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Information Article

Effects of Alactic Phosphagen Power Training on Serum Creatine Phosphokinase (CPK) Activity, Explosive Strength, and Rate of Force Development in Premier League Futsal Athletes

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ABSTRACT

This study aims to determine the effect of phosphagen capacity training protocols on serum creatine phosphokinase (CPK) enzyme activity, explosive power, and speed-strength in futsal players. The researcher utilized a single-group pretest-posttest experimental design. The target population comprised senior football/futsal players from the Aliyat Al-Shorta Sports Club for the (2025–2026) sports season. The sample was randomly selected, comprising (n = 10) players.

Baseline pre-test measurements were collected for phosphagen capacity, CPK enzyme levels, explosive power, and speed-strength, followed by an 8-week structured training intervention comprising (24) training units conducted at a frequency of three sessions per week. Following post-intervention testing, datasets were processed using SPSS.

The primary findings demonstrated that the phosphagen training protocol induced positive muscle cell adaptations by significantly upregulating CPK enzyme activity and enhancing both explosive power and speed-strength in the research sample. Furthermore, targeted phosphagen conditioning allowed for higher repetitions and maintained technical execution velocity during training sessions. The study recommends integrating high-intensity phosphagen conditioning protocols into the training regimens of professional league players and prioritizing energy system development tailored to the metabolic demands of the sport.

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1. Introduction

Futsal has witnessed significant development in recent years as a result of scientific advancement in sports training and supportive sciences. Performance demands in this sport have come to rely primarily on speed, continuous changes of direction, and the ability to execute motor skills with maximum power in the shortest possible time. Consequently, coaches and researchers have directed their attention toward the energy systems responsible for rapid energy production, particularly the phosphagen system, which represents the primary energy source during short-duration, high-intensity performance.

Phosphagen training is considered one of the modern training methods aimed at developing an athlete's capacity for rapid anaerobic energy production by stimulating phosphocreatine stores within the muscles, thereby contributing to the improvement of physical and technical performance in sports that require speed and explosive power, including futsal. Furthermore, this training is linked to several physiological variables, most notably the activity of the creatine phosphokinase (CPK) enzyme, which serves as a biomarker of muscular activity and adaptation resulting from training loads.

The phosphagen and lactic systems constitute the two fundamental pillars of energy production during high-intensity playing periods in soccer and futsal. The phosphagen system (also termed the ATP-PC system) relies on limited intramuscular phosphocreatine stores to resynthesize adenosine triphosphate (ATP) at an extremely rapid rate without requiring oxygen. It represents the primary energy source for short-duration efforts lasting between 5 and 10 seconds, such as powerful shots and rapid sprints to receive the ball (Baker, McCormick, & Robergs, 2010). In futsal, players depend on phosphagen power to execute short explosive movements such as rapid sprints, jumping, and shooting.

Futsal is characterized by a fast-paced nature of play and reliance on repeated explosive abilities, including short sprints, shooting on goal, and rapid transitions between defense and offense. This requires players to possess high levels of explosive power and speed-strength, as these capacities are among the most critical factors influencing technical performance success during matches.

The significance of the research lies in determining the effect of phosphagen power exercises on developing key physiological and physical variables among futsal players—specifically CPK enzyme activity, explosive power, and speed-strength—given the essential role of these variables in enhancing technical and tactical performance during matches. Furthermore, this study contributes to providing scientific findings that can be utilized in designing appropriate training programs aimed at elevating athletic achievement.

Research Problem

Through the researcher's observation of futsal matches, it was noted that both explosive power and speed-strength represent fundamental physical requirements in futsal, relying heavily on the operational efficiency of the phosphagen (ATP-PC) system, which is characterized by rapid energy production but limited sustainability. The rapid depletion of this system's substrates, combined with brief recovery intervals during matches, leads to a decline in players' ability to maintain explosive performance levels throughout the game. Additionally, incomplete resynthesis of intramuscular phosphocreatine stores—which is linked to creatine kinase (CPK) enzyme activity—contributes to diminished physical performance efficiency. Consequently, a need

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emerges to adopt specialized training modalities targeting the enhancement of phosphagen system efficiency, thereby improving related physical capacities and elevating players' performance levels. Hence, the research problem is defined as identifying the effect of phosphagen power exercises on CPK enzyme activity, explosive power, and speed-strength among senior futsal players of the Al-Aliyat Al-Shorta Sports Club.

