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Comparison of Complex Training with Resistance Training on The Performance of Futsal Athletes

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Keywords

Complex training; Resistance Training; Futsal Performance.

Abstract

The purpose of study assesses the effectiveness of complex training CT and resistance training RT to enhance sprint speed and leg explosive power and agility and anaerobic capacity of futsal athletes. The research used a quasi-experimental pretest-posttest control group design to study 30 male futsal players aged 15 to 17 who were divided into two groups through random assignment to the CT group n 15 and the RT group n 15. The two groups participated in eight weeks of training which took place three times each week. The researchers used the Tests Sprint 20 Meter and Vertical Jump Test and Illinois Agility Test and Running Anaerobic Sprint Test (RAST) to assess athlete performance. The researchers used paired t-test and independent t-test for data analysis with a significance level of α = 0.05. The study results demonstrated that both training methods produced significant improvements across all performance measurement variables. The CT group outperformed the RT group in their increases for both leg explosive power and anaerobic capacity. The two groups showed no statistically significant differences in their sprint speed and agility performance. The research findings show that complex training functions as a more effective conditioning method which enhances explosiveness and anaerobic capacity in futsal players through Post-Activation Potentiation (PAP) mechanisms.

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INTRODUCTION

Futsal is a team sport that takes place in enclosed spaces and features gameplay which requires players to sustain high energy levels while showing advanced physical skills (Naser et al., 2017; Sekulić et al., 2021; Spyrou et al., 2020). Futsal players must execute their game duties through rapid acceleration and sudden direction changes and jumping and sprinting activities which they must repeat during brief intervals of play with short recovery times (Naser et al., 2017; J. Ribeiro et al., 2024; Sturgess, 2017; Yiannaki et al., 2020). Futsal athletes need to develop their physical capabilities through training which enables them to achieve optimal speed and agility and explosive power and anaerobic capacity (Barbieri et al., 2016; Naser et al., 2017).

The quest to enhance physical capabilities in futsal athletes has resulted in the development of various training methods which emerge from sports science research (Barbieri et al., 2016; Méndez-Dominguez et al., 2022). The research focuses on two training methods which include resistance training and complex training as the two most studied techniques for improving team sport athletes performance. Resistance training is a training method which employs external weights to develop muscle strength and muscl e endurance and body composition (Kraemer et al., 2017; Kraemer & Ratamess, 2025; Zouita et al., 2023). The method establishes its effectiveness through its ability to boost maximum strength and muscle hypertrophy which serve as the foundation for developing overall physical performance (Currier et al., 2026; Swinton et al., 2024).

Complex training, as a training approach, combines high-load resistance exercises with plyometric exercises through sequential execution of both types of exercises in a single training session (Ebben, 2002). (Hodgson et al., 2005), (Seitz & Haff, 2016), (Olsen et al., 2025), and (Garbisu-Hualde & Santos-Concejero, 2021) state that this method uses Post-Activation Potentiation (PAP), which causes a temporary enhancement in muscle strength following intense resistance training. The PAP mechanism promotes physiological changes through increased myosin light chain phosphorylation and enhanced motor unit recruitment which together strengthen the muscles' explosive power capacity (Blazevich & Babault, 2019; Hodgson et al., 2005; Zero & Rice, 2024).

Several studies demonstrate that complex training methods lead to more specific neuromuscular adaptations which athletes need for explosive sports performance. (Seitz & Haff, 2016) and (Thapa et al., 2021) found through their systematic review that complex training methods produced better results for vertical jumps and sprinting and agility tests than single exercise training methods. According to (Seitz & Haff, 2016), (Lin et al., 2026) and (Formiglio et al., 2024), the effectiveness of complex training depends on three elements, namely the characteristics of the subject and the design of the training protocol as well as the performance metrics assessed by the researcher.

The existing research on futsal training methods lacks sufficient studies which assess physical performance through multiple performance components (Rašković et al., 2025; J. N. Ribeiro et al., 2026). Most existing studies investigate only one or two performance variables which prevents a complete understanding of how the two methods compare in effectiveness. The unique physiological and biomechanical traits of futsal require separate studies which cannot use research findings from other sports such as soccer and basketball as generalizable evidence.

The study aims to compare the effectiveness of complex training and resistance training on the physical performance improvement of futsal athletes who need to enhance their sprinting speed and lower body explosiveness and agility and anaerobic capacity. The research results will provide empirical evidence that supports the development of more effective and organized training programs for futsal athletes while expanding the scientific knowledge base of sports coaching.

METHODS

The research utilizes a quantitative method which employs a pretest-posttest control group design of quasi-experimental research according to the framework established by (Killen & Robinson, 1988). The experimental group participated in complex training programs while the control group followed resistance training programs. The design was selected to evaluate

the impact of two distinct training interventions on physical performance metrics which were assessed before and after the training program implementation.

