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EFFECT OF DIFFERENT DOSES OF CREATINE SUPPLEMENTATION ON POWER AND SPEED DURING THE PREPARATION PERIOD IN FOOTBALL PLAYERS

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Abstract. **Aim.** The current study sought to investigate the influence of various creatine supplementation (CrS) dosages on muscular power and speed performance in elite athletes throughout the preparation period. **Materials and methods.** This study was conducted on 24 professional football players (age – 23.5 ± 3.8 years; weight – 72.4 ± 6.2 kg; height – 172 ± 5.2 cm) in a course of 30 days. Twelve football players (Egr) received 15 gr/d of creatine monohydrate in the first 10 days, 10 gr/d in the second 10 days, and 5 gr/d in the third 10 days. We also conducted a placebo-controlled parallel-group study (Cogr) including twelve (12) football players. The tests were performed several times: at the beginning of the experiment and each 10-day period. Tests included 20 m sprint, medicine ball throw, long and triple jumps. The two groups' differences in the study parameters were assessed using the t-test, and the impact of the CrS dosage was investigated using a factor analysis of variance (ANOVA). **Results.** The results revealed that CrS significantly impact results of 20 m sprint and the medicine ball throw test in all 3 periods (10, 20 and 30 days), although effect size (η^2) was between 44.59 to 80.28 % ($p < 0.01$). CrS did not affect significantly the long and triple jump tests, the effect size (η^2) was between 2.58 to 22.08 % ($p > 0.05$). **Conclusion.** In conclusion, the reduction of CrS dosage does not affect significantly the effect size of the study parameters. CrS leads to significant improvement in speed of running and muscle power of football players, and it may be used to support the pre-season training.
Keywords: creatine doses, performance effect, football players

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ВЛИЯНИЕ РАЗНЫХ ДОЗ КРЕАТИНА НА СИЛОВЫЕ И СКОРОСТНЫЕ КАЧЕСТВА ФУТБОЛИСТОВ В ПОДГОТОВИТЕЛЬНОМ ПЕРИОДЕ

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Аннотация. **Цель.** Настоящее исследование направлено на изучение влияния разных доз креатина (CrS) на мышечную силу и скоростные показатели у элитных спортсменов в течение подготовительного периода. **Материалы и методы.** Исследование проводили в течение 30 дней при участии 24 профессиональных футболистов (возраст – 23,5 ± 3,8 года; вес – 72,4 ± 6,2 кг; рост – 172 ± 5,2 см). Двенадцать футболистов экспериментальной группы (Egr) в первые 10 дней получали моногидрат креатина в дозе 15 г/сут., в следующие 10 дней в дозе 10 г/сут. и в последние 10 дней в дозе 5 г/сут. Параллельно исследование проводили в группе плацебо (Cogr), включающей двенадцать (12) футболистов. Тесты выполняли несколько раз: в начале эксперимента и каждые 10 дней 30-дневного исследования. Тесты включали спринт (20 м), бросок медицинского мяча, прыжок в длину и тройной прыжок. Межгрупповые различия в параметрах исследования оценивали с помощью t-критерия, а влияние дозы креатина анализировали с использованием дисперсионного анализа (ANOVA). **Результаты.** На основании полученных результатов пришли к выводу, что использование креатина приводит к статистическому изменению результатов спринта (20 м) и бросания медицинского мяча на всех трех этапах оценки (10, 20 и 30 дней), при этом величина эффекта (ƞ2) составила от 44,59 до 80,28 % (p < 0,01). Использование креатина не оказало существенного влияния на результаты прыжковых тестов, величина эффекта (ƞ2) составила от 2,58 до 22,08 % (p > 0,05). **Заключение.** Установили, что снижение дозы креатина не приводит к статистическому изменению величины эффекта параметров исследования. Использование креатина значительно улучшило скорость бега и мышечную силу футболистов, что позволяет рекомендовать его в качестве вспомогательного средства в ходе предсезонной подготовки.