Research Objectives

1. Design phosphagen training exercises for senior futsal players of Al-Aliyat Al-Shorta Sports Club.
2. Determine the effect of phosphagen power exercises on CPK enzyme activity among senior futsal players of Al-Aliyat Al-Shorta Sports Club.
3. Determine the effect of phosphagen power exercises on developing explosive power and speed-strength among futsal players.

Research Hypotheses

1. There are statistically significant differences between pre-test and post-test measurements of CPK enzyme activity among senior futsal players of Al-Aliyat Al-Shorta Sports Club.
2. There are statistically significant differences between pre-test and post-test measurements of explosive power and speed-strength among senior futsal players of Al-Aliyat Al-Shorta Sports Club.

Research Scope

1. **Human Domain:** Senior players of Al-Aliyat Al-Shorta Sports Club participating in the Professional League for the 2025–2026 season.
2. **Temporal Domain:** The period from January 16, 2026, to March 18, 2026.
3. **Spatial Domain:** The indoor sports hall of Al-Shabab Sports Club in Baghdad, Palestine Street area.

2. Research Methodology and Field Procedures

2.1Research Method

The experimental method with a single-group pre-test/post-test design was employed to achieve the research objectives and test its hypotheses, as illustrated in Table 1.

Table 1. Experimental Design of the Study

Group	Pre-test	Main Experiment	Post-test
Experimental Group	Physiological and Physical Tests	Phosphagen Power Exercises	Physiological and Physical Tests

2.2 Research Population and Sample

The research population was defined as players from Iraqi Professional Futsal League clubs. The research sample was selected using the simple random method and comprised players from Al-Aliyat Al-Shorta Sports Club (n .(10=Goalkeepers (n (3= were excluded. The sample represented 11.57% of the total research population.

Table 2. Descriptive Statistics of the Research Variables

Variables	Units of Measurement	Mean	Median	Standard Deviation	Skewness Coefficient
CPK Enzyme	**IU/L**	**312.444**	**316**	**22.345**	**0.034-**
Explosive Power	**Centimeters**	**201.111**	**201**	**6.716**	**0.002**
Speed-Strength	**Meters and fractions**	**10.944**	**11**	**0.277**	**0.015-**

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2.3 Tools and Equipment Used in the Research

2.3.1 Data Collection Methods Employed by the Researcher:

- Arabic and international references / the global information network (Internet) / physiological and physical tests.

2.3.2 Equipment Used:

- 10size-4 futsal balls
- 20m metric measuring tape
- 10cones
- Colored adhesive paper tape
- 12plastic hurdles (15, 20, 30 cm)
- 2Fox whistles
- 10training bibs
- 2agility ladders
- 2stopwatches
- DELL personal computer

2.4 Field Research Procedures

2.4.1Identification and Testing of Research Variables:

The dependent research variables were identified as CPK enzyme activity, explosive power, and speed-strength. Previous literature was consulted to select appropriate measurement protocols for the research sample.

2.4.2 Description of the Research Variable Tests:

First: CPK Enzyme Test Blood concentration levels of the CPK enzyme were measured immediately following physical exertion after the speed-strength test. Upon completing the exertion, the participant was seated on a chair within 5 seconds. A 2 cc venous blood sample was drawn by a chemical specialist from the 10 participating players; this volume was sufficient according to the manufacturer instructions accompanying the assay kits. Blood was deposited into medical test tubes labeled with the player's name and identification number, and transported directly to the laboratory where analysis was performed using specialized enzyme assay kits by the specialist physician.

