Effects of concurrent and mixed-methods training on physical performance in futsal athletes

Efectos del entrenamiento concurrente y de métodos mixtos sobre el rendimiento físico en atletas de fútbol sala

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Abstract

Introduction. Futsal requires high-intensity performance, involving both aerobic and anaerobic energy systems. Athletes must maintain agility, strength, speed, and endurance throughout matches.
Objective. This study aimed to compare the effects of concurrent training and mixed-methods training on agility, maximal strength, speed, repeated sprints, VO_2 max, and power in futsal athletes in Thailand.
Methodology. Thirty-six male futsal players were randomly assigned into three groups: concurrent training, mixed-methods training, and control. The training groups trained three times per week for eight weeks. Pre-, mid-, and post-intervention tests were conducted. Variables were measured using standard physical fitness assessments, and statistical analysis was performed using two-way ANOVA and ANCOVA.
Results. Both training methods significantly improved multiple performance variables. Concurrent training led to greater improvements in maximal strength, VO_2 max, and power, while mixed-methods training showed superior effects on agility and repeated sprints. The control group showed minimal improvements.
Discussion. Findings align with prior research, confirming that concurrent training improves strength and aerobic capacity, while mixed-methods training enhances agility-related abilities. The specificity of training programs influenced the type of physical adaptation achieved.
Conclusions. Both concurrent and mixed-methods training are effective for enhancing the physical fitness of futsal athletes in Thailand, and should be selected based on specific performance goals.

Keywords

Agility; concurrent training; futsal; mixed-methods training; VO_2 max.

Resumen

Introducción. El fútbol sala exige un rendimiento de alta intensidad que involucra sistemas energéticos aeróbicos y anaeróbicos. Los atletas deben mantener la agilidad, la fuerza, la velocidad y la resistencia durante todo el partido.
Objetivo. Este estudio tuvo como objetivo comparar los efectos del entrenamiento concurrente y el entrenamiento de métodos mixtos sobre la agilidad, la fuerza máxima, la velocidad, los sprints repetidos, el VO_2 máx y la potencia en atletas de fútbol sala en Tailandia.
Metodología. Treinta y seis jugadores masculinos de fútbol sala fueron asignados aleatoriamente a tres grupos: entrenamiento concurrente, entrenamiento de métodos mixtos y grupo control. Los grupos de entrenamiento participaron tres veces por semana durante ocho semanas. Se realizaron pruebas antes, a la mitad y después del programa. Se utilizaron evaluaciones estándar del estado físico y se aplicaron análisis estadísticos mediante ANOVA y ANCOVA.
Resultados. Ambos métodos de entrenamiento mejoraron significativamente diversas variables de rendimiento. El entrenamiento concurrente mostró mayores mejoras en fuerza máxima, VO_2 máx y potencia, mientras que el entrenamiento de métodos mixtos tuvo mejores efectos sobre la agilidad y los sprints repetidos. El grupo control mostró mejoras mínimas.
Discusión. Los hallazgos coinciden con investigaciones previas, confirmando que el entrenamiento concurrente mejora la fuerza y la capacidad aeróbica, mientras que el entrenamiento de métodos mixtos favorece habilidades relacionadas con la agilidad. La especificidad de los programas influye en la adaptación física obtenida.
Conclusiones.Ambos tipos de entrenamiento son eficaces para mejorar la condición física de los atletas de fútbol sala en Tailandia y deben elegirse según los objetivos específicos de rendimiento.

Palabras clave

Agilidad; entrenamiento concurrente; fútbol sala; entrenamiento de métodos mixtos; vo_2 máx.

Introduction

Futsal is a sport with two competing teams of five players each. Each futsal match is 40 minutes long with a 10-minute break between halves, and teams have unlimited substitutions (Travassos et al., 2011). An important physical component of futsal players is aerobic endurance as futsal players must compete at high intensity and for an extended period. Therefore, players need to be able to maintain their aerobic endurance until the end of the match (Nohrizal & Kahri, 2020). Futsal players may play in an intensity range greater than 50% of their highest intensity (>90% of maximum heart rate) (Amani-Shalamzari et al., 2019) with a blood lactate concentration of 5.3 mmol L-1 and spend 46% of the match at an intensity higher than 80% of their maximum oxygen consumption (VO2 max)(Castagna et al., 2009; Naser et al., 2017). Professional futsal players need to have the ability to use explosive power (jumping and shooting) and have aerobic and anaerobic efficiency. Therefore, players must have a VO2 max greater than 60 mL·kg−1 min−1 to be suitable for competitions (Alvarez et al., 2009; Castagna & Alvarez, 2010; Marques et al., 2019).