Ключевые слова: креатин, влияние разных доз, результативность, футболисты

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Introduction. Over the past 20 years, football has evolved into one of the most intense intermittent team sports, in which the physical demands increase. It is played over ninety minutes in two halves of 45 minutes at mostly submaximal intensity [33]. As the game and the preparation for the season demand more and more effort, the courses and the intensity of running distances have to be done mostly at maximal and submaximal speed. This requires an ability to accelerate and perform maximal intermittent sprints, as well as many jumps [27]. To meet these demands, athletes need more external sources of power [10, 17]. Protein is thought to be a component in supplements that promote weight gain, and when paired with resistance training, it can effectively promote the gain of lean mass [11]. Phosphocreatine (PCr) storage in muscle controls the amount of ATP replenishment that occurs during the phosphorylation of adenosine diphosphate (ADP) into adenosine triphosphate (ATP) [14]. That physical requirement depends on a player's role. The fact that all roles, with few exceptions, go through a similar series of tests in the annual Tunisian Ligue Professionelle 1 (Tunisian Professional League) is counterproductive.

Studies show that creatine supplementation (CrS) has a minor but considerable effect on performance and physiological changes of the body. This performance boost can only be achieved under very specific training conditions. This suggests that the results of the use of creatine supplements for performance enhancement in athletes have not been thoroughly studied.

The need for CrS increases proportionally with physical activity [27]. CrS improves performance of single or repetitive high-intensity exercise in football [8, 37]. Some studies suggest that physical performance may be improved by short bursts of extremely powerful activity, particularly during high-intensity repetitive exercise. According to the authors [27], a higher PCr concentration in muscle is critical for activities that require rapid bursts of high power [8]. It corresponded with the hypothesized advantages of higher PCr levels in skeletal muscle.

Research has shown that CrS causes significant weight gain within the first few days, most likely due to water retention associated with Cr absorption in muscle. In addition, CrS is associated with increased strength in strength training programs. Weight gain was the initial response of the muscles to various programs defined by high volume and intensity [12]. In this case, our preparation program includes muscle, power, speed, endurance and resistance exercises.

As far as we know, Cr is one of the most popular food supplements among football players. The need for CrS in various doses can increase several times depending on the amount of physical stress. CrS can immediately improve performance in strength and power sports, as well as aid in lean mass gain during training [2, 7, 12]. Furthermore, CrS is utilized to replenish body reserves and improve performance [30]. Studies have shown that supplementing the diet with roughly 20 g/d of creatine monohydrate for 2–7 days can increase the total creatine content in muscle by 10–20 % and intramuscular creatine by 20–40 % [35]. In addition, some studies show that CrS may impact cardiac and skeletal muscle metabolism by increasing the rate of ATP resynthesis during and/or after repeated bursts of high-intensity activity. On the other hand, research propose that a high dose of 20 g/d is unnecessary, as 3 g/d will accomplish the same increase in PCr over time. Ingesting carbs with Cr may improve muscle absorption. Nevertheless, the process demands a considerable amount of carbohydrates [3, 34].

In general, it appears that Cr has a significant effect on power regardless of sport, gender or age [1]. Therefore, the aim of this study is to evaluate the muscle efficiency and its ability to change in performance after different CrS doses. These doses were applied during the preparation period, and we studied the improvement in speed and power of professional football players, as well as the intergroup and intragroup specific results.

Materials and Methods. Twelve professional football players (age – 23.5 ± 3.8 years, weight – 72.5 ± 6.2 kg, height – 172 ± 5.2 cm) formed the experimental group in this study, while other twelve football players (age – 24.6 ± ± 2.8 years, weight – 73.4 ± 5.8 kg, height 173 ± ± 5.6 cm) formed the control group. A calibrated digital scale with an accuracy of ± 0.02 kg was used to assess body mass (Sterling Scale Co., Southfield, MI). The experiment took place during the 30-day preparation period, which began on August 1, 2021, and ended at the end of that month.

