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Current Trends of Creatine Use in Exercise: A Systematic Review

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Abstract

Creatine, which is a popular ergogenic aid, is shown among the most effective methods used as a performance enhancer in athletes. The aim of this review is to summarize the current publications to show the uses and effects of creatine in exercise. In the present study prepared in a systematic review style, full-text articles about creatine use published in Science Citation Index (SCI), SCI-Expanded, and PubMed/MEDLINE databases' journals between 2010 and 2021 were examined. The searching was performed by "creatine", "creatine monohydrate" and "creatine supplementation" keywords. Data from 46 studies showed that creatine loading in individuals who train during high intensity and short term exercise forms affect performance positively, develop muscle mass/strength and increase muscle creatine phosphate (PCr) stores. It was also found that creatine supplement applied with strength training in elderly individuals increased muscle mass, muscle strength, and movement capacity. It is determined that there is no definitive and clear procedure regarding the usage dosage for creatine. In addition, though some studies have reported that creatine use has a positive effect on cognitive performance, a definite judgment has not been reached. Consequently, it has been demonstrated that creatine supplementation is an effective ergogenic aid for the development of muscle and strength for athletes of all levels. The increase in the number of studies on the creatine usage dosage to be examined in different athlete profiles may lead to a decrease in the contradictions about the usage procedure.

Key Words: Athletic performance, creatine, ergogenic aid, supplement

Özet

Popüler bir ergojenik yardım ürünü olan kreatin, uzun yıllardır sporcularda performans artırıcı olarak kullanılan en etkili yöntemler arasında gösterilmektedir. Bu derleme çalışmasının amacı; 2010-2021 yılları arasında gerçekleştirilen güncel yayınları inceleyerek, kreatinin egzersizdeki kullanımı ve etkilerini ortaya koymaktır. Sistematik derleme tarzında hazırlanan çalışmada, kreatinin son yıllarda hangi amaçla / ne şekilde kullanıldığı ve güncel eğilimlerin belirlenmesi için, Science Citation Index (SCI), SCI-Expanded ve PubMed/MEDLINE veri tabanlarındaki dergilerde 2010-2021 yılları arasında yayınlanmış tam metin makaleler (İngilizce) incelenmiştir. "Creatine, "creatine monohydrate" ve "creatine supplementation", araştırmalar yapılırken çoğunlukla kullanılan anahtar kelimelerdir. Belirtilen şartları sağlayan makalelerdeki bulgulara göre; yüksek şiddetli ve kısa süreli formlarda gerçekleştirilen antrenmanlarda kreatin yüklemesinin, atletik performansı olumlu yönde etkilediği, kas kütlesi/kuvvetini geliştirdiği ve kas kreatin fosfat (PCr) depolarını arttırdığı tespit edilmiştir. Yaşlı bireylerde kuvvet antrenmanları ile birlikte uygulanan kreatin takviyesinin de kas kütlesi, kas kuvveti ve hareket kapasitesini arttırdığı görülmüştür. Kullanım dozu ile ilgili ise standart bir prosedür olmadığı belirlenmiştir. Ayıca bazı çalışmalarda kreatin kullanımın bilişsel performansa pozitif etki ettiği bildirilse de kesin bir yargıya varılamamıştır. Sonuç olarak kreatin takviyesinin her seviyeden sporcu için kas ve kuvvetin gelişiminde etkili bir ergojenik madde olduğu ortaya koyulmuştur. Farklı sporcu profillerinde incelenecek olan kreatin kullanım dozu ile ilgili çalışma sayısının artmasının, kullanım prosedürü hakkında oluşan çelişkilerin azalmasına yol açabileceği düşünülmektedir.