Performing aerobic training and strength training concurrently is a systematic integration of endurance training and resistance training (Fyfe et al., 2014). The main purpose of a concurrent training program is to improve both endurance and adaptability in resistance training. This type of training program is used by both the general population and athletes to improve physical fitness, quality of life, and body composition. In general, the combination of endurance and strength training within the same program results in a higher number of total weekly training sessions for strength development and muscle gain (Hickson, 1980; Ruseski et al., 2011; Schumann et al., 2015; Wilson et al., 2012).

Mixed-methods training is the combination of two similar or different training methods, such as mixed-methods strength training, to increase the efficiency of athletes to achieve their highest goals in competition. One week of training may be divided into 1 day of power training, 1 day of maximum strength training, and 1 day of hypertrophy training by training every other day (Del Vecchio & Reaburn, 2013; Greco et al., 2019; Newton et al., 2002; Newton & Kraemer, 1994). The results of two groups of weightlifters who underwent 8 weeks of mixed-methods strength training (MST) and pyramidal training (PT) showed that the MST group improved their maximum strength more than the PT group. These findings show that alternating MST and increasing-intensity training with PT may be more effective than pure PT in increasing the maximum strength in weightlifters. This can be considered a valid and inspirational alternative to traditional strength training methods (Greco et al., 2019). Comparing concurrent training and mixed-methods training in futsal is important for Thailand due to its potential to enhance players' agility, strength, power, and endurance efficiently. Given the limited resources and time in many Thai sports settings, identifying a time-effective and scientifically supported training method is essential. Moreover, since most existing studies have been conducted in Western contexts, research involving Thai athletes is necessary to provide context-specific insights that can guide coaches and sports scientists in developing evidence-based training programs tailored to Thai futsal players. In light of this, the present study aimed to compare the effects of concurrent training and mixed-methods training on agility, maximal strength (1RM), maximal speed, repeated sprint ability, VO_2 max, and power.

Method

This study used a three-parallel-groups pretest and posttest design (pre-training; after week 4 and week 8) to monitor changes in agility, maximal strength (1RM), maximal speed, repeated sprints, VO2 max, and power. The training that affected each variable were concurrent training, mixed-methods training, and control group training.

Participants

The sample consisted of 36 male futsal players were recruited to participate in the study according to the following inclusion criteria: i) be a futsal athlete of North Bangkok University in the 47th Thailand University Games, ii) possess a minimum of three years of experience in futsal, iii) free from injury for a minimum of six months prior. The exclusion criteria were: i) completed < 75% of programmed intervention training sessions, ii) missed testing session before or after program. The mean and standard deviation (SD) values of age, height, weight, and body mass index (BMI) of the group were 19.8 (1.2)

years, 173.1 (5.1) cm, 68.5 (10.5) kg, and 22.7 (3.1) %, respectively. The sample size was calculated using G*Power version 3.1,(Faul et al., 2009) The experiment was set to have power = 0.80, a significance value (p) = 0.05 and a determined effect size (ES) = 0.5, while 10 participants per group were required. However, to account for participants dropping out of the research, we recruited at least 12 participants per group. This study was reviewed and approved by the ethics committee of the Srinakharinwirot university, SWUEC/E/G-334/2563, and all participants had given written consent before starting the study. Using the data obtained from the maximum strength tests, the athletes were arranged in order from the strongest to the least strong athlete, and these test results were used to divide the sample into three equal groups. Next, simple sampling was performed by drawing lots. The defined training groups were as follows: concurrent training group, mixed-methods training group, and control group.

Procedure

Training Programs

The participants were taught exercises, and they practiced the exercises until they were able to perform them correctly before joining the program. The program was designed to train the athletes 3 days a week for 8 weeks.