Over the course of three ten-day periods, subjects received six days of 90-minute training per week divided into categories of strength, power, resistance, speed and endurance. For the first 10 days, the experimental group (Egr) received creatine monohydrate at a dose of 15 g/d (3×5 g/d: 5 g before, during and after the training session), followed by a dose of 10 g/d (2×5 g/d: before and at the end of the training session) in the second period, and doses of 5 g/d (before the training session) in the third period. The control group (Cogr) received flavored powder (glucose polymer). In order to ensure double-bind conditions, the supplements were individually packaged in generic foil packets. The supplement/placebo was taken in a form of liquid, combined with 0.33 l of mineral water. During the preparation phase of the study, players were instructed not to take any additional nutritional supplements, ergogenic aids, or prescribed medications. Subjects from Egr and Cogr went through a standardized schedule of training sessions led by the coaches on Monday, Tuesday, Wednesday, Thursday (test match), Friday, and Saturday during the three ten-day period of supplementation intake. Depending on the curriculum, there were three days a week of morning and afternoon training, plus a day off on Sunday. The professional football players gave their permission to participate in the study.

In addition, the experiment was conducted in accordance with the guidelines for human subject research. In addition, neither the researchers nor the coach knew which group was taking the supplements. We recorded the dynamics of the results in some of the performance and speed capability parameters as a scoring criterion. All the results obtained are presented in separate tables. During the study, four tests were carried out: 7.5 kg medicine ball throw (m), long jump (cm), triple jump (cm), and 20 m sprint (s). The tests were carried out one day prior and then once every ten days during the experiment. It should be noted that these repeated tests were performed by the same researcher with the same equipment, at the same time of the day, and in the same place.

The tests from the National Football League (NFL) draft were used to estimate the performance, power and speed abilities of the test subjects. We used a factor analysis of variance (ANOVA) to evaluate the effect of CrS on performance of the players. In order to confirm whether there were any differences in performance before and after the experiment, a t-test was used. The mean and standard deviation (SD) were used for data presentation. A significance level of 0.05 was applied.

Tests description:

1. Medicine ball throw: the subject stands on the line, feet side by side and slightly apart, facing the direction in which the ball will be thrown, the ball is held in front of the stomach. The throwing motion is similar to the football sideline throw-in. The ball is pulled back behind the head and thrown as far forward as possible. The subject is allowed to walk forward across the line after the ball is thrown. Three attempts are allowed. The measurement is recorded to the nearest 10 cm. As a result, the best result is recorded.

2. Long jump: the test is designed to identify the explosive power of the legs. The starting line is marked on the ground. The athlete stands behind the line, feet slightly apart. Both feet take off and land simultaneously. The person tries to jump as far as possible and land on both feet without falling backwards. Three attempts are allowed and the best result is recorded.

3. Triple long jump: the test is designed to identify the explosive power of the legs. The starting line is marked on the ground. The athlete stands behind the line, feet slightly apart. When ready, the athlete jumps forward and lands on one leg (the hop), then in one continuous motion jumps forward to step on the opposite leg (the step), then jumps into the landing pit, landing on both feet (the jump) without falling backward. Vigorous arm swinging and knee bending are encouraged to achieve maximal forward movement and jump distance. Three attempts are allowed.

4. 20 m sprint: the test is performed after a warm-up, from a stationary position with one foot behind the other, on the starting line, without swinging. The player starts at the signal and the performance is estimated at the finish line. Three attempts are allowed and the best time is recorded.