Anahtar Kelimeler: Ergojenik yardım, kreatin, atletik performans, suplement

INTRODUCTION

Ergogenic aids are defined as a pharmacological method or psychological technique that can increase exercise performance (41). In recent years, many athletes have used ergogenic aids to maintain fitness level, enhancing recovery and physiological adaptations during long-term training periods. So, the efficacy of ergogenic aids has always attracted great attention, and many researchers have sought to combine ergogenic aid and exercise training programs to strengthen the benefits of training (65). Creatine, which is an ergogenic aid, is shown among the most effective methods used as a performance (strength) enhancer in athletes (17, 30, 44, 63, 68). Creatine, whose performance has been increasing continuously since the 1990s, is more effective especially when used with exercises performed in high intensity and short-term forms. For this reason, it is frequently preferred by individuals who participate in strength and fitness training both as professionals and as amateurs (9).

Creatine is a natural and nitrogen containing amino acid compound which is found mainly in red meat and sea products and it plays a role in protein synthesis (32). It is produced endogenously 1 g per day in liver and kidneys and less than 1 g in pancreas (20). It can also be taken into the body through food synthesized from essential and non-essential amino acids (33). Although creatine is mostly found in skeletal muscles (95%) in the body, it is also found in certain amounts (5%) in the brain and testicles (43). Although it has different types structurally, the most widely used and preferred type of creatine is creatine monohydrate (CrM) (37). The primary effect of CrM is to increase muscle creatine stores during exercise (40). It is also known to increase exercise capacity, endurance and muscle mass in addition to having a positive effect on bone mineral density (BMD), muscle damage and recovery (5, 25, 36).

Creatine supplement has many ergogenic properties such as muscle recovery, increased protein synthesis and energy storage in the form of creatine phosphate (PCr) (36). Using appropriate dose of creatine, which acts as an energy substrate, for contraction in skeletal muscle increases the usability of Adenosine 3'-triphospate (ATP) especially in high intensity/short term exercise lasting 30 seconds or shorter by increasing PCr muscle storage (20). The main purpose of creatine supplementation is to delay fatigue for a short time in order to increase performance and to increase resting PCr levels and free creatine level (9). While short-term creatine supplement increases PCr stores by 10%-40%, an increase of 10% - 30% occurs in total creatine (52).

In general, creatine use (mostly CrM) is not recommended by American College of Sports Medicine (ACSM) due to possible health problems such as liver/kidney failure, dehydration and cramp (62). Considering that CrM is commonly used especially in individuals who exercise as an amateur, when not used in proper dosage, negative effects (side effects) as well as positive effects can be seen in most of the supplements (8). However, despite all these potential side effects, it was found that CrM supplement did not have negative effects on liver and kidney functions in healthy individuals; CrM supplement was even found to prevent cramp and dehydration during exercise under adverse environmental conditions (15).

The aim of this study is to review current publications between 2010 and 2021 to show the uses and effects of creatine in exercise. The aim is to guide athletes/trainers in terms of usage methods of creatine, which is a popular supplement, and to give ideas in the design of scientific studies to be carried out with the results presented in the study.

MATERIAL AND METHOD

The study was prepared in a systematic review format. Basically, answers were sought to questions such as the development of creatine in recent years, what purposes it is used for, timing of use and what the recommended daily use should be. In order to reach the answers to these questions, a comprehensive research was carried out by examining the full text articles (English) published between 2010 and 2021 on creatine use in Science Citation Index (SCI), SCI-Expanded and PubMed/MEDLINE databases. “Creatine”, “creatine monohydrate” and “creatine supplementation” are the key words used while searching.

After “title” and “abstract” parts were examined respectively, the findings related to the research questions, and the conditions for including information about the aim and procedure of creatine use were sought. While reviewing the studies, no restrictions were applied on classifications such as review, meta-analysis, research article or variables such as sport branch, type of exercise and gender.

As a result, a total of 46 articles which met the specified conditions were examined (Figure 1).

Ethical approval was not required for this systematic review.