Concurrent Training Program

Each session began with a warm-up (10-minute run, dynamic stretches specific to futsal) at 50% constant intensity, followed by training. The strength training for weeks 1-4 consisted of three sets of six repetitions at 75% intensity of maximum strength (Enright et al., 2015). Weeks 5-8 consisted of three sets of three repetitions at 85% intensity of maximum strength. Endurance training for weeks 1-4 consisted of high-intensity interval training (3x3 minutes) and a small-sided game at 60-75% intensity of maximum heart rate. Weeks 5-8 consisted of high-intensity interval training (4x4 minutes) and a small-sided game at 60-75% intensity of maximum heart rate (Aspenes et al., 2009). The players proceeded with the training program with the trainer closely monitoring them. The training schedule for the group was three 90-minute sessions per week for 8 weeks. The group trained on Mondays, Wednesdays, and Fridays and followed the usual futsal program.

Mixed-Methods Training Program

Each session began with a warm-up (10-minute run, dynamic stretches specific to futsal (at 50% constant intensity)). For the maximum strength training program, weeks 1-4 consisted of three sets of six repetitions at 75% intensity of maximum strength. Weeks 5-8 consisted of three sets of four repetitions at 85% intensity of maximum strength. The group trained for 90 minutes on Tuesdays for 8 weeks and followed the usual futsal program. For the explosive strength training program, weeks 1-4 consisted of three sets of six repetitions, at 35% intensity of maximum strength. Weeks 5-8 consisted of four sets of four repetitions at 40% intensity of maximum strength. The group trained for 90 minutes on Thursdays for 8 weeks and followed the futsal program as usual. For weeks 1-4 of the power and speed training (complex training) program, power training consisted of three sets of six repetitions at 30% intensity of maximum strength, and speed training consisted of six sets of a 200-250 meters sprint at 60-75% intensity of maximum heart rate. For weeks 5-8, power training consisted of four sets of four repetitions at 35% intensity of maximum strength, and speed training consisted of four sets of a 200-250 meters sprint at 60-75% intensity of maximum heart rate (Del Vecchio & Reaburn, 2013). The group trained for 90 minutes on Saturdays for 8 weeks and followed the futsal program as usual.

Control group

The participants followed the futsal program as usual.

Table 1. Training Program.

Group	Frequency	Duration	Components
Concurrent Training	3x/week (Mon/Wed/Fri)	90 min/session for 8 weeks	Warm-up + Strength + Endurance (Weeks 1–4: 75% 1RM & 3x3min HIIT) (Weeks
Mixed-Methods Training	3x/week (Tue/Thu/Sat)	90 min/session for 8 weeks	Tue: Max Strength (Weeks 1–4: 75% 1RM, 3x6) (Weeks 5–8: 85% 1RM, 3x4) Thu: Explosive Strength

			(Weeks 1–4: 35% 1RM, 3x6) (Weeks 5–8: 40% 1RM, 4x4) Sat: Power & Speed (Weeks 1–4: 30% 1RM & 200–250m sprints)
Control	As usual futsal program	90 min/session for 8 weeks	Regular futsal program

Outcome measures

The testing of the variables was divided into 2 days.

Day 1: The test was organized by dividing it into three stations.

1. Participants' characteristics, namely, weight, height, and fat percentage, were recorded, which took approximately 1 hour.
2. For the speed test over 20 meters, the subjects warmed up for 10 minutes and were tested one person at a time, taking approximately 1 minute per person. This process took approximately 1 hour, and subjects rested 1 hour before going to the next base.
3. The power test was performed by using a bicycle to measure work at its highest level. The subjects warmed up for 10 minutes and then took the test, one person at a time, taking approximately 2 minutes each. When the test was finished, they warmed up their bodies and stretched their muscles. This process took about 3 hours.

Day 2: The test was organized by dividing it into three stations.

1. An agility T-test was performed by having the sample group warm up for 10 minutes and do the test 1 person at a time, taking approximately 1 minute per person. This process took approximately 1 hour, and participants rested 1 hour before starting the next test.
2. The maximal strength test with half-squat maximal strength (one repetition maximum) was performed using a weight training machine. The subjects warmed up and performed dynamic stretches. The researcher explained the testing method and allowed the athletes to perform a simulated test without using weight plates. After that, the researcher took athletes to do the test, one person at a time, taking 3 minutes per time. The participants chose a weight and lifted the chosen weight until failure, and the number of reps was recorded. The researcher then used the obtained weight values to calculate the 1 RM value using the prediction method of Baechle and Earle (Baechle & Earle, 2008; Brzycki, 1993). Participants rested 2 hours before starting the next test.
3. The testing of VO_2 max was performed with a yo-yo intermittent recovery test. The first research assistant divided the sample into four sets of eight people before explaining the testing method and taking the first group of subjects to warm up for 15 minutes. The second research assistant gave the signal for testing. In this test, 8 people were tested at a time. The test took 30 minutes for each set. It took approximately 3 hours to complete the process. When the first batch of the sample had finished testing, a third research assistant led the sample in warming up and stretching.

