

EFFECTS OF CREATINE MONOHYDRATE TO STRENGTH AND BODY COMPOSITION

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DOI 10.7251/SIZEN2001090B

ISSN 1840-152X

UDK 796.012.11:547.495.9

<http://sportizdravlje.rs.ba/>

<https://doisrpska.nub.rs/index.php/SIZ>

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REVIEW ARTICLE

Abstract: Creatine has become highly popular supplement among athletes. Contemporary research also suggests that there is also a large number of potential therapeutic applications of creatine. Aim of this systematic overview is to test the effects of CR to muscle strength and body composition on the basis of the collected data and analysed papers published in the period 2018–2020. Literature research was performed in the following data bases: PubMed, Scholar Google and DOAJ. Papers were selected according to multiple criteria and they suggest that CR in combination with an exercise program produces results in increase of muscle mass and strength and it reduces time required for execution of a specific activity. Changes in body composition were observed in increase of total mass and muscle mass, as well as amount of water in body composition. Use of CR in amount of 10–20 g per day and frequency of 4–5 days a week is an efficient tool used for increase in sport performances and positive changes in body composition.

Key words: weight, bench press, 1RM, body, BIA, supplements

1. Introduction

According to manuscripts human race has always reached for the most efficient non-hormonal supplements for amplification of physical abilities and possibilities. The first written data originates from the Olympic games in Greece in 776 BC. (Grivetti & Applegate, 1997). Use of supplements is widespread all over the world. In addition to common food products designed for athletes and physically active people, many companies developed supplements, mostly claiming that the sport effect can be increased. Supplements used for the purpose of increasing effects of exercise and sport performances come in various shapes, including pills, capsules, liquids and powders. Many of the aforementioned products also contain variety of ingredients in different combinations and percentages. The most common ingredients are amino acids, proteins, creatine and caffeine (LaBotz & Griesemer, 2009). There is a large number of studies observing the influence of

supplementation to physical abilities (El Khoury & Antoine, 2012; Morrison, Gizis, & Shorter, 2004; Rocha & Pereira, 1998; Pereira, Jajolo, & Hirschbruch, 2003; Gomes, Degiovanni, Garlipp, & Chiarello, 2008; Goston & Correlia, 2010; Oliver, Leon, & Hernandez, 2008) and changes of body composition (Earnest et al., 1995; Kreider, Ferreira, et al., 1998; Kreider, Klesges, et al., 1996; Vandenberghe et al., 1997). CR is also a part of diet and is mostly found in meat and fish and when consumed 98% is deposited in the muscles and the remaining part in the brain, heart and other organs, while the excess is processed by kidneys and excreted in the form of creatinine (Cannan & Shore, 1928). CR is one of most commonly used supplements for increase of exercising effects and sport performances (Kreider, et al., 2017). It facilitates the production of ATP and delivers energy into muscles, especially in case of short-term activities (Salomons, et al., 2010). CR may have four-fold positive effects to muscle performances: by increasing the cells of phosphocreatine which is used for generating the ATP at the start of intensive exercise, by increasing the speed of phosphocreatine re-synthesis after exercising, by depressing the degradation of adenine nucleotides and accumulation of lactates and/or by increasing the glycogen depositing into skeletal muscles (Salomons, et al., 2010). Oral ingestion of CR increases the creatinine and PCR (Polymerase Chain Reaction) content of human skeletal muscles (Casey, et al., 1996; Febbraio, Flanagan, Snow, Zhao, & Carey, 1995; Greenhaff, Bodin, Soderlund, Hultman, 1994; Harris, Soderlund, & Hultman, 1992; Vandenberghe, et al., 1997). Typical protocol for the start of CR intake for adults, regardless of sex and body size, consists of the loading phase in the period of 5–7 days when CR is consumed in the amount of 20 g/day divided into four parts (5 g), followed by the maintenance phase of 3–5 g/day (Cooper, Naclerio, Allgrove, & Jimenez, 2012). Impact of CR to strength and changes to body composition were also mentioned in other studies (Haff, et al., 2000; Meyer, et al., 2000). Regarding the fact that strength is one of the most important motoric factors, it was defined many times. Maximum strength is the maximal ability of muscle or a group of muscles to produce force. It is frequently measured by one-repetition maximum (1RM), which is operatively defined as the maximum amount of weight that a person can possibly lift for one repetition in provided time and in technically correct manner (Pereira & Gomes, 2003). With this systematic overview we will try to point out benefits of supplementation by CR in terms of increase in strength, all changes in body composition shall also be followed. Jose & Ciccone (2013) examined the effects of CR (5g/day) to strength and body composition in their study. Research was conducted on 19 participants who did body building aged 23.1 ± 2.9 . Over the course of four weeks five trainings were applied. In addition to body composition one-repetition maximum (1RM) was also tested at bench press and 3 repetitions at leg press. Significant differences were noted in increase of muscle mass, while the increase of total fat and body weight was not significant. Increase in strength was