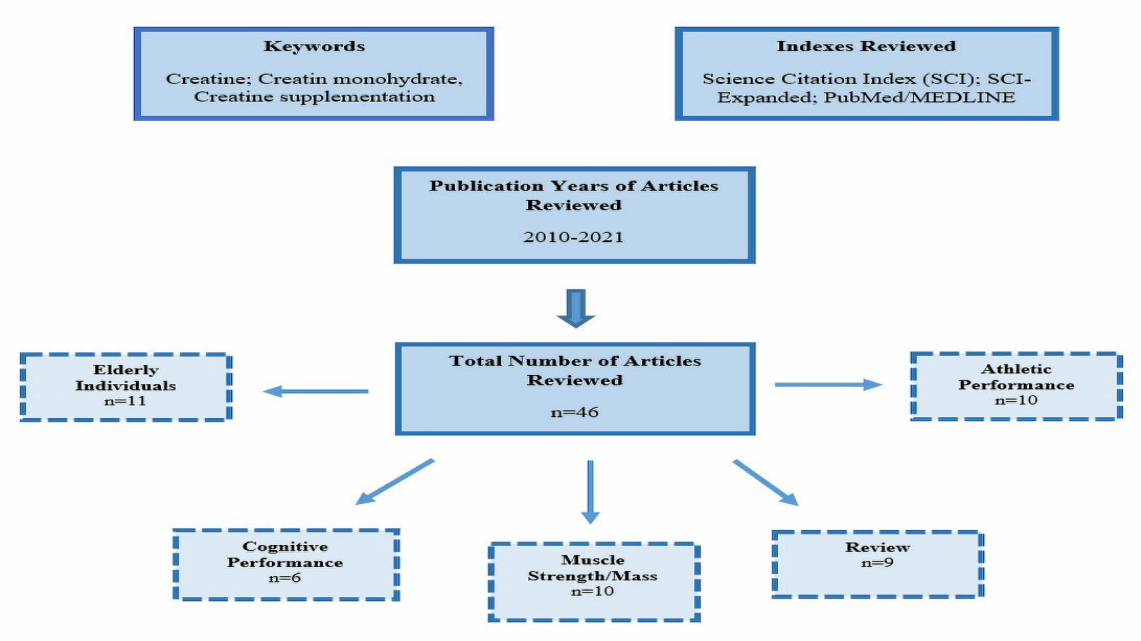

Figure 1. Chart of study selection

RESULTS

A total of 46 full text articles which met the specified conditions were examined. In the articles reviewed, it was found that the widespread use of creatine continues today and the number of scientific studies on the subject is gradually increasing. Important findings were reached regarding for what purposes creatine has been used in recent years, the effects of creatine on athletic/cognitive performance and muscle strength/mass and its use in elderly individuals.

It was found that creatine loading in individuals who train during high intensity and short term exercise forms affect performance positively, develop muscle mass/strength and increase muscle PCr stores. It was also found that creatine supplement applied with strength training in elderly individuals increased muscle mass, muscle strength and movement capacity, while no changes were observed regarding BMD. However, although there is no definitive and clear procedure as the usage dosage for creatine supplement, many studies have shown that continuing routine daily creatine intake (0.03 g/kg/day or average 5 g.) after creatine loading (0.3 g/kg/ day or average 20 g) applied in the first 5-6 days is an effective method. Although there are limited number of studies examining the long-term use of creatine, existing studies have emphasized the need to be careful about this issue (especially with continuous use for a year) and that its short term use is safer in terms of health.

Some of the findings from reviewed studies are shown in Table 1.