Participants and Sampling Procedures

A total of 30 male futsal athletes aged 15-17 years participated in this study. The researchers selected all participants through purposive sampling which used the following inclusion criteria for participant selection: (1) active practice of futsal for at least one year, (2) no muskuloskeletal injuries during the past three months, (3) no active participation in other special training programs during the research study, and (4) commitment to complete all training sessions. The researchers assigned the participants to two study groups through random assignment which created two groups with 15 members each: the Complex Training Group and the Resistance Training Group.

Training Protocols

The training program for both groups ran for eight weeks with three sessions each week on Monday, Wednesday, and Friday which resulted in 24 training sessions. The session began with 10 minutes of warm-up which included light jogging and dynamic stretching, followed by 10 minutes of cool-down.

The Complex Training (CT) group implements a workout system which uses heavy weight lifting exercises together with plyometric training in a superset format (Ebben & Watts, 1998). The training session utilizes back squat (80–85% 1RM) and power clean (70–75% 1RM) as back squat and power clean 1RM exercises and box jump and broad jump as respective plyometric exercises. The rest period between exercise pairs is set at 3–4 minutes which allows for the maximum effectiveness of PAP. The training program increases both volume and intensity of exercises at two-week intervals according to the progressive overload training method.

The Resistance Training (RT) group conducts their weight training program to achieve strength gains and muscle growth in their leg muscles. The training program includes back squat, leg press, Romanian deadlift, leg curl, and calf raise exercises which are performed at 70–80% 1RM intensity and 3–4 set volume with 8–12 repetitions per set (Faigenbaum et al., 1999). The system uses double progressive method to increase weights through a progression which moves from lower weights to higher weights.

Measurement Instruments

Four testing instruments were used to measure athlete physical performance during pretest sessions which occurred three days before program start and posttest sessions which took place three days after program end. The 20 Meter Sprint test measures running speed through timing gates which record time with an accuracy of 0.01 seconds. The Vertical Jump Test measures lower leg muscle power through measurements of jump height which employs a jump mat digital system. The Illinois Agility Test establishes agility skills through its testing process which requires time measurement through a stopwatch that provides 0.01 second accuracy. The Running Anaerobic Sprint Test (RAST) evaluates anaerobic capacity through its assessment of maximum power and minimum power alongside fatigue index measurement. The test requires participants to perform six sprints which each cover 35 meters while they have to take 10 seconds of passive recovery time between every sprint.

Data Collection Procedures

Data collection is carried out through three stages which include the pre-intervention phase and the training program implementation phase and the post-intervention phase. The researcher conducted four physical performance tests during the three-day pre-intervention period which preceded the start of the training program. The standardized testing sequence was established to minimize fatigue effects on all groups during their performance assessment. All participants were required to refrain from all types of strenuous physical activity for a period of 24 hours before their testing session. The tests were conducted on the same surface which had identical environmental conditions to ensure measurement reliability.

The researchers monitored participant attendance and program compliance during the eight-week interventional period through their attendance at scheduled sessions. The research

team decided to remove athletes who missed more than two sessions from the analysis in order to maintain the study's integrity. Certified coaches supervised all training sessions to guarantee that participants used proper technique and correct weight distribution and maintained their safety. The post-intervention testing occurred three days after the final training session using the same protocol that was used during pre-intervention testing. The same evaluators who conducted the pre-test also performed the post-test which helped to reduce measurement variation among different evaluators. The researchers coded and stored the test data from both testing phases into a database before performing statistical analysis.

Statistical Analysis

Data assessment was conducted through analysis using SPSS software version 26.0 which operated at a significance level of $\alpha = 0.05$. The research team executed statistical analysis through five distinct methods which included (1) descriptive statistics that utilized mean and standard deviation to portray the data characteristics and (2) Shapiro-Wilk test which served to assess normal distribution of data samples and (3) Levene test which functioned to determine whether different groups maintained equal distribution of their data and (4) paired sample t-test which scientists employed to evaluate changes in test scores from pretest to posttest during the research study and (5) independent sample t-test which researchers used to compare how both groups improved their performance abilities.