noted in all applied variables. Similar research results were obtained by Cribb, & Hayes (2006). CR consumption before and after training results in higher gain in fat body weight, size of muscle fibers and muscle strength. Similar results were obtained in other research (Soderlung, Balsom, & Ekblom, 1994; Hultman, Soderlung, Timmons, Cederblad, & Greenhaff, 1996; Volek, 1997; Bembien, et al., 2010). Aim of the systematic overview is to test the effects of CR to muscle strength and body composition.

2. Method

Electronic databases PubMed, Scholar Google and DOAJ were used for the purpose of obtaining data for this research. Search for papers was performed in the period 2018–2019. Following key words were used in the search: weight training, muscle mass, 1RM, placebo, BIA, supplements. Found titles of the research papers, abstracts and full texts, were then examined and analysed. Research paper had to meet two criteria in order to be accepted for final analysis: the first criterion is in connection with the issues related to creatinine monohydrate and the second one to conducting analysis of papers issued in the defined period. Research that met the criteria was then analysed and represented through the following parameters: reference (first letter of the author, publishing year, year when the research was performed), sample (age, number of participants and groups of participants), exercise program, duration of program and research findings.

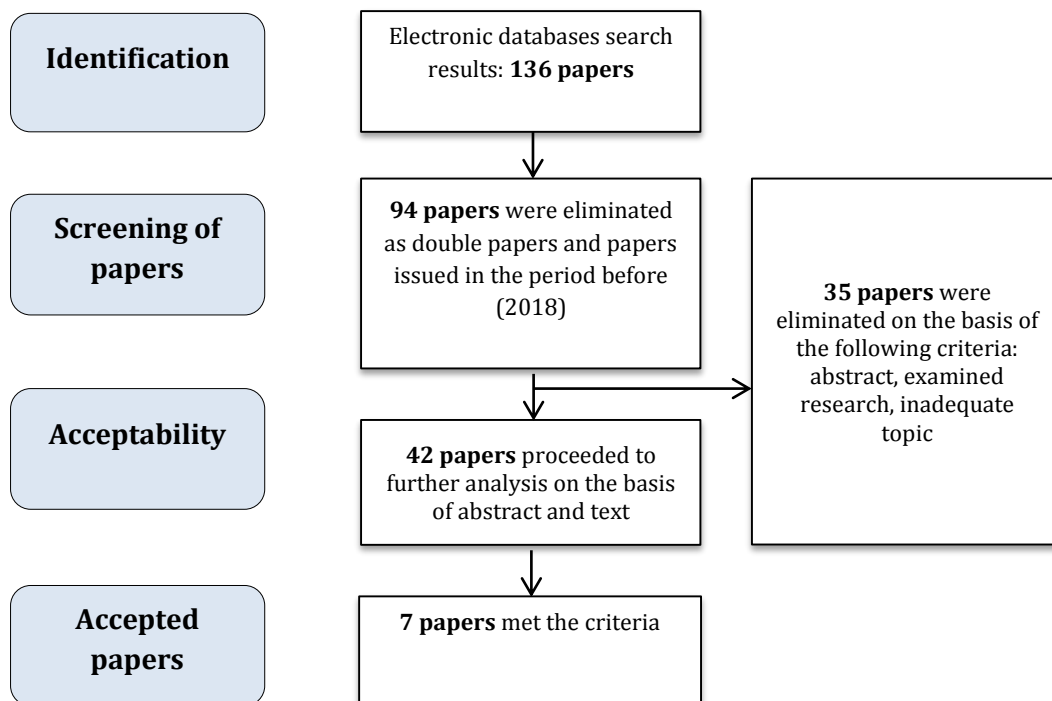
3. Results

Procedure of data collection, analysis and elimination is presented graphically (Graph 1). Using the key words 136 papers were obtained. Number of research immediately eliminated on the basis of title, double papers, and publishing date (before 2018) was 94, while 42 papers proceeded to further analysis which resulted in elimination of 35 papers according to various criteria: abstract, because they were systematic overviews and lack of adequate information relevant to our research. Remaining seven papers (Table 1) met the criterion that it was issued in period 2018–2020.