Data analysis

A set of 3 (groups) × 3 (testing periods) between-group analysis of variance (ANOVA) tests was run on all dependent variable scores in order to evaluate the interaction and main effects of the training program. One-way ANOVA and one-way ANOVA with repeated measures were used when significant interaction effects were found. Also, one-way ANCOVA was used if significant differences at the time of the pretest were found. A significance level of $p<0.05$ was applied. Cohen's classification of partial eta squared as small (0.01), medium (0.06), or large (0.16) effects was used to help with the interpretation of the results. For all analyses, SPSS version 23.0 for Windows was used.

Results

Descriptive Statistics

The average age, weight, height, and BMI of the participants are shown in Table 2. There were no significant differences between the concurrent, mixed-methods, and control groups in any of the demographic and dependent variables at the time of the pretest. The mean scores of dependent variables in each time period and each group were shown in table 3.

Table 2. Participant's characteristics.

Variable/Group	Concurrent $\bar{x} \pm$ S.D.	Mixed methods $\bar{x} \pm$ S.D.	Control $\bar{x} \pm$ S.D.	p
Age)year(	20 ± 1.24	19.12 ± 0.83	20.37 ± 1.30	.094
Height)cm(	174.33 ± 5.74	174.12 ± 4.70	171.37 ± 4.80	.430
Weight)kg(	69.16 ± 12.93	72.25 ± 8.73	65.00 ± 8.38	.495
BMI	22.74 ± 3.92	23.51 ± 2.80	22.10 ± 2.24	683

*Significant differences, p< .05.

Table 3. Mean score of outcome variables in each time period and group.

	Concurrent			Mixed methods			Control		
	Pre	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
Agility (sec.)	11.35±.59	10.91±.10	10.79±.12	11.45±.27	10.76±.24	10.43±.16	11.29±.16	11.17±.16	11.11±.16
Maximal Strength (kg.)	59.45±2.90	66.00±2.74	82.16±1.53	71.00±1.51	75.62±4.50	77.00±5.06	57.93±2.29	58.62±2.19	58.50±2.17
Speed Test (sec.)	3.49±0.05	3.36±0.08	3.39±0.09	4.46±0.29	3.77±0.13	3.50±0.04	3.76±0.05	3.72±.07	3.67±0.05
Repeated Sprint (sec.)	4.90±0.58	5.39±0.83	4.91±1.23	5.25±0.95	5.03±0.68	6.12±1.37	4.12±0.66	3.75±0.72	3.83±0.50
Vo2Max (ml/kg/min)	43.20±0.51	49.11±0.85	54.51±1.01	43.52±0.77	46.73±1.68	50.60±1.75	42.21±0.42	45.51±0.29	48.78±0.44
Power (m)	2.38±0.04	2.46±0.05	2.57±0.11	2.29±0.07	2.32±0.06	2.31±0.05	2.20±0.05	2.27±0.05	2.31±0.06

*Significant differences, p< .05.

Main effects

Agility

The two-way ANOVA showed that there was a significant interaction effect of training groups classified by testing period on agility ($p < .05$, $eta^2 = .22$). The main effects of the training on agility were not significant at the time of the mid-test ($p > .05$). However, they were significantly different at the time of the post-test ($p < .05$). The results showed that the mixed-methods group was significantly better than the control group ($p < .05$) in terms of agility (Fig. 1), but the other pairs of groups were not different (all, $p > .05$). Compared to agility at the time of the pretest, agility was higher after 8 weeks of training with statistical significance in the concurrent training group ($p < .01$, $eta^2 = .47$), mixed-methods training group ($p < .01$, $eta^2 = .60$), and control group ($p < .05$, $eta^2 = .53$).

