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Potential advantages and disadvantages of using creatine supplements by professional volleyball players

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Summary

Creatine, a peptide built from three amino acids: arginine, glycine and methionine, is one of the most popular diet supplements used by people who train not only strength sports but also other popular disciplines, including team sports, i.a. volleyball. The benefits of creatine supplementation, such as weight, strength and muscle mass gain, are widely known, which translates directly into improved sports performance. However, is it really possible to consider such supplementation as a model solution for absolutely every athlete practicing volleyball?

This brief review was intended to summarize the indications and effects of supplementation of volleyball players with creatine, taking into account the theoretical side of potential benefits, i.e. creatine metabolism in the creatine kinase (CK)-phosphocreatine (PCr) system and energetic advantages for muscle cells coming from the "renewing" of the basic useful energy carrier that is ATP (transferring the phosphate group to ADP) by creatine phosphate, as well as visual effects of training achieved in practice by volleyball players after supplementation with creatine, taken mostly in the form of monohydrate. This work also reviews possible potential side effects that are usually the result of exceeding the recommended dose of a supplement or taking preparations that are not subject to appropriate analytical tests, i.e. those who do not have appropriate certificates or attests.

Keywords: Body, volleyball, supplementation, creatine

Introduction

Volleyball, like any sport practiced professionally, is associated with many hours of intense training, which clearly increase the body's need for energy and nutrients. Even a properly balanced and rigorous adhered diet often covers only the current, high energy demand, not being able to provide excessive amounts of energy and nutrients in order to achieve the desired training effects. In order to deliver them, the athlete would have to increase several times the mass of consumed products and liquids, which would put a strain on the digestive system and would make it impossible to take part in full-value trainings. The ideal solution in this case seem to be dietary supplements. The purpose of consuming supplements is to provide in the highly concentrated form nutrients, that are deficient in everyday food or to increase the absorption of nutrients in a harmless way to the body. The use of supplements in sport is aimed mainly at accelerating the regeneration and increasing the efficiency of the organism (Dymkowska-Malesa, Walczak, 2011). Research carried out by Frączek and colleagues proves that the vast majority of athletes (86.5%), including 82% of men and as many as 91% of women, declare taking nutritional aids (Frączek et al., 2012).

Dietary supplements allowed for athletes can be divided into those that have an impact on: increase in muscle mass, fat loss, increase in immunity, improvement of mental fitness or regeneration process of the musculoskeletal system (Zając et al., 2012). Among the supplements for muscle mass growth, the most popularity, already in the 90s, gained creatine. Creatine is a physiologically active substance necessary for muscle contraction. Chemically, it is methylguanidinoacetic acid with the formula $C_4H_9N_3O_2$, which, when bound to phosphate, forms a backup form for rich-energy phosphates. Under physiological conditions, mainly during anaerobic efforts - creatine phosphate plays an important role in the restitution of ATP in the body (Morawska-Staszak, 2012). The creatine content in the body varies on average from 120 to 140 grams, of which 98% is stored in the muscles. The upper limit of creatine content, which was recorded in the human body at 160 g, causes that athletes with full creatine stores will not use supplementation, because such supplementation will not cause increased muscle mass increase, and moreover, overdose may occur and side effects of creatine use as a consequence (Hall M., Trojian T.H., 2013).

Creatine metabolism

Creatine naturally occurs in human muscle cells. It is synthesized from three amino acids: methionine, arginine and glycine in the pancreas, kidneys, liver and in small amounts in the brain and testis. In addition to the ability of various organs in the human body to synthesize creatine, it can also be delivered with food, mainly meat, fish and other animal products. Creatine can occur in muscle in two forms - free creatine (30-40%) and creatine phosphate - PCr (60-75%) (Szewczyk, Poniewierka, 2015). The amount of PCr present in the muscles is 3-4 times greater than the amount of adenosine triphosphate (ATP). Its main task is to provide energy to rebuild used ATP particles, which are the primary source of energy during contraction of working muscles (Morawska-Staszak, 2012). Phosphocreatine is one of the eight phosphagens found in the animal world. Each of them has a characteristic guanidine group and its own enzyme, the phosphagen kinase (Grzyb, Skorkowski, 2008). Phosphagen kinase for phosphocreatine is creatine kinase, whose isoenzymes together with phosphocreatine form an important metabolic system, the function of which is the transport of

phosphorylated high energy compounds between various cell compartments (Echegaray, Rivera, 2001). Creatine kinase in the cytosol (CK) catalyzes the phosphorylation of adenosine diphosphate (ADP) with phosphocreatine (PCr) to produce adenosine triphosphate (ATP). This reaction can be represented as:

$$Cr + MgATP^{2-} + H^{+} \leftrightarrow PCr + MgADP^{-}$$

In this way PCr becomes a short-term energy buffer. About 70% of the total amount of phosphocreatine stored in fast twitch fibers is consumed after 10 seconds of maximum contraction. To reproduce phosphocreatine, creatine needs to be phosphorylated, which requires ATP energy. ATP is obtained by oxidative phosphorylation of ADP, which occurs in the mitochondria. Mitochondrial creatine kinase (MtCK) catalyzes the transfer of ATP to creatine to obtain PCr, which passes through the outer membrane of the mitochondrion and remains in the cytosol until the next muscle contraction. After the maximum effort, it takes about 30 to 60 seconds until half the amount of PCr is re-synthesized, and about 5 minutes until all its storage is rebuilt (Ferrauti, Remmert, 2003). Schematic representation of the creatine/phosphocreatine-shuttle is shown in Figure 1.