In four papers the research was performed on around 133 male participants istraživanja (Amirsasan, Nabilpour, Pourraze, Curby, 2018; Wang, Fang, Lee, & Yang, 2018; Vilar-Neto et al., 2018; Bjelica et al., 2020), in two papers research participants were 54 women. In the paper by Mills et al. (2020) it was combination of male and female participants. All the participants used creatinine monohydrate as supplement to regular diet, in addition to activity. Program duration varied. In the research performed by Farah & Dos Santos (2018) CR treatment was performed in

the course of 5 days, and in case of Atakan, Karaveliođlub, Harmancıb, & Bulut (2019) it was seven days.

Graph 1. Procedure for collection, analysis and elimination of obtained papers



In the research by Vilar-Neto et al. (2018) experimental treatment was in duration of 35 days. In a large number of studies were emphasised positive effects of short-term use of CR (5–7 days) to performing of exercises. In majority of studies it was suggested that creatine supplementation can significantly amplify strength, power, performances such as sprint or activities where a large number of muscle groups is engaged (Williams & Branch, 1998; Kraemer & Volek, 1999; Kreider, 1999; Balsom, Soderlund, & Ekblom, 1994; Hultman, Soderlund, Timmons, Cederblad, & Greenhaff, 1996; Greenhaff, 1997). Other authors mentioned significantly longer duration of experimental treatment, specifically in case of Wang et al. (2018) it was four weeks, Mils et al. (2020) six weeks, Amirsasan et al. (2018) eight weeks, Bjelica et al. (2020) sixteen weeks. CR intake was in range 0.1g/kg – 0,3g/kg or in total 5–20g per day. At weekly level CR intake was 4–7 times a week.

Seven accepted papers that met the required criteria are presented in Table 1. The research is comprised of contemporary research which dealt with the selected topic. References in the table are represented in the following manner: first author, age,

sex and division of groups, type of treatment, scope, duration of experimental protocol and results of each study respectively.