Second: Leg Explosive Power

- **Test Name:** Standing Broad Jump Test (Al-Dulaimi, 2015, p. 119).
- **Test Objective:** Measure the explosive power of the leg muscles.
- **Performance Description:** A starting line of 1 m is drawn. The player stands behind the line with feet slightly apart, touching the outer edge of the starting line. Distance is measured from the starting line and marked with increments spaced 5 cm apart up to 3 meters. The player initiates the test by swinging arms backward from a standing position with knees flexed and leaning slightly forward, then jumps forward with maximal power through extension of knees and hips and pushing off the ground while swinging arms forward. The jump is performed using both feet simultaneously.
- **Scoring:** Two trials are given and the best attempt is recorded. Distance is measured from the starting line to the rearmost point of body contact with the ground, recorded in centimeters.

Third: Leg Speed-Strength

- **Test Name:** Hopping / Jump-Run Test (Ahmed Zamil, 2017, p. 129).

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- **Test Objective:** Measure leg speed-strength along with balance and coordination.
- **Performance Description:** The participant stands behind the starting line and performs 3 consecutive forward bounds with maximal possible power. Free arm swing is permitted. The landing on the third bound must be executed on both feet.
- **Scoring:** Measurement is taken from the starting line to the closest point of landing contact after the final jump. Two trials are allowed, and the best score is recorded.

2.4.3 Pre-tests:

The assistant work team administered the tests for the study variables (CPK enzyme, explosive power, and speed-strength) on the research sample at the indoor sports hall of Al-Shabab Sports Club on Tuesday, January 13, 2026, at 4:00 PM following a warm-up, lasting for 30 minutes.

2.4.4 Main Experiment:

The assistant work team implemented the specialized training program designed by the researcher with the experimental group. These exercises were applied in the first part of the main section of the training sessions starting on Friday, January 16, 2026, and concluding on Wednesday, March 11, 2026. The training sessions were conducted over a period of 8 weeks, comprising 24 total sessions at a rate of 3 sessions per week, each lasting 30 minutes. Interval and repetition training methods were utilized with a 3:1 training load wave progression.

2.4.5 Post-tests:

Following the completion of the training intervention designed by the researcher, the assistant team conducted post-tests for the variables (CPK enzyme, explosive power, and speed-strength) on the research sample at the indoor sports hall of Al-Shabab Sports Club on Friday, March 13, 2026, at 4:00 PM after a warm-up, lasting for 30 minutes. The researcher ensured that post-tests were conducted under conditions nearly identical to the pre-tests to prevent external confounding effects on the results.

2.5 Statistical Methods

The researcher utilized the Statistical Package for the Social Sciences (SPSS) using the following formulas/tests:

- Mean
- Standard Deviation
- Paired-samples t-test
- Skewness Coefficient

3. Results Presentation and Discussion

3.1 Presentation of Results for the Studied Variables

Following the statistical processing of physical and motor test data, the researcher presented the results in tabular form to determine the extent to which the research objectives were achieved, as displayed in Table 3.

Table 3. Means, Standard Deviations, Calculated Paired-Samples t-Values, Significance Levels, and Statistical Significance of Differences Between Pre- and Post-Tests for the Studied Variables

Variables	Unit	Pre-test		Post-test		Mean Difference (D(⁻	SD of Differences (SD(	Calculated t-value	Sig. (p-value)	Significance
		(X(⁻	SD (s(	(X(⁻	SD (s(					
CPK	IU/L	312.4	22.3	410.6	21.8	98.222	15.360	19.183	0.00	Significa

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Enzyme		44	45	67	52				0	nt
Explosive Power	Centimeters	201.111	6.716	216.222	5.630	15.111	5.183	8.747	0.000	Significant
Speed-Strength	Meters and fractions	10.944	0.277	12.394	0.170	1.450	0.307	14.173	0.000	Significant

3.2 Discussion of Results

The results obtained in the tables above demonstrate that the research sample exhibited notable development following the training intervention across explosive power and speed-strength, with statistically significant differences emerging between pre- and post-tests. The researcher attributes this improvement to the diversity of the exercises implemented in the training sessions, which targeted multiple physical and technical objectives. This led to enhanced kinesthetic awareness and neuromuscular coordination among body parts, creating a training environment that closely mimicked competitive conditions in terms of energy production and muscular group recruitment.