Results. It should be noted that there was no evidence of muscle cramping during training or testing. We registered the dynamics of each measured parameter depending on the characteristics of the player and on the group (Egr and Cogr). The results show that the changes in performance depend on the quantity of CrS used per day. When comparing the results of the four tests in intragroup, we discovered that Egr had a notable increase. In the medicine ball throw test during the first 10 days the increase amounted to 1.05 m ($p = 0.2$) followed by 0.81 m ($p = 0.21$) in the second period, and 0.40 m ($p = 0.22$) in the last period. Similar effect was registered in the long jump test, where the dose increased but the level of performance did not: from 9.1 cm ($p = 9.64$) in the first 10 days to 4.8 cm ($p = 11.74$) in the final period. In the triple jump test, results were 68.8 cm ($p = 24.57$) in the first period, followed by a decrease to 30 cm ($p = 27.14$) in the last period of CrS. The data show that CrS had a different effect on lower limb strength depending on the dose. Interestingly, the results of 20 m sprint changed from 0.04 s ($p = 0.04$) to 0.05 s ($p = 0.02$). Total results were as follows: 2.25 m in medicine ball throw, 19.8 cm in long jump, 136.7 cm in triple jump, and 0.17 s in 20 m sprint. We observed a total body mass increase of 3.3 kg in Egr compared to Cogr. In Cogr, the values of the studied parameters increased from period to period, but the overall performance levels were low compared to Egr. Total results for Cogr were as follows: 0.90 m in medicine ball throw, 12.7 cm in long jump, 102.5 cm in triple jump, and 0.08 s in 20 m sprint.

The results of the Egr and the Cogr performance before the experiment are shown in Table 1. At the beginning, there were changes in the medicine ball throw test (0.05 m, p = 0.67) or 20 m sprint (0.01 s, p = 0.39). In contrast, the triple jump test shows an insignificant difference (10 cm, p = 0.22) in Cogr, as well as the long jump test (1.1 cm, p = 0.63). The difference in body mass was also insignificant in comparison between Cogr (73.4 ± 5.8 kg) and Egr (72.5 ± 6.2 kg). In fact, there were no significant differences found in any of the tests among the mean change scores, which represent the variations between the pre-supplementation values.

During the first 10 days, significant differences in performance between the Egr and Cogr were as follows: in the medicine ball throw test – 0.60 m (p = 0.01), in the triple jump test – 25.5 cm (p = 0.04), and 0.04 s (p = 0.01) in 20 m sprint (Table 2). Results of the long jump test did not differ significantly (2.50 cm, p = 0.30). In terms of intra-group comparison, a substantial difference was registered in the medicine ball throw test: 1.05 m in Egr, and only 0.4 m Cogr. In the long jump test, the increase amounted to 9.1 cm followed by 68.8 cm in the triple jump test in Egr, while in Cogr the increase was only 4.8 cm (p = 0.20) and 38.1 cm respectively. Body mass increased by 1.1 kg in Erg but decreased in Cogr by 0.6 kg.

Table 3 shows results obtained after the second ten-day period of CrS. A difference was registered in dynamics of the studied parameters in both groups. When comparing the results between Egr and Cogr, we found a significant difference in the medicine ball throw test (1.1 m, p = 0.01), in 20 m sprint (0,05 s, p = 0.03), and in body mass (0.8 kg in Egr and 0.3 kg in Cogr).

Table 1

Mean differences between the experimental (Egr) and control (Cogr) groups in studied tests before the experiment

Tests	Egr		Cogr		T	P <
	M	SD	M	SD		
Medicine ball throw, m	12.15	0.30	12.20	0.23	0.45	0.67
Long jump, cm	223.7	9.37	224.8	6.96	0.51	0.63
Triple jump, cm	685.00	20.97	695.00	37.28	1.39	0.22
20 m sprint, s	4.08	0.02	4.09	0.02	0.93	0.39
Body mass, kg	72.5	6.2	73.4	5.8	0.62	0.79

Table 2

Mean differences between the experimental (Egr) and control (Cogr) groups after 10 days of CrS (15 g/day)

