power. Sprint speed was assessed using an infrared timing device, consisting of a long-range transmitter and receiver. Sprint speed was displayed on a Polaris multi-event timer. Power output was calculated with the following equation: Power: [weight (kg) $\times$ distance (m^2) / time (s^3)] [28].

Aerobic capacity

Maximal oxygen uptake ($\dot{V}O_2max$) was obtained indirectly using a multi-stage run test. All participants performed a 20 m shuttle run test, as previously described by Leger et al. [14].

Training procedures

The CG participated only in compulsory volleyball and basketball courses, which were both two hours per week in their school programs, whereas the TG participated in an 8-week training program on 4 non-sequential days per week, beginning 9 weeks prior to the match season (Table 2).

TABLE 2. SKILL-BASED TRAINING PROGRAM

Weeks	Number of repetitions	Duration of a repeat	Recovery time between repetitions	Recovery time between stations	Total workout time of three stations for each player
1–2	4	20–25 s	30 s	4 min	33-35 min
3–4	5	20–25 s	30 s	4 min	33-35 min
5–6	6	20–25 s	30 s	5 min	35–37 min
7–8	7	20–25 s	30 s	5 min	35–37 min

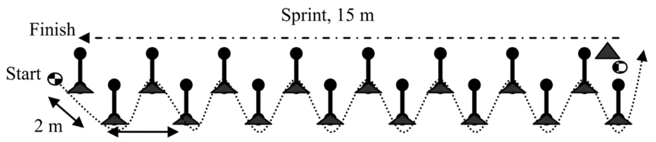

FIG. 1. SLALOM DRIBBLING AND SPRINT

Note: Station 1: Slalom with the futsal ball using right and left feet around sticks (8+8=16 pieces) of 1 meter height located parallel to each other with 2 meters of distance and 60 degrees and then sprint for 15 meters.

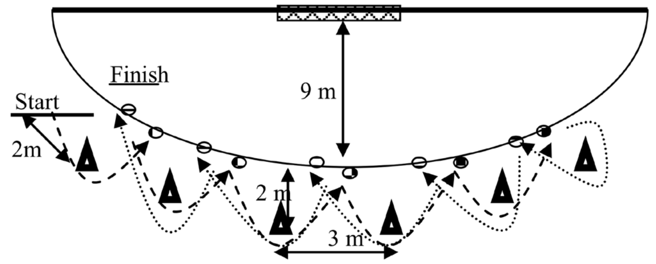

FIG. 2. AGILITY AND SHOOTING THE GOAL

Note: Station 2: A bow of 28.26 meters was drawn starting from one side to another of the 18-meter goal line. Five balls were placed on the line with 3 meters away from each other, starting 8.13 meters away from the point where the goal line and the bow meets. Six cones of 45 centimetres height were placed 2 meters away from the balls and 3 meters away from each other, in a 60-degree angle to the balls. The start point was marked 2 meters away from the first ball and on the right of the pitch. The players shot the balls with their right and left feet by making turns around the cones. After directly turning back from the last cone, they repeated the same shoots (10 shoots total)

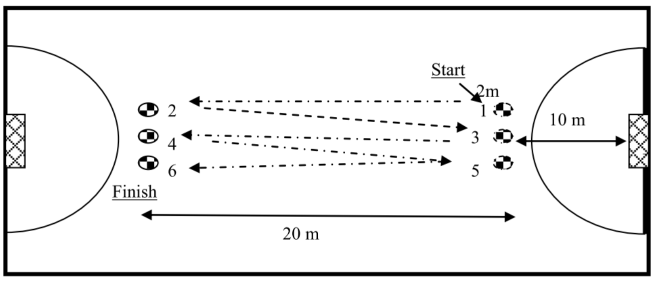

FIG. 3. AGILITY AND SHOOTING THE GOAL

Note: Three spots were numbered from 1 to 6 on each side of the pitch (3+3=6 spots total), 10 meters away from the central projection of each goal line and 2 meters away from each other. A futsal ball was placed on each numbered spot. Making a start 2 meters away from the 1st spot, the players took a shoot at the goal with either their right or left foot using the ball on the 1st spot and going to the 6th spot and sprinting between each spot.