Table 1. Some examples of studies on the use of creatine in exercise

Study	Subjects	Creatine Procedure	Summary of findings
Hammet et al. (31) (2010)	22 healthy individuals Cr n=11 Pla n=11	Creatine 20 g / day in 2 equally divided doses for 5 days and 5 g creatine once daily for the next 2 additional days	Increased cognitive performance
Mohebbi et al. (51) (2012)	17 Football players (age: 17.18 years) Cr n=8 Pla n=9	5 g of creatine, 4 doses per day for 1 week	Changing in positive way in repetitive sprinting and dribbling skills
Gualano et al. (29) (2014)	Age ≥ 60 women Pla n=15 Cr n= 15 Pla+RT n=15 Cr+RT n=15	Creatine 20 g / day, divided into four doses for the first 5 days; 5 g doses per day (during lunch) for the following 23 weeks	Improvement in muscle strength and muscle function in the elderly individuals. No change in BMD.
Candow et al. (14) (2014)	Adults aged 50-64 Pla n=11 Cr-Pre Training n=11 Cr-Post Training n=11	Creatine taking on training days only	Increase in muscle mass. No difference between the creatine groups.
Campillo et al. (57) (2015)	33 amateur women football players Pla n=10 Cr n=10 C n=10	5 g creatine 4 times a day for 5 days followed by 5 g creatine daily for 5 weeks (at lunch)	Improvement in repetitive sprinting and jumping performance. No change in endurance performance.
Turner et al. (64) (2015)	15 healthy individuals (age: 31years) Cr n=8 Pla n=7	4 doses of 5 g of creatine per day for 1 week.	Increase in neural creatine level. Decrease in attention disorders at the time of hypoxia
Pinto et al. (55) (2016)	Healthy, untrained women and men aged 60-80 Cr + RT n=13 Pla + RT n=14	5 g creatine daily After lunch on rest days	Increase in muscle mass.
Merege-Filho et al. (48) (2016)	67 healthy children (aged 10-12) Pla n=32 Cr n=35	0.3 g.kg-1 per day	No change in neural creatine level and cognitive performance
Wang et al. 65) (2018)	Baseball, basketball and tchoukball players Pla n=15 Cr n=15	0.3g / kg creatine 4 times a day for 6 days. 2 g of creatine during training and 2 g after training	Increase in muscle strength.

Pla: Placebo Group; Cr: Creatine Group; Cr + RT: creatine + resistance training group; Pla + RT: Placebo + Resistance training group; C: Control Group

DISCUSSION

Creatine is shown among the most effective and popular methods used as a performance enhancer in athletes. The present review examined current studies conducted on the use of creatine in exercise. The results of the present study revealed that creatine loading affect athletic performance positively especially during high intensity exercise forms. It was also found that creatine supplement could be useful for elderly individuals to increase muscle mass and movement capacity. It is determined that there is no clear procedure regarding the usage dosage for creatine. Reviewed studies and the results were discussed under different headings.

Creatine and Muscle Strength /Mass

There are many studies which show that creatine, which is frequently preferred by athletes of all levels among ergogenic aids, increases muscle strength when used during strength training (3, 10, 20, 50, 67, 68). When studies recently conducted are examined, it was found that Nunes et al. (54) found that 8-week long creatine loading during strength training (first week 4 doses of 0.3 g/kg; 7 weeks single dose of 0.03 g/kg) increased muscle strength significantly when compared with the placebo group. In their study, Wang et al. (65) found that strength training with 4- week long creatine supplement (4 doses of 5 g in the first six days; a total of 4 g, 2 g before and after 3-week long training) affected muscle strength positively. The results of Kaviani et al. (39) are similar. In a different

study by Claudino et al. (17) on football players, 7-week long creatine loading (first week 4 doses of 5 g; daily 5 g for the remaining 6 weeks) affected lower extremity strength statistically positively. Candow et al. (12) reported that different doses of creatine loading (low dose group: 0.10 g/kg 3 days a week; high dose group: 0.15 g/kg) increased strength when compared with the placebo group. However, no difference was found between the doses applied.

As a result, it can be seen clearly that when applied within the doses in literature, creatine loading develops muscle strength and power. The reason for this is the increase in muscle creatine phosphate stores during creatine loading period and the positive effect on performance as a result of faster ATP resynthesis between sets during training. Therefore, it is thought that creatine supplement is an important method for strength development.

Creatine and Athletic Performance

Combined application of aerobic and anaerobic exercises in team sports are considered as indispensable in terms of the development of strength and endurance. The use of creatine supplement for fatigue caused by long-term aerobic exercise in order not to affect athletes' performance is a subject that has been investigated in literature (22) because it is thought that as a result of the increase in muscle Pcr with creatine supplement, activities connected to energy system may be affected by this process (40). Results of studies on the subject have shown that creatine use causes different (inconsistent) results in athletes (28,44, 45, 53, 60,66).