Table 1. Overview of the analysed papers

Reference	Population/sex	Treatment	Protocol	Results
Amirsasan et al. 2018	Football players ♂ EG+CR=10; EG+PG=10. SG=18-26yo	1RM/BP, 1RM/BS, TK- InBody 300	8 weeks, EG+CR=0.3g/kg, EG+PG=MD	In EG+CR, increase 1RM, TT, MM, reduction in TM compared to EG+PG.
Farah et al. 2018	Cyclers ♀ EG1=5; EG2=5;KG=5 SG=26.57 ±7.09yo	EG1,EG2,KG-crease, size, TT,MM, strength(W/Kg), resistance (W/Kg)	5 days, EG1=CR;EG2=CR+ MD; 4x10g; KG=/	EG1+EG2-changes in TK, increase in MS, TT, TM. KG without significant changes.
Wang et al. 2018	Athletes ♂ EG=15; PG=15 SG=20 ± 2yo	EG/PG - squats 5RM, jumps, TK, sprint 30m	4 weeks, EG=20g CR+ 2g dex. PG - 5g dex.	Increase of 1RM in EG, improved MMS and faster recovery after training.
Vilar-Neto et al. 2018	Students ♂ EG1=12;EG2=12; PG=12; SG=22,5 ± 4,3yo	1RM/BP, PU/1min., SU/1min.	35 days, PG, EG1-3g CR, EG2-5g CR	In EG1-Eg2 increase of 1RM, endurance only in EG2
Atakan et al. 2019	Football players ♀ EG=15; PG=15; SG=19.83 ± 1.13yo	SP 10,20,30m, 1RM/BS, AGL	7 days, EG= CR 0.25 g/kg; PG=MD	In EG improved AGL, SP 10,20,30m, no increase in TT.
Bjelica et al 2020	Body builders ♂ EG=6; PG=8 SG=24±6yo	1RM/BP, 1R;/BS, SB/max, TK-Tanita bc- 545n	16 weeks, EG=CR/7days/5g after+dex; PG=dex/20g	Changes of TK in EG, increased MM, reduced TM, increased W. Increase of strength in all variables.
Mills et al. 2020	Physically active population ♀ CR=13; PG=9; SG=26 ± 4 yo	1RM/BP; 1RM/BS; VS; BK; 1RM/BPmax; 1RM/Bsmax.	6 weeks, EG= CR/0.1g x kg-1 x d-1 PG=CR/0,0055g x kg -1	Changes in TK, increased strength in variable 1RM/BP, 1RM/BS. PG with no significant changes.

MM –muscle mass; *MT* – body mass; *CR*- creatinine monohydrate; *EG*- experimental group; *KG*- control group; *1RM*-one-repetition maximum; *PG*- placebo group; *dex*-dextrose; *SG*- age group; *MMS*- maximum muscle strength; *MD*- maltodextrine; *TK*- body composition; *MS* –muscle strength; *TT*- body weight; *TM*- body fat; *MM*- muscle mass; *BP*- Bench press; *BS*- barbell squats; *PU*-push-ups; *SU*- sits-ups; *SP*- speed; *AGL*- agility; *W*- water; *VS*- vertical jump; *BK*- ball throw.

4. Discussion

Many studies which dealt with the effects of CR confirmed that the body weight increases after a period of oral ingestion (Fairman, Kendall, Hart, Taaffe, Galvao, & Newton, 2019; Vilar-Neto, et al., 2018; Earnest, Snell, Rodriguez, Almada, & Mitchell, 1995; Hultman, Sijderlund, Timmons, Cederblad, & Greenhaff, 1996; Kreider, Ferreira, & Wilson, 1998). Previous studies confirm that 10–20g of CR at daily level with the frequency of five days a week is sufficient for increase in strength and