The TG group performed a standard 20 min general systemic warm up followed by a dynamic range of motion exercises and 5 min cool down (jogging and stretching) just before and after all training applications. The main training periods comprised skill-based training including slalom-dribbling and sprint (Station 1, Figure 1), agility and shooting the goal (Station 2, Figure 2), sprint and shooting the goal (Station 3, Figure 3) and 10-min small-sided games (Station 4) (playing area size: 15×25m; number of players: 6 vs. 6) at maximal effort. Each exercise time was recorded (King-tech digital chronometer) individually and each player was instructed to minimize differences between the repeated physical loads of each exercise. Minimum and maximum completion durations of each station were first calculated and players were then warned of these during the repetition of each set. A Polar R-800sd (Polar, Electro Oy, Finland) heart rate monitor was used to determine the intensity of each training station and the small-sided games.

Statistical analysis

The descriptive data of demographic characteristics were expressed as means ± standard deviation (SD). All data were tested for normality with the Shapiro–Wilks test. All calculations were done with SPSS version 17 (SPSS Inc., Chicago, IL) using two-way analyses of variance (ANOVA) for repeated measures. And a one-way ANOVA was performed via a paired *t*-test with a Bonferroni adjustment to compare the mean values within each group. Data were presented as means ± standard deviation (SD). Statistical significance was set at $P < 0.05$.

RESULTS

The baseline results and the changes after the 8-week training period for aerobic and anaerobic performance scores of the TG and CG are presented in Table 3.

The $\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$), and the maximum, minimum and mean anaerobic power (W) scores of the TG were significantly higher than the CG in both the pre- and post- training tests ($p<0.05$). There were significant improvements in all tested values of the TG after the 8- week training period ($p<0.05$) that increases in $\dot{V}O_2max$, maximum, minimum and mean anaerobic power were 4.1 ($ml \cdot kg^{-1} \cdot min^{-1}$), 68.8 (W), 60.1 (W) and 61.6 (W), respectively, and decrease in fatigue index was 0.6 ($W \cdot s^{-1}$). But, the chang-

TABLE 3. AEROBIC AND ANAEROBIC PERFORMANCE VALUES OF TG AND CG AT PRE AND POST TESTS

Variables		Aerobic Performance	Anaerobic Performance			
Groups		VO2max (ml kg–1 min–1)	Maximum Power (W)	Minimum Power (W)	Mean Power (W)	Fatigue Index (W/sec.)
CG	Pre test	34.18 ± 1.37c	256.26 ± 12.68c	163.73 ± 9.51c	203.03 ± 10c	2.21 ± 0.2c
	Post test	35.87 ± 1.4c	270.76 ± 12.64c	175.45 ± 8.73c	217.91 ± 10.5c	2.36 ± 0.17c
TG	Pre test	39.47 ± 1.01b	344.62 ± 15.21b	232.56 ± 14.85b	280.95 ± 13.9b	3.26 ± 0.16b
	Post test	43.61 ± 0.8a	413.42 ± 17.67a	292.68 ± 17.34a	342.64 ± 18.9a	2.64 ± 0.17a

Note: All data points in each column are the means of n=12 with ± SD. [a,b,c] statistically significant (P < 0.05). TG= Training group, CG= Control group es in tested mean values of CG were not significant that increases in $\dot{V}O_2max$, maximum, minimum, mean anaerobic power and fatigue index were 1.6 ($ml \cdot kg^{-1} \cdot min^{-1}$), 14.5 (W), 11.7 (W), 14.9 (W) and 0.15 ($W \cdot s^{-1}$), respectively.

DISCUSSION

Skill-based training strategies are commonly used by coaches to direct players towards physical, physiological and technical targets. However, the scientific basis for how such training influences players' physical performances is unclear. In addition, there is a lack of information within the literature on the trainability of physical performance variables in female futsal players. Therefore, this study examined the effects of skill-based maximal-intensity interval-training on aerobic and anaerobic performance variables among female futsal players. Following a program of skill-based maximal-intensity interval-training, elite female futsal players showed significant improvements in both aerobic and anaerobic performance variables. However, no significant changes were observed for the control group.