In their study, Hickner et al. (35) examined the effects of 28-day creatine supplement applied to 12 cyclists (creatine and placebo group) on exercise performance. As a result, it was found that creatine loading applied as a single dose daily (3 g) with dinner for 28 days did not affect sprint performance. Forbes et al. (26) examined the effects of high intensity interval training (HIIT) applied with 4–week long creatine supplement on physical performance. According to the results of the study, it was found that creatine supplement for HIIT training did not have an effect on cardiorespiratory fitness and performance and body composition. In their study conducted on 30 amateur female football players (placebo, n=10; creatine, n=10, control, n=10).

Campillo et al. (57) examined the effects of creatine supplement applied with 6-week long plyometric training on aerobic and anaerobic performance. As a result of the study, although no statistically significant difference was found between the creatine and placebo group in terms of endurance performance, a positive difference was found in the creatine group in jumping and repeated sprint tests. Similarly, in a study they examined the effects of creatine supplement on sprint and sportive performance in young football players (creatine and placebo group), Mohebbi et al. (51) found that using daily 4 doses (breakfast, lunch, dinner and before sleep) for 1 week in the creatine group developed repeated sprint and dribbling performance more statistically when compared with the placebo group. Crisafulli et al. (21) also found similar results. In a review conducted by Mielgo-Ayuso et al. (49), it was reported that creatine supplement in football players increased intramuscular creatine concentrations and supported ATP-PC energy system.

Different results can be seen in studies conducted on the effects of creatine use on athletic performance. Despite contradictory results, it is thought that creatine use may cause increase in high intensity exercise performance. However, while interpreting the effects of creatine use on athletic performance, how energy systems are used and the type of exercise should be specified clearly.

Creatine and Cognitive Performance

Based on the fact that creatine use shows development in athletic and sportive performance, the effects of creatine use in athletes, sedentary, elderly individuals and some patient population is an area researched in literature (34,56, 58,59). Contradictory results have been found in studies conducted on the use of creatine (2, 18, 31, 56). Turner et al. (64) examined the effects of creatine supplement during acute lack of oxygen in young adults on neurophysiological and neuropsychological functions. As a result, it was found that creatine supplement increased neural creatine level and prevented attention disorders that occurred during lack of oxygen. Merege-Filho et al. (48) found that 1-week long creatine supplement (0.3 g.kg-1 per day) did not have any effects on brain creatine level and cognitive abilities. In a review by Dolan et al. (24), it was stated that creatine supplement increased brain creatine level and caused improvement in cognitive peformance; however, it was emphasized that the number of studies was not sufficient to verify this thesis. It was

also reported that there is no precise creatine loading procedure in increasing brain creatine level.

It is an accepted fact that regular exercise improves brain health and cognitive performance. In this context, the judgement that creatine use increases athletic and sportive performance is seen as a process that is not completely clear for cognitive performance.

Creatine Use in Elderly Individuals

Aging is a process characterized by morphological, functional and biochemical changes in the human body, including the muscoskeletal system. This process also includes the loss of muscle and bone mass along with muscle strength (4). Loss of muscle mass and decrease in muscle performance due to aging has a negative influence on physical functions while also reducing performing daily life activities (47). For this reason, various strategies are recommended to prevent the progression of these negative effects in elderly individuals. Among these strategies, the use of creatine comes to the fore with strength training (46).