Maximum strength

The two-way ANOVA showed that there was a significant interaction effect of training groups classified by testing period on maximum strength ($p < .01$, $eta^2 = .63$). The main effects of the training on maximum strength were significantly different at the time of the post-test ($p < .01$, $eta^2 = .82$). The results showed that concurrent training was significantly better than mixed-methods training and the control group (all, $p < .01$) in terms of maximum strength. The mixed-methods training group was also significantly better than the control group ($p < .01$) in terms of maximum strength (Fig. 2). Compared to the maximum strength at the time of the pretest, the maximum strength was higher after 4 and 8 weeks of training with statistical significance in the concurrent training group ($p < .01$, $eta^2 = .85$), but these results were not found in the mixed-methods training group ($p > .05$, $eta^2 = .37$), and the control group ($p > .05$, $eta^2 = .25$).

Figure 1. Agility performance at post-test. Significant differences between groups were observed (*p < .05; **p < .01). CT = concurrent training; MixT = mixed method training.

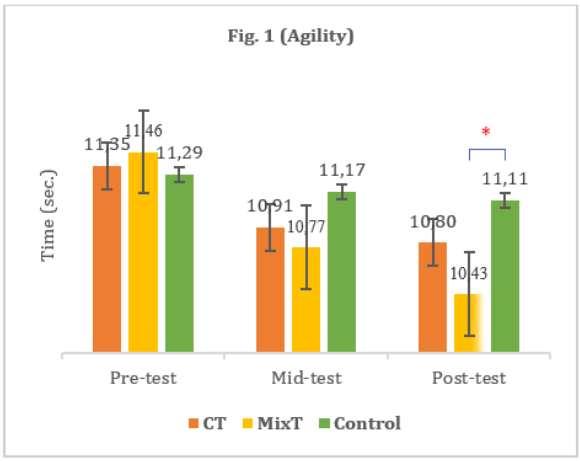
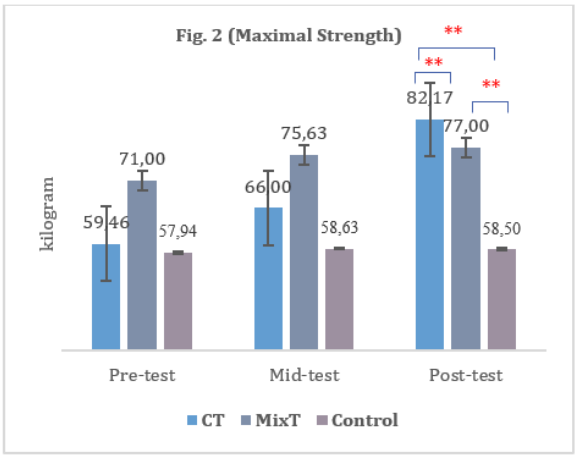


Figure 2. Maximum strength performance at post-test. Significant group differences were found (*p < .05; **p < .01). CT = concurrent training; MixT = mixed method training.



Speed

The two-way ANOVA showed that there was a significant interaction effect of training groups classified by testing period on speed ($p < .01$, $eta^2 = .38$). The main effects of the training on speed were not significant at the time of the mid-test and the post-test (all, $p > .05$; Fig. 3). Compared to the speed at the time of the pretest, the speed was higher after 8 weeks of training with statistical significance in the mixed-methods training group ($p < .01$, $eta^2 = .61$) and control group ($p < .05$, $eta^2 = .36$, but these results were not found in concurrent training group ($p > .05$, $eta^2 = .09$).

Repeated Sprints

There was no significant interaction effect of training groups classified by testing period on the repeated sprints ($p > .05$, $eta^2 = .01$). The main effects of the training on the repeated sprints were not significant at the time of the mid-test (all, $p > .05$). However, they were significantly different at time of the post-test ($p < .05$). The results showed that the mixed-methods training group was significantly better than the control group ($p < .05$) in terms of repeated sprints (Fig. 4), but the other pairs of groups were not different (all, $p > .05$). The repeated-sprint ability was not significantly higher after weeks 4 and 8 of the training in all three groups (all, $p > .05$).

Figure 3. Speed performance at post-test. Significant differences between groups were observed (*p < .05). CT = concurrent training; MixT = mixed method training.