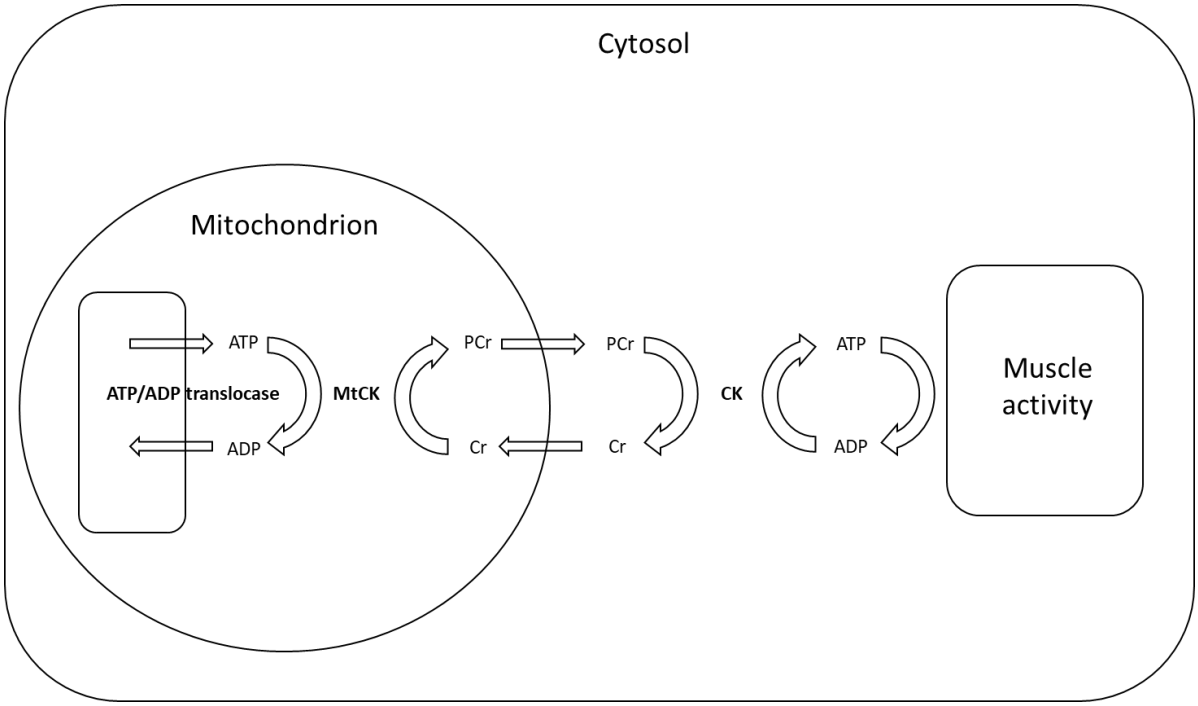

Figure 1 Schematic representation of the creatine kinase (CK)-phosphocreatine (PCr) system in muscle. Similar system also functions in kidney epithelial cells. Figure showing the use of mitochondrial PCr by cytosolic creatine kinase and rephosphorylation of creatine (Cr) in mitochondria. CK isoenzymes are either associated with ATP-delivery processes like oxidative phosphorylation or glycolysis and ATP-consuming processes connected with muscle activity

The importance of creatine supplementation in volleyball

Creatin supplementation in ballgames, including volleyball, can have a very significant impact for a variety of reasons. Depending on the length / duration and frequency of high-intensity activity, for each ball game a different metabolic profile may be defined, consisting of aerobic, anaerobic-alactic and anaerobic-lactic activities. Low blood lactate during volleyball matches (2-3 mmol / L) indicates, that energy during short periods of increased activity is mainly delivered from creatine phosphate, while oxygen pathways restore energy sources during the rest period (Künstlinger et al., 1987). Creatine supplementation increases the availability of creatine phosphate, and higher initial levels of creatine phosphate in the muscles can help maintain muscle contraction. Creatine phosphate resynthesis also increases, and a higher initial level of creatine causes that more creatine phosphate may be synthesized during the passive phase of game. Another important factor is the reduction of

muscle acidification, because, being a metabolic buffer, it consumes hydrogen cations during the ATP resynthesis with ADP (Williams et al., 1999).