number of repetitions (Urbanski, Loy, Vincent, & Yaspelkis, 1999; Izquierdo, Ibañez, & González-Badillo, 2002). Such statements are in line with the selected research papers presented in the systematic overview (Amirsasan et al., 2018; Farah et al., 2018; Wang et al. 2018; Atakan et al., 2019; Bjelica et al., 2020). The research papers have confirmed that with aging changes start to occur in overall body composition and that the level of water (fluids) also drops (Ritz, et al., 2001). One should keep in mind that human body consists of 50–70% of water (Sawka & Coyle, 1999). In the research performed by Bjelica et al. (2020) increase in body water was detected in both groups of participants (CR and placebo), which was the result of physical stress caused by applied training with load. Although there is small number of research papers where body water level was observed, all the data is in favour of training on platform of aerobic exercising or training with load leads to increase in body fluids (water) in human organism (Francaux & Poortmans, 1999; Ho et al., 2012; Davidson et al., 2009; Church et al., 2010; Park & Randone, 2003). Muscle mass, as an integral part of overall mass is significantly increased with CR supplementation. In some papers it was noted that there is also increase in total mass in range 0.7–1.6 kg after short-term CR intake in combination with exercises with load (Becque, Lochmann, Melrose, 2000; Earnest, Snell, Rodriguez, Almada, & Mitchell, 1995; Vandenberghe, Van-Hecke, Leemputte, Vanstapel, & Hespel, 1999). LaBotz & Griesemer (2009) established significant increase of body mass of 0.84 kg in CR group, in relation to the control group. It is important to note that no changes occurred in fat percentage in any of the groups of participants, which is an additional confirmation that CR affects only increase of muscle mass and to certain extent body water levels. Such findings were noted in other studies (Aedma, Timpmann, Lätt, & Ööpik, 2015; Soderlund, Balsom, & Ekblom, 1994; Saab, Marsh, Casselman, & Thompson, 2002; Abdi, et al., 2012; Ferneti, et al., 2018). Studies on supplementation by creatinine show positive effect on performances and strength in duration of short-term maximum exercising intensity measured in one-repetition maximum and effect on muscle endurance and speed (Becque, Lochmann, & Melrose, 2000; Volek & Rawson, 2004; Vandenberghe, 1997; Vandenberghe et al., 1997; Volek & Rawson, 2004). Increased strength on bench press after CR supplementation was mentioned in some of the papers (Amirsasan et al., 2018; Vilar-Neto et al., 2018; Bjelica et al., 2020; Mills et al., 2020). Other research demonstrated similar improvements in bench press performances (Camic et al., 2014; Kilduff et al., 2002; Rawson & Volek, 2003). Regarding sports which require combination of aerobic and anaerobic sources with participation of strength and endurance, fatigue may occur and hence efficiency reduces. With CR supplementation it is possible to prevent loss of strength due to aerobic and anaerobic activity of the athlete. Earnest, Snell, Rodriguez, Almada, & Mitchell (2005) established that creatine supplementation (20 g / day x 4 days and 10 g / day x 6 days) improves activity performances to exhaustion in two cycles in

duration of approximately 90 seconds. Smith, Stephens, Hall, & Jackson (1998) established that creatine supplementation (20 g / day x 5 days) increases the time of performance of exercises which last 90–600 seconds, mostly in short, more intensive activities. Nelson et al., (2000) established that creatine supplementation (20 g / day x 7 days) reduces sub-maximal number of heart pulses and oxygen intake volume (VO₂), while the ventilation anaerobic threshold increases (VANT) as well as total time to exhaustion during maximum exercising program in 36 adults. Rico-Sanz & Mendez (2000) established that creatine supplementation (20 g / day x 5 days) increases time to exhaustion (29,9 ± 3,8 do 36,5 ± 5,7 min), simultaneously reducing the ammonia levels (marker of adenine nucleotides decomposition) in cycling to 30% and 90% from maximum load threshold. Upon the literature overview, it was established that CR, in combination with an exercising program, results in increase of muscle mass (Hultman, Sijderlund, & Timmons, 1996; Harris, Soderlund, & Hultman, 1992), strength (Birch, Noble, & Greenhaff, 1994; Vandenberghe, et al., 1997), and that it reduces time required for performing an activity (Balsom, Soderlund, & Ekblom, 1994).

5. Conclusion

Results of this study suggest that CR supplementation in combination with any form of training may be efficient in improving sport performances of male and female population of participants. However, additional research is required in order to test the long-term effects of supplementation. CR in combination with an exercising program results in increase of muscle mass and strength, and it also reduces time required for performing an activity. Changes in body composition are observed in increase of total mass and muscle mass, as well as in body water levels. CR supplementation in amount of 10–20g at daily level with the frequency of 4–5 days a week is an efficient tool for improvement of sport performances and positive changes in body composition.

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Received: 09.09.2020.
Approved: 15.10.2020.

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