Tests	Egr		Cogr		T	P <
	M	SD	M	SD		
Medicine ball throw, m	13.20	0.20	12.6	0.30	6.74	0.01
Long jump, cm	232.8	9.64	230.30	6.97	1.15	–
Triple jump, cm	753.80	24.57	728.30	33.71	2.71	0.04
20 m sprint, s	4.00	0.01	4.04	0.02	3.78	0.01
Body mass, kg	73.6	3.1	72.8	6.2	1.80	0.05

Table 3

Mean differences between the experimental (Egr) and control (Cogr) groups after 20 days of CrS

Tests	Egr		Cogr		T	P <
	M	SD	M	SD		
Medicine ball throw, m	14.0	0.21	12.9	0.39	7.90	0.01
Long jump, cm	238.7	10.72	234.7	6.47	1.50	–
Triple jump, cm	791.7	29.94	778.30	30.60	1.04	–
20 m sprint, s	3.95	0.02	4.00	0.03	3.45	0.02
Body mass, kg	74.4	2.8	72.5	2.3	2.62	0.05

Table 4

Mean differences between the experimental (Egr) and control (Cogr) groups after 30 days of CrS

Tests	Egr		Cogr		T	P <
	M	SD	M	SD		
Medicine ball throw, m	14.4	0.22	13.08	0.47	7.42	0.01
Long jump, cm	243.50	11.74	237.50	6.34	2.18	0.05
Triple jump, cm	821.70	27.14	796.70	24.22	1.98	–
20 m sprint, s	3.91	0.02	3.97	0.03	5.27	0.02
Body mass, kg	74.7	5.20	72.30	2.60	3.8	0.02

Table 5

Mean differences between the experimental (Egr) and control (Cogr) groups from the beginning to 30 days of CrS

Tests	Egr		Cogr		T	P <
	M	SD	M	SD		
Medicine ball throw, m	14.4	0.22	12.20	0.47	7.42	0.04
Long jump, cm	243.50	11.74	237.50	6.34	2.18	0.05
Triple jump, cm	821.70	27.14	796.70	24.22	1.98	–
20 m sprint, s	3.91	0.02	3.97	0.03	5.27	0.02
Body mass, kg	74.7	5.20	72.30	2.60	3.8	0.02

The differences in the long jump (4 cm, p = 0.19) and triple jump tests (13.30 cm, p = 0.34) were insignificant.

As shown in Table 4: by the end of the experiment, during the third period, the 5g CrS also has its impact but not as great one compared to two previous periods of CrS. The comparison between two groups demonstrates a significant improvement in the medicine ball throw test (1.30 m, p = 0.01) and in the long jump test (6 cm, p = 0.05) in Egr. An insignificant difference in the triple jump test (25 cm, p = 0.10) was also found. A significant difference in 20 m sprint (0.06 s, p = 0.02) and in body mass (0.3 kg, p = 5.20) was identified in Egr, while the changes in body mass amounted to 1.1 kg (p = 2.60) in Cogr.

The total improvement of CrS during the 30-day preparation period is shown in Table 5, where the differences were calculated with the t-test: significant differences were found in the results of the medicine ball throw test, 20 m sprint, the long jump test and in body mass (p < 0.05). Changes in the triple jump test remained insignificant. Body mass increase in Egr may have a reducing effect on the degree of improvement of lower limb strength.