As important as the aforementioned advantages of creatine supplementation during increased physical intensity, is an increase in body weight. Increased lean body mass and muscle mass may be beneficial for all strength activities involving upper limbs (for example, a spike in volleyball) and lower limbs (for example, vertical jump). Two potential mechanisms underlying such growth have been proposed: total body water growth and increased myofibrillar protein synthesis (Bessman, Savabi, 1990).

The volleyball game is intermittent. There are active and passive phases. Time of active phases is on average 9-10 s, intervals between actions usually last 7-10 s. (Grządziel, 2012). During the active phase with very high intensity, players are involved in both defensive and offensive jumping activities. Spike jump and block jump activities are responsible for about 80% of points gained during international matches (Staganelli and others, 2008). Many studies have shown a strong relationship between the strength and power of the player and the vertical jump performance (Ashley, Weiss, 1994; Peterson and et al., 2006). Lim and Choy also argue, that supplementation with creatine, combined with a good conditioning program, can significantly increase muscle strength, to the extent that conditioning programs alone are unable to do so. Their research group consisting of 36 women practicing volleyball at the academic level, took 5 g of creatine monohydrate (n = 18) or placebo (n = 18) for a period of ten weeks. After this time, the group supplemented with creatine showed a significant increase in both vertical jump and bench press. The direct association between creatine supplementation and the increase in jump performance was also demonstrated by Lamontagne-Lacasse and colleagues. In a research conducted on the volleyball team of the University of Sherbrooke, they prove that supplementation with creatine monohydrate for 28 days causes that athletes can jump higher for a much longer time, compared to the participants taking placebo, which is related to the fact, that the increased concentration of creatine in skeletal muscles accelerates the rate of restoration of creatine phosphate (Lamontagne-Lacasse et al., 2011).

Side effects of creatine supplementation

Despite, undoubtedly, a whole range of advantages of creatine supplementation for professional athletes practicing volleyball and many studies, that prove that creatine supplementation is completely safe (Bizzarini, De Angelis, 2004; Cancela et al., 2006), every supplemented athlete must be careful both with the size of the used dose and with the frequency and length of supplementation. Creatine, like many other supplements, can cause side effects.

Often you can meet the opinion of athletes taking creatine, that such supplementation causes increased muscle cramps. This is partly confirmed by Juhn et al., who studying a group of 52 baseball and football players, taking creatine monohydrate for 5 and 3 months respectively, recorded as much as 25% of the increased frequency of muscle cramps (Juhn et al., 1999). However, taking into account the earlier studies of Kreider et al. and Vandenberghe et al., who did not observe statistically significant differences in their research groups, it can be assumed that the increased frequency of muscle cramps is more associated with increased intensity of exercise during training, than with creatine supplementation itself.

Another common statement that one can encounter when reading about the side effects of creatine is that it causes gastrointestinal discomfort (upset stomach, vomiting, diarrhea) in consumers who take it by oral way. This hypothesis seems to be confirmed by scientific research. Vandenberghe and colleagues found slight gastrointestinal inconvenience in 33% of the subjects (Vandenberghe et al., 1996), while Juhn reported diarrhea in 31% of the subjects in his above-mentioned studies on baseball and football players (Juhn et al., 1999). It is believed that these side effects may be associated with an extremely high osmotic load of the gastrointestinal tract of some subjects. In addition, Francaux and Poortmans in their publication present results demonstrating the lack of negative effects of supplementation with creatine monohydrate on the liver and kidneys, at the same time emphasizing that there is one documented case of the patient described by Koshy et al., with whom kidney biopsy after supplementation with monohydrate creatine revealed acute interstitial nephritis and a coil damage (Koshy et al., 1999).

Conclusions

Creatine is one of the most well-known supplements used by people practicing sports. The purpose of this brief article was to answer the question, whether supplementation with creatine is really able to improve the results of professional volleyball players in a short time. After reviewing the scientific literature devoted to this subject, the question can be answered in the affirmative, however, there are some recommendations which should be followed. Firstly, creatine supplementation should be limited only to individuals who strictly require it in the training process, for example having a deficiency in power or body weight. Such supplementation should not be considered as prophylaxis and should not be applied to the whole team without any exceptions. In the case of very young players, at the initial stages of their careers, medications should only be a necessity if the training and proper diet does not bring the desired results.

In addition, creatine users should be mature, aware and informed about the whole range of effects of supplementation and potential side effects. Proven, possible side effects, such as gastrointestinal discomfort, cause that athletes supplemented with creatine must remain under strict control of the training staff and medical personnel and regularly report their health (Ferrauti, Remmert, 2003). Few cases of renal failure have not been confirmed in studies conducted on a larger group for a longer period, however, anyone who is supplemented with creatine should be careful and in case of any doubts about health, contact a physician (Francaux, Poortmans, 2006). Another indication is not exceeding the recommended dose and maintaining special caution regarding the purity of market creatine supplements.

Being a coach recommending supplementation with creatine monohydrate to his players, it is essential to remember that an injury or health problems of a key player may be such a serious problem for the team, that small positive ergogenic effects in other players will not be able to compensate for this (Ferrauti, Remmert, 2003).

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