RESULTS AND DISCUSSION

The following are the results and findings of the research:

Table 1. Initial characteristics of participants

Variable	CT (n=15) M ± SD	RT (n=15) M ± SD	p-value
Age (Years)	16.07 ± 0.80	15.93 ± 0.80	0.632
Height (cm)	165.24 ± 3.66	165.48 ± 4.36	0.873
Body Weight (kg)	58.05 ± 4.40	58.88 ± 4.69	0.621
BMI (kg/m²)	21.30 ± 1.98	21.55 ± 2.16	0.742

The initial participant characteristics table shows no significant differences between CT and RT-groups across all measured variables. The two groups exhibited no age difference because the CT group's average age was 16,07 ± 0,80 years while the RT group had an average age of 15,93 ± 0,80 years which resulted in a p value of 0,632. The CT group has an average height of 165,24 ± 3,66 cm while the RT group has an average height of 165,48 ± 4,36 cm which shows no significant difference since their height measurements have a p value of 0,873. The two groups showed no significant difference in body mass index (BMI) because the CT group had an average BMI of 21,30 ± 1,98 kg/m² and the RT group had an average BMI of 21,55 ± 2,16 kg/m² with a p value of 0,742.

Table 2. Results Pretest-Posttest Comparison CT

Variable	Pre (M±SD)	Post (M±SD)	Δ%	p
Sprint	3.719 ± 0.114	3.511 ± 0.138	-5.59%	0.000
Vertical Jump	41.727 ± 4.565	47.767 ± 4.667	+14.48%	0.000
Agility	16.801 ± 0.592	15.971 ± 0.645	-4.94%	0.000
RAST	359.007 ± 28.264	405.653 ± 35.142	+12.99%	0.000

The analysis of pre-test and post-test results from CT group showed that all variables experienced significant changes with a p value less than 0.05. The sprint variable showed time reduction from 3,719 ± 0,114 to 3,511 ± 0,138 which represented a speed improvement of Δ = -5,59%. The vertical jump height increased from 41,727 ± 4,565 to 47,767 ± 4,667 which indicated a 14,48% increase in leg muscle explosive power. The agility test showed time reduction from 16,801 ± 0,592 to 15,971 ± 0,645 which represented improvement in agility abilities. The RAST variable showed capacity increase from 359,007 ± 28,264 to 405,653 ± 35,142 which represented a 12,99% increase in anaerobic power. The findings demonstrate that the implemented interventions successfully enhanced all measured physical performance components in athletes.

Table 3. Paired t-Test Results Pretest-Posttest RT Comparison

Variable	Pre (M±SD)	Post (M±SD)	Δ%	p
Sprint	3.740 ± 0.080	3.582 ± 0.090	-4.23%	0.000
Vertical Jump	42.873 ± 4.252	45.887 ± 4.599	+7.03%	0.000
Agility	16.834 ± 0.517	16.255 ± 0.597	-3.44%	0.000
RAST	350.780 ± 22.246	374.647 ± 25.556	+6.80%	0.000

The analysis of pre-test and post-test results for the RT group shows that all variables experienced significant changes at a significance level of p < 0,05. The sprint variable demonstrated a time reduction from 3,740 ± 0,080 to 3,582 ± 0,090 which resulted in a speed improvement of Δ = -4,23%. The vertical jump measurement increased from 42,873 ± 4,252 to 45,887 ± 4,599 which resulted in an increase of Δ = +7,03% that demonstrates better leg muscle explosive strength. The agility variable showed time reduction from 16,834 ± 0,517 to 16,255 ± 0,597 which resulted in a Δ value of -3,44% that shows better agility performance. The RAST variable showed an upward trend which increased from 350,780 ± 22,246 to 374,647 ± 25,556 with a Δ value of +6,80% that indicates better anaerobic capacity development. The results demonstrate that the physical performance components improved through the intervention program although the improvement magnitude was lower than the other groups.

Tabel 3. Independent t-Test Results for Comparison of Gain Scores Between Groups

Variable	Gain CT (M±SD)	Gain RT (M±SD)	t	p
Sprint	-19.000 ± 9.732	-14.000 ± 6.095	-1.686	0.103
VJ	60.400 ± 19.383	25.933 ± 15.229	5.415	0.000
Agility	-72.267 ± 32.638	-51.267 ± 31.302	-1.799	0.083
RAST	399.867 ± 223.660	238.667 ± 63.545	2.685	0.016

The independent t-test results show that only some variables demonstrated significant differences between the CT and RT groups. The sprint variable showed that the CT group had a larger time reduction of -19,000 ± 9,732 compared to the RT group which achieved a time reduction of -14,000 ± 6,095. The groups exhibited no significant difference because the p-value reached 0.103. The CT group showed better agility results than the RT group with their scores of -72,267 ± 32,638 and -51,267 ± 31,302 respectively although the result did not reach statistical significance (p = 0,083). The vertical jump variable (VJ) showed a significant difference between CT (60,400 ± 19,383) and RT (25,933 ± 15,229) groups because p = 0,000 indicated that CT members experienced greater muscle leg power improvements. The researchers discovered a significant difference between CT (399,867 ± 223,660) and RT (238,667 ± 63,545) groups which resulted in a p-value of 0.016. The results show that CT group members achieve better progress than RT group members who especially perform better in explosive power and anaerobic capacity.