Discussion

The strength of our experimental research is that our method and duration of CrS differed from other studies. The vast majority of scientific works investigating the effects of CrS have focused on its potential ergogenic benefits during exercise after short periods of activity (5–7 days). They found that CrS improved repetitive running, sprint performance, power, and the amount of work performed during repeated sets of isokinetic contractions [11]. However, other studies have shown no ergogenic benefits in terms of resistance, endurance, or single sprint performance [18]. Fewer studies have examined the effects of prolonged CrS on exercise performance. Pfeiffer et al (2010) found that 28 days of CrS (20 g/d) during resistance training significantly improved 1RM press bench performance, the volume of bench press lifted at 70 % of 1RM, as well as the 3×30-s maximal effort cycling. Similarly, other researchers [4, 32], reported that 8 weeks of CrS (21 g/d and 10.5 g/d) did not significantly improve the changes in 1RM bench press, vertical jump performance during off-season football resistance/agility training, which is in our study was the strength and power of the upper and lower limbs and the supplementation varied in quantity from period to period. Results of this study indicate that 30 days of CrS with different decrease in dosage generated significantly higher increases in body mass, upper limb, the medicine ball throw test and 20 m sprint. These findings support previous studies that creatine can increase total body mass [2, 31], and/or lean body mass [6]. CrS increases power and improves performance before and after intense activity [5, 25, 26]. Our findings confirm the results of previous studies regarding the weight gain under CrS and demonstrate that 15, 10, and 5 g doses of creatine supplementation are effective.

The primary conclusion of the current study is as follows: first, varying amounts of CrS in equal amounts did not affect the adjustment of performance-related parameters to each 10 days of the preparation period. Second, the choice of dosage and the precision of CrS timing before, during, and after training are crucial for performance enhancement. When we compare the results of the two groups, we see that CrS has a significant effect on all Egr parameters. Body mass increased in Egr, but decreased in Cogr. The training results were not comparable in both groups. Creatine consumption before, during, and after exercise affects the overall adaptation of the body. In this scenario, it is crucial to understand how and how much of this nutrient is beneficial for muscle growth. The scientific data show that training adaptations are caused by the buildup of CrS during each individual training session [9, 29].

CrS significantly impacts results of 20 m sprint and the medicine ball throw test during all three periods of the experiment (10, 20 and 30 days). The effect size (η^2) was between 44.59 % to 80.28 % ($p < 0.01$), which corresponds with the findings from other studies [14, 17]. However CrS did not affect significantly the long jump test results in Cogr, η^2 was between 2.58 % to 22.08 % ($p > 0.05$) (Fig. 1, Table 6). Weight gain from 72.5 ± 6.2 kg to 74,70 ± 5.6 kg was registered in Egr ($p < 0.05$), which is also similar to results of other works [13]. On the contrary, body mass in Cogr decreased. The results demonstrate that CrS is linked to an increase in muscle growth and power, although this association may sometimes be exaggerated. The connection between increasing muscle mass and power and protein nutrition has been the subject of recent reviews [22–24, 27]. The degree of muscular hypertrophy is mostly determined by how the muscles react to training. According to research by Peake et al. (2017) and Krustrup et al. (2006), we can state that the length, volume, intensity, and frequency of training sessions have the strongest effect on the metabolic response to exercise [15, 20]. CrS may also have an impact on this response.

In our case, different doses have different effect in intra-group comparison (backfields, midfields and forwards, as well as a significant impact in Erg compared to Cogr). The exercise activity was the same for all players in a course of 30 days. This difference may be related to the total

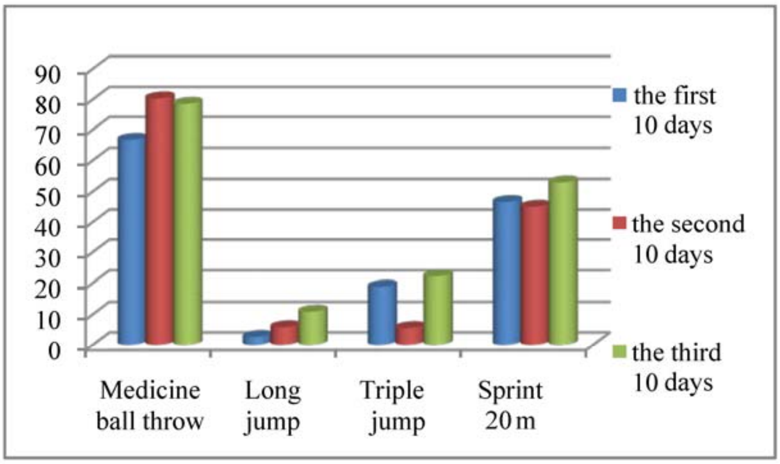

Fig. 1. Effect size (η^2, %) of CrS during the preparation period of football players