Anaerobic performance is mainly determined by fiber-type proportion and glycolytic enzyme capacity of skeletal muscle, both of which are largely influenced by genetic factors; however, there is always a training potential to be considered [21]. Improvement in anaerobic performance may vary according to training intensity, training period and trainability of athletes. Previous studies reported that high- or maximal-intensity training methods influenced the improvement of anaerobic performance variables in female team sport players [11,23]. In this study, the maximum, minimum and mean anaerobic power of the TG group showed significant increases of 20.6%, 29.2%, 22.1% ($p<0.05$), respectively and fatigue index decreased by 19% ($p<0.05$). The increases in power after the training program could be partly related to the increases in muscular performance; or muscle-fiber size for muscle force production have been associated with increases in muscle-fiber size [12]. Developing muscle performance with a training program may also be partly related to increase motor unit function or neuromuscular adaptation. A previous study indicated that neuromuscular adaptations such as increased inhibition of antagonist muscles and contraction of synergistic muscles might account for improvements in power output [13]. Medbo and Burges [16] provided evidence that anaerobic performance can be enhanced the maximal-intensity intermittent training program. It is also agreed that maximal-intensity intermittent training has different training effects on anaerobic performance [15]. Anaerobic performance, in relation to the increase in muscle enzyme activities, can be improved with high- or maximal-intensity exercises [1,11]. Parra et al. [18] indicated that maximal-intensity training for six weeks enhanced muscle enzyme activities. Another mechanism affecting improvement of anaerobic performance is cellular regulations providing the continuity of energy production. Maximal-intensity training is suggested to increase anaerobic performance due to the improvement of cellular regulations. These regulations in the cellular mechanism buffer metabolic acidosis, which increases during exercise, causing fatigue; thus fatigue may be delayed or the resistance to fatigue may increase [6,22]. Therefore, it was assumed that the anaerobic performance of female futsal players might be improved by increasing both muscle buffering capacity and enzyme activities, which are both affected by training stimulus. The study suggests that improvements in anaerobic performance may provide an advantage for the players to effectively and continuously perform their technical skills and motor abilities under competitive conditions.

High- or maximal-intensity interval-training was previously reported to produce significant improvements in aerobic performance of team-sport athletes in relatively short time periods. In the present study, the TG showed a significant increase of 10.7% in aerobic performance. This improvement may provide very important contributions both to meeting players' energy requirements during repeated bouts of short-duration high- or maximal-intensity intermittent maneuvers [10] and also in aiding rapid recovery during short-term rest periods during the game [27]. Tabata et al. [26] reported that high-intensity training for six weeks resulted in a significant increase (7%) in $\dot{V}O_2max$. In another study, Dupont et al. [5] reported that maximal aerobic speed was increased by 18% following high-intensity interval-training during the usual training season. These results may be explained by the fact that the resynthesis of adenosine tri-phosphate (ATP) during maximal intensity exercises depends on both aerobic and anaerobic processes [16]. A study on the kinetics of oxygen uptake during short-term intense exercise revealed that the contribution of oxidative metabolism was significant; and that high- or maximal-intensity training imposed intense stimuli on both aerobic and anaerobic energy systems [10]. In previous studies, it was reported that both aerobic capacity and anaerobic power were significantly improved by maximal intensity exercise [11,23,25]. These results are consistent with the increases observed in the present study. These findings have obvious contributions to team sport players, who require both a high aerobic capacity and anaerobic power to reproduce multiple high-energy outputs.

CONCLUSIONS

In conclusion, our results indicate that significant improvements in both aerobic and anaerobic performances can be achieved in 8 weeks of skill-based maximal-intensity interval-training, which can be useful for athletes, especially during the last preparatory phase before in-season competition. The research is extensive in its support for the notion that skill-based maximal-intensity interval-training should be the predominant method employed by futsal coaches. It can be suggested that, although technical skills have not been tested in this study, this training method may be the preferred model for futsal coaches and players to improve both physical performance and technical skills. Athletes can use this type of program not only to break the monotony of training but also to improve their physical and technical performance. The current results and training modality may provide an important contribution to athletes and coaches who prefer skill-based training as a means of increasing aerobic and anaerobic performances.

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