Additionally, the equipment utilized in the exercises contributed to maintaining engagement, preventing monotony, emphasizing high-intensity execution, and ensuring sufficient repetitions during both the exercises and overall training units. Furthermore, the systematic progression from simple to complex exercises, weekly repetitions, and variation in distances and hurdle heights during drill performance contributed to these outcomes. This was reflected in exercises utilizing distances between 3–7 meters and 2–5 hurdle jumps. The researcher attributes these adaptations to the fact that the exercises targeted energy production pathways, increased creatine stores in working muscles, and recruited a larger number of motor units through high-intensity execution.

The researcher considers that the training intervention induced functional adaptations in bodily systems due to exposure to maximal physical loads operating within the phosphagen energy pathway, which demands rapid energy release over execution durations of approximately 10–14 seconds. The CPK enzyme is regarded as a key and direct factor in accelerating energy liberation within the body via ATP resynthesis. The phosphagen system depends on phosphocreatine (Creatine Phosphate) to resynthesize ATP; CPK catalyzes the transfer of a phosphate group from creatine phosphate to adenosine diphosphate (ADP) to form adenosine triphosphate (ATP) and creatine, and vice versa. Athletes require this energy to sustain physical performance, as "the energy liberated during the breakdown of ATP is considered the direct source of energy used by muscle tissue to perform work; however, the amount of ATP stored within muscle is very small and insufficient to produce energy beyond a few seconds. In the absence of ATP in muscle cells, movement or muscle contraction cannot occur; thus, ATP is continuously resynthesized via ATP replenishment systems" (Jari, 2024).

This aligns with findings by Mohamed Hassan Allawi, who emphasized that structured training programs assist in developing sport-specific physical capacities due to their capacity to increase training intensity (Mohamed Hassan, 2004, p. 125).

Similarly, the study by Reilly and Williams confirmed that modern soccer training focuses on developing players' specific abilities while employing drills that simulate match technical performance requirements (Reilly & Williams, 2003, p. 89).

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Mohamed Sobhi and Ahmed Kasra also emphasize that developing sprinting ability and speed-strength is achieved through repeated sprint efforts over specific distances (Mohamed & Ahmed, 2004, p. 79).

Furthermore, Osama Kamel states that neuromuscular coordination improves during the execution of complex exercises (Osama Rateb, 1991, p. 62).

Muwaffaq Al-Mawla indicates that the game of soccer entails diverse demands, requiring players to possess multiple physical capacities that are utilized concurrently during play (Muwaffaq Al-Mawla, 2000, p. 78).

Because the designed exercises relied on high-intensity, short-duration bouts, they led to the development of the phosphagen system by increasing high-energy phosphate stores and enhancing the rate of ATP resynthesis, corroborating the findings of Bompa and Buzzichelli (2019).

Physiological adaptations resulting from anaerobic training encompass enhanced activity of enzymes responsible for rapid energy production, which leads to elevated muscular power (McArdle et al., 2015, p. 168).

This is also consistent with Chu (1998, p. 45), who indicated that explosive exercises improve muscular power by developing neural drive and contraction velocity.

These findings can further be interpreted through the principle of functional adaptation, whereby consistent exposure to appropriate training loads induced physiological and neural adaptations that were positively reflected in performance levels.

4. Conclusions and Recommendations

Conclusions

1. The training program contributed to muscular cellular adaptations by increasing CPK enzyme activity as well as explosive power and speed-strength capacities in the research sample.
2. Phosphagen training provided the training units with the capacity to increase repetitions and the speed of technical execution.

Recommendations

1. Continuously incorporate the designed training protocols within training curricula for professional league club players.
2. Emphasize the development of energy systems according to the specific physiological demands of futsal.
3. Conduct similar investigations across different age categories.
4. Provide modern specialized measurement tools and laboratories to evaluate physical and functional development.

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