Table 6

Effect size (η^2%) of CrS during the preparation period of football players

Tests	The first 10-day period	The second 10-day period	The third 10-day period
Medicine ball throw, m	66.67*	80.28*	78.48*
Long jump, cm	2.58	5.76	10.81
Triple jump, cm	18.70*	5.49*	22.08*
20 m sprint, s	46.49•	44.95•	52.92•

Note: * – $p < 0.001$; • – $p < 0.01$.

amount of CrS ingested each 10 days. It should be enough to support the increased anabolism from exercise [22]. On the other hand, the amount of CrS necessary to optimize muscle hypertrophy has never been determined, especially during long periods of training. Increased muscle mass in response to training and nutrition is clearly individual and depends on factors other than just the amount of CrS [16]. In our case, replenishing muscle and liver glycogen every 10 days is essential for recovery in between training sessions or competitive matches, especially when football players with different roles perform different types of exercises.

According to Betts and Williams, CrS helps to load muscles with Cr and increase PCr storage [21]. It helps develop the ability to generate energy during explosive workouts and high-intensity activity, as well as strengthen the ability to recover from short, intense exercise.

This is particularly confirmed in our first test, during the first and second ten-day periods. In our case, these results also seem to be important, as they are consistent with the results of the first and the second consecutive periods of CrS (d = 0.67 m for medicine ball throw, d = 2.50 cm in long jump, and d = 23.83 cm in triple jump). In support of these findings, research has also shown that CrS increases the intramuscular PCr concentrations [36]. Tables 2 and 3 show substantial changes in strength, power, and running speed for Egr.

According to the findings of Kreider et al. (2003), Terjung et al. (2000), all studies show substantial results. The majority of research data demonstrates that CrS appears to be a generally effective dietary ergogenic aid for a variety of exercise demands in different sports and clinical groups [14, 34]. The strong and significant ($p < 0.001$) influence of CrS in the medicine ball throw test in all three periods can be explained by the high level of the upper limb muscle training required in many football techniques. The high influence of CrS in 20 m sprint ($p < 0.01$) in all periods can be explained by the fact that sprint is a repetitive movement in football training and competition. These results correspond to findings of other researchers [3, 19]. However, the long jump is an explosive movement that does not require rapid recovery of ATP, so in this case, CrS played a lesser role and its effect was not statistically significant. CrS enhances results in exercises that require maximal effort and repetitive sprints associated with short duration of exercise. Prolonged exercise in a course of 30 days could lead to a low but progressive impact of CrS doses on the lower limb. The lengthy 30-day experimental design used to investigate the effects of CrS on exercise performance may be one reason for the contradictory results. Most studies have used a cross-sectional experimental design or an ordered treatment. Few studies have used a crossover experimental design, partly because the time required for total muscle creatine (TCr) to return to basal levels after CrS is uncertain. According to Bird (2002), a number of factors, including but not limited to sample size, exercise modality, rest and recovery intervals, residual effects of CrS, gender- and age-related effects, as well as the applied methods, make interpretation of existing data on Cr research extremely difficult [3].

Conclusion. The results of our study show that during the preparation period, athletes from Egr outperformed Cogr in power, and speed. CrS can improve the quality of training by increasing the body's ability to tolerate greater workloads, resulting in better physical attributes. A dose taken at a different time of day will have a different effect. It is important to determine the ideal dosage for the season and the preparation phase. Although the 5 g/d dose has no discernible effect on performance after 10 days of training, lower doses will affect performance during training and competition.

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