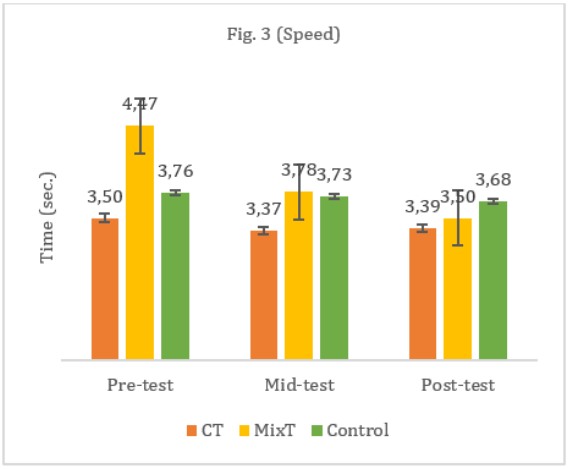
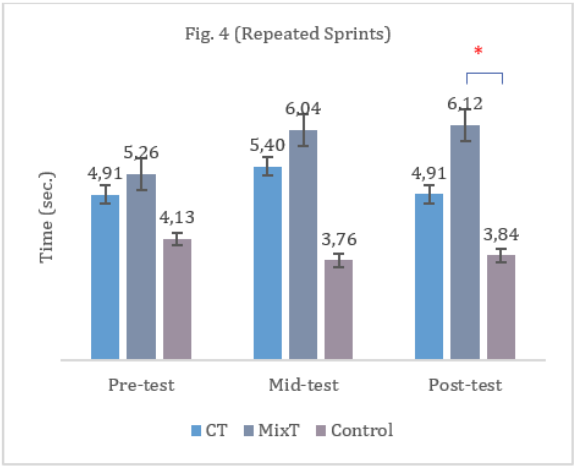


Figure 4 Repeated sprint performance at post-test. Significant differences were found between groups (*p < .05). CT = concurrent training; MixT = mixed method training.



VO₂ max

*

There was a significant interaction effect of training groups classified by testing period on VO_2 max ($p < .01$, $eta^2 = .28$). The main effects of the training on VO_2 max were not significant at the time of the mid-test ($p > .05$). However, they were significantly different at the time of the post-test ($p < .01$). The results showed that the concurrent training group was significantly better than the control group ($p < .01$) in terms of VO_2 max (Fig. 5), but the other pairs of groups were not significantly different (all, $p > .05$). Compared to the VO_2 max at the time of the pretest, the VO_2 max was higher after 4 and 8 weeks of training with statistical significance in the concurrent training group ($p < .01$, $eta^2 = .89$), and control group ($p < .01$, $eta^2 = .98$), and after 8 weeks in the mixed-methods training group ($p < .05$, $eta^2 = .69$).

Power

There was no significant interaction effect of training groups classified by testing period on power ($p > .05$, $eta^2 = .04$). The main effects of the training on power were not significant at the time of the pretest and the mid-test (all, $p > .05$). However, they were significantly different at the time of the post-test ($p < .05$; Fig. 6). The results showed that the concurrent training group was significantly better than the control group ($p < .05$) in terms of power, but the other pairs of groups were not different (all, $p > .05$). Power was significantly higher after weeks 4 and 8 of training in all three groups (all, $p < .05$).

Figure 5. VO_2max at post-test. Significant differences between groups were found (*p < .05; **p < .01). CT = concurrent training; MixT = mixed method training.

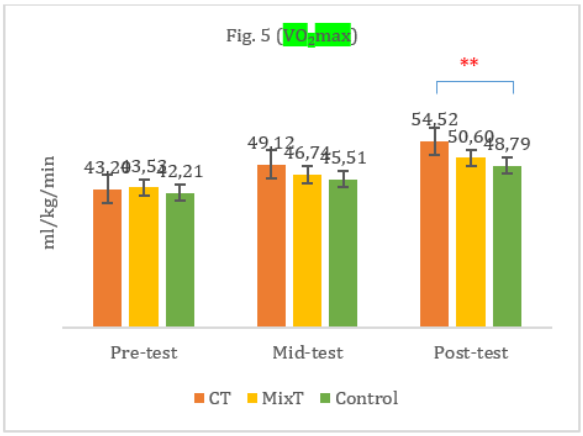
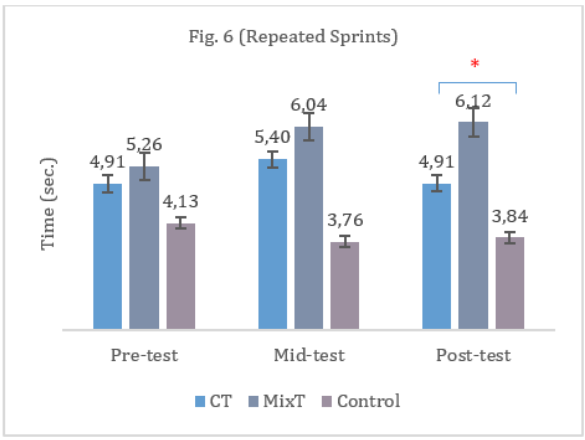


Figure 6. Repeated sprint performance at post-test. Significant differences were found between groups (*p < .05). CT = concurrent training; MixT = mixed method training.