DISCUSSION

The study results provide essential information which helps individual understand how different exercise training methods work in futsal sports. The study results show that complex training outperforms conventional resistance training for developing explosive power and anaerobic capacity according to its physiological benefits as a conditioning method. The theoretical framework of Post-Activation Potentiation (PAP) supports the effectiveness of complex training because it serves as the primary foundation for this training method (Blazevich & Babault, 2019; Hodgson et al., 2005). The CT group achieved greater improvements in leg explosive power which directly show the specific neuromuscular adaptations that result from this training method. The CT protocol uses high-resistance weight training together with plyometric exercises in superset format to create optimal PAP responses through its stimulation of myosin light chain phosphorylation and motor unit recruitment (Blazevich & Babault, 2019; Seitz & Haff, 2016). The process creates temporary conditions which boost muscle readiness for explosive contractions and this leads to better jumping performance results. The results of this study match the systematic review findings of (Seitz & Haff, 2016) which found that complex training methods showed better results than single exercise methods for vertical jump tests (Houlton et al., 2026).

The CT group showed greater improvements in anaerobic capacity which directly benefits their futsal performance capabilities. Futsal matches require players to perform multiple high-intensity actions which they must repeat after short recovery periods thus making anaerobic capacity their most critical performance factor (J. Ribeiro et al., 2024; Yiannaki et al., 2020). Complex training helps athletes build their explosive power which results in improved anaerobic energy production through better phosphagen system capacity and increased effectiveness of type II muscle fiber recruitment (Blazevich & Babault, 2019; Kumar & Pandey, 2023; Olsen et al., 2025). The results demonstrate that complex training improves every aspect of muscle performance by enhancing both muscle strength development and the body's metabolic response during anaerobic activities.

The results which failed to demonstrate any significant difference between the two groups in their sprint and agility performance present an interesting scientific perspective. The CT group showed greater improvements in both variables yet this difference fell below the threshold needed for statistical significance. The results can be explained through two different perspectives. The small sample size in each group restricted the statistical power to identify clinically significant differences according to the argument made by (Formiglio et al., 2024) about the essential methodological considerations that should guide PAP study design. The findings demonstrate that both training methods produce equal results for linear speed and agility training thus athletes can choose their training methods based on their current training phase and experience level and the available training facilities.

The two groups showed statistically significant improvement across all measured performance variables. The research demonstrates that structured training programs produce significant physiological adaptations which occur during an eight-week period regardless of the specific training methods used. The findings support the research conducted by (Rašković et al., 2025) which demonstrated significant biomechanical parameter improvements in futsal players who underwent six weeks of intensive training. The ongoing strength improvements in RT groups demonstrate that resistance training effectively establishes foundational strength and muscle endurance in young athletes according to (Faigenbaum et al., 1999) and (Swinton et al., 2024) recommendations.

The research findings provide evidence that complex training should be included as a fundamental component of futsal athlete conditioning programs according to practical coaching needs. The back squat or power clean exercise combination with plyometric training in superset pairs delivers dual training effects which enable athletes to build both structural strength and explosive power within a single training session. Futsal requires players to develop both basic strength and their ability to produce maximum power repeatedly which this method effectively achieves. Coaches and sports conditioning professionals should use periodization frameworks to implement complex training during their planned training activities according to the forward-looking strategy which includes special preparation periods before competitions.

The research study contains multiple limitations which must be acknowledged. The research sample consisted exclusively of male athletes aged 15 to 17 from a single educational institution, which restricted the ability to apply research results to different age groups and different genders and to athletes with higher performance levels. The eight-week intervention period did not provide enough time to observe long-term changes which would result from each intervention method. Future studies should choose larger and more diverse study samples while extending intervention time frames and including additional physiological markers which include maximum strength 1RM and VO2max and hormonal profile assessment to investigate deeper adaptive mechanisms.

CONCLUSION

The research demonstrates that both complex training and resistance training lead to significant improvements in the physical performance of male futsal athletes who are aged 15 to 17 during an eight-week training program. The complex training method results in superior improvements for both leg power and anaerobic capacity when compared to resistance training. The two methods showed no statistically significant differences for sprinting speed and agility performance, but the complex training group showed greater improvements than the other group.

The study results provide strong empirical support to recommend complex training as the better conditioning method for futsal athletes who want to improve their explosive power and anaerobic capacity during their training programs. Coaches should apply PAP-based superset protocols which combine heavy resistance training with plyometric exercises as part of their structured periodization programs to achieve better physical conditioning results for their futsal athletes.

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