Studies on the subject show that creatine supplement with strength training has positive effects on muscle mass and strength in elderly individuals (1, 6, 7, 10,16, 19, 27, 38). Gualano et al. (29) examined the effects of creatine supplement with 24-week long strength training on muscle strength/function and bone mass in elderly women (≥ 60 years). The participants were grouped in four as creatine group (Cr: n=15), creatine + strength training (Cr+RT: n=15), placebo group (Pla: n=15) and placebo + strength training group (Pla+RT: n=15). As a result, it was found that Cr+RT group showed more improvement in muscle strength and muscle function parameters when compared with the other groups. No change was found in bone mass. In their study they examined the effects of pre-exercise and post-exercise creatine intake with strength training on muscle strength in elderly individuals, Candow et al. (14) found that both pre-exercise and post-exercise creatine use caused improvement in muscle strength when compared with the placebo group. No difference was found between the groups in terms of the time of creatine use. Similar results were found in a study conducted by Candow et al. (13). Pinto et al. (55) examined the effects of low dose creatine (single dose of 5 g) with strength training (12 weeks, 3 days a week) on muscle mass, strength and bone mass in elderly individuals. As a result of the study, it was found that creatine group showed more improvement than the placebo group in terms of strength, while no change was found in bone mass.

The results of studies examined showed that the use of creatine in elderly individuals had a positive effect on strength development. This situation proves the importance of using creatine in elderly individuals in order to maintain mobility, balance and daily life activities and to increase the quality of life in general especially with advancing age. Similarly, Stares and Bains (61) stated that creatine use was safe in elderly individuals and the use of creatine with especially moderate and high intensity strength training increased muscle strength and mass in elderly individuals. Further studies are needed for clearer findings on bone mass and BMD.

Creatine Loading and Usage Dose

Although there are a large number of studies which show that creatine improved muscle strength and athletic performance, it can be seen that there is no definitive judgment about the dosage of use. In their meta-analysis, Devries and Phillips (23) reported that daily 0.07 g.kg-1 or 5 g creatine use with strength training showed positive results in increasing muscle mass and strength. In their review, Kim et al. (42) stated that the fastest method in maximizing muscle creatine stores is daily single dose of 0.3 g.kg-1 creatine for 5-7 days. In their review, Hall and Troijnan (30) stated that optimum creatine procedure is daily single dose of 0.3 g.kg-1 the first 5-7 days and daily single dose of 0.03 g.kg-1 the following 4-6 weeks. Cooper et al. (20) stated that ideal creatine loading procedure should consist of "loading (daily 4 doses of 29 g creatine the first 5-7 days)" and "care (daily single dose of 5 g)" phases. In a review which researched the issue of loading and maintenance phases, Mielgo-Alusa et al. (49) found that 9-week long daily single dose of 5 g maintenance care phase application following a total of 20 g creatine loading phase with daily 3-4 doses during the first 6-7 days in football players has a positive effect on anaerobic strength.

In general, it was concluded that daily 5 g of creatine use is a common use following the loading period. However, considering that there are a large number of studies on creatine, which still keeps its popularity for all levels of athletes as an ergogenic aid, the fact that there is no clear procedure about its usage dose comes to the fore as an issue that should be emphasized.

CONCLUSION

Considering that the use of ergogenic aids and athlete food is increasing and becoming widespread, the importance of up-to-date results on creatine, which is a popular product, is also increasing. In the light of the findings in reviewed studies, it can be said that creatine use has a positive effect on the increase in muscle creatine phosphate stores and especially on muscle strength/mass and athletic performance. However, the effect of creatine on cognitive performance is not clear. Although there is a widespread use about its dose (daily 5 g), it is a fact that there is still no clear usage procedure.

Although creatine is widely used in athletes and individuals who exercise regularly, the present study shows its use and effects in elderly individuals also. While no relationships is found between bone health and intensity and creatine use in terms of preventing osteoporosis, which is a systemic metabolic bone disease causing a tendency for fractures in elderly individuals, it has been concluded that creatine use has a positive effect on strength development in elderly individuals in terms of the ability to move.

As a conclusion, an increase in the number of studies relating the creatine usage dose to be examined in different athlete profiles will cause a decrease in the contradictions about how and in what dosage creatine, which appeals to a high population, should be used. In this direction, it is thought that possible side effects of creatine use and negative situations that may occur depending on its usage period can be shown clearly.

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