Discussion

From the results, it was found that the concurrent training significantly improved maximum strength more than the mixed-methods training. However, there was no statistically significant difference between the two types of training in terms of improvement in the agility, speed, repeated sprints, VO2 max, and power of futsal athletes. Furthermore, the concurrent training improved maximum strength, VO2 max, and power significantly better than the control group, while there was no significant difference between the mixed-methods training group and the control group, except in terms of maximum strength. In contrast, the mixed-methods training improved agility, maximum strength, and repeated sprints significantly better than the control group, while there was no significant difference between concurrent training and the control group training in terms of these components.

Concurrent training, which involves the simultaneous performance of strength and endurance exercises, has been shown to produce the "concurrent training effect" (CTE)—a phenomenon where endurance training may attenuate strength-related adaptations. This interference is thought to be driven by molecular mechanisms such as the antagonistic interaction between AMPK and mTOR pathways (Coffey & Hawley, 2017; Fyfe et al., 2014). In particular, high-volume, moderate-intensity, and continuous endurance training appears to have a deleterious impact on resistance training outcomes (Eddens et al., 2018). On the other hand, it appears that brief sessions of sprint interval training (SIT) or high-intensity interval training (HIIT) have less of an adverse impact—or perhaps none at all—on the adaptations

brought about by resistance training in a concurrent program, while offering roughly the same metabolic benefits (Methenitis, 2018). In this study, the program was designed to use HIIT and small-sided games. Thus, the CTE was reduced and endurance training did not affect the results of strength training.

The results of the concurrent training in this study confirmed that it could improve maximum strength better than the mixed-methods training and improve maximum strength, VO2 max, and power better than the control group. The effects of the concurrent training program on both strength and metabolism have been studied, and it has been found that concurrent training is able to improve strength and increase performance in soccer players (Adlof et al., 2017), improve cardiometabolism (Da Silva et al., 2020), and improve hypertrophy, strength, and power more than endurance training alone (Wilson et al., 2012). According to earlier studies, in order to prevent competing adaptations, athletes who wish to train simultaneously to achieve increases in strength, endurance, and muscular hypertrophy should choose an endurance training modality that closely resembles their sport (Wilson et al., 2012). The HIIT and small-sided games in the concurrent training program in our study followed these recommendations, and it was shown that it could improve strength, power, and cardiovascular endurance (i.e., VO2 max). Also, for those who want to improve their endurance performance above all else, strength training could be included without worrying about compromising their aerobic capacity (Wilson et al., 2012). These suggestions could be related with the results in this study, which found that there was no difference between concurrent training and mixed-methods training in terms of improving the physical performance of futsal athletes and that concurrent training was able to improve it better than the control group, who only followed the usual futsal program.

The mixed-methods training improved agility, maximum strength, and repeated sprints better than the control group. The results of the training are related to the fact that the training program was designed to include maximum strength, explosive strength, power and speed training, with each exercise performed every other day. Although the results of the mixed-methods training were not different from the concurrent training in terms of these components, they were different from those of the control group. Meanwhile, the results of the concurrent training were not different from those of the control group in terms of these components. It shows that mixed-methods training is likely to have a better effect on agility and repeated-sprint development. Therefore, sports coaches may choose mixed-methods training if they want to improve agility and speed.

Conclusions

It can be concluded that the concurrent training developed strength better than the mixed-methods training, but there was no difference in other variables. Compared to the control group, the concurrent training better developed maximum strength, VO2 max, and power, while mixed-methods training better developed agility, maximum strength, and repeated sprints. This suggests that both types of training can be used to improve the physical fitness of futsal athletes. Although both types of training can similarly improve components of futsal performance (except for strength), each type of training has different benefits in terms of improving certain physical abilities. Therefore, both types of training should be applied to improve an athlete's performance during each period of the training plan.

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