Review Article

Open Access Journal of
Biomedical Science
ISSN: 2690-487X

A Narrative Review On Athletic Performance And Safety Of Creatine Supplementation For Adolescents

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ABSTRACT

Creatine is an organic nitrogenous compound that can be obtained from the diet or produced by the body. It has been widely used and tested in laboratories mainly on adults. There are few studies aimed at adolescents (classified hesre as between 13 and 18 years old), but the studies point to promising results in improving performance and safety for the health of adolescents. Therefore, the purpose of this review is to contribute to the evidence-based discussion on the use of this supplement for adolescents.

KEYWORDS: Creatine; Sports nutrition; Sports medicine; Health; Performance

INTRODUCTION

Despite being an endogenously produced nutrient found in meat, chicken, and fish, creatine is regarded as one of the more consumed, researched, and efficacious nutritional supplements available (Figure 1); [1]. When supplemented occurs increases in intramuscular creatine stores and can improve effort capacity and training adaptations. Creatine has been established as a legitimate nutritional adjunct in rehabilitation.

Creatine is naturally found primarily in the flesh of animals, with the majority (~95%) being present in skeletal muscle. Approximately two-thirds of intramuscular creatine is phosphorylated (phosphocreatine-CrP). Metabolism of creatine results in 1-2% creatinine production and it being excreted *via* kidneys (Figure 2). The process of lost creatine leads to a daily ~2 g of creatine required per day to maintain normal creatine cells concentration. The human diet provides approximately half of this amount. The remaining amount of the total rate of appearance is provided by endogenous synthesis by the kidney and liver [2], 2000; [1].

Creatine is stored within the skeletal muscle as both free creatine and as phosphocreatine serving as a key substrate for the resynthesis of ATP [3]. It mainly serves as a critical metabolic intermediary of energy transfer by facilitating the recycling of ATP, the source of energy for use and storage at the cellular level. Consequently, creatine is abundant in organs with high energy turnover, with ~95% of the human body's creatine stores found in the skeletal muscle and the remaining 5% in the brain, liver, kidney, and testes (muscle or brain maintain a total cellular Cr pool of up to 30-40 mM) [4].

DISCUSSION

Supplementation

It is described that exogenous supplementation of creatine is an effective strategy to increase intramuscular (and other tissue) phosphocreatine stores by ~20-40% [1] depending on baseline levels. There are 3 ways, with slight variations, to supplement creatine. The first way, known as loading, is to supplement 3.0 grams per kilogram of body weight per day. To avoid intestinal discomfort, this dose is usually divided into 4 times distributed throughout the day. This strategy lasts from 3 to 7 days, which would be enough to saturate the cells [5].

The second supplementation strategy, called maintenance, consists of ingesting 0.3g of creatine per kilogram of body weight per day. It is normally ingested at a single moment of the day and usually takes more than 14 days to saturate the cells, and can be prolonged for weeks or months [5]; [1].

Quick Response Code:

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Received: February 21, 2022 **Published:** March 22, 2022

How to cite this article: Marco Machado. A Narrative Review On Athletic Performance And Safety Of Creatine Supplementation For Adolescents. 2022- 4(2) OAJBS.ID.000419.
DOI: 10.38125/OAJBS.000419

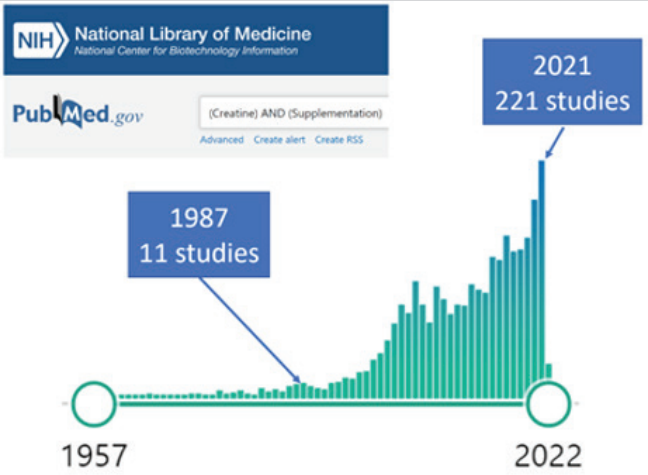

Figure 1: Number of studies registered in Pubmed year by year. There has been an increase of approximately 2,000 percent in the almost last 4 decades.

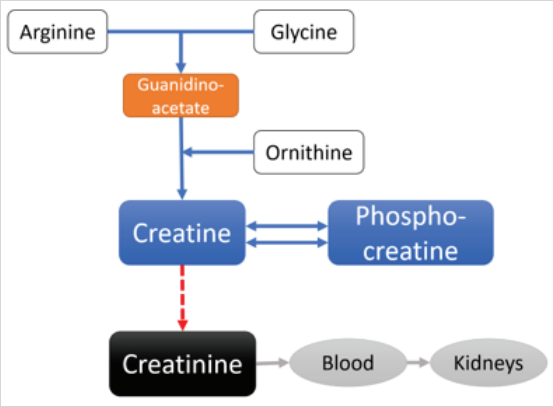

Figure 2: Creatine and creatinine metabolism. The white rectangles represent the amino acids, the orange rectangles the intermediate ones, the blue rectangles the creatine and phosphocreatine. Blue arrows are enzymatic chemical reactions, red arrows represent spontaneous (non-enzymatic) chemical reactions. Gray ellipses represent tissues and organs, gray arrows the creatinine pathways.

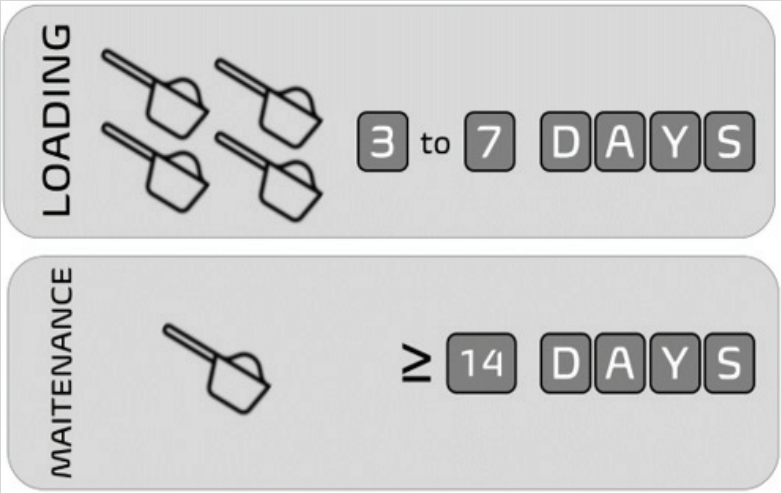

Figure 3: In the upper part of the image, ~3.0g of creatine per kilogram of body mass is divided into 4 daily doses for 3 to 7 days, this form of supplementation is called loading. At the bottom, is the maintenance strategy in which ~0.3g of creatine is given in a single dose for periods generally longer than 14 days. It is common to start supplementation with the loading dose followed by the maintenance dose.

The last strategy would be a mixture of the two previous ones, in which the person would start with the loading dose for 3 to 7 days (3.0g per kg of weight) and persist using the maintenance dose (0.3 grams per kg of body weight) on subsequent days [5]; [1]. A summary can be seen in Figure 3. When supplementation ceases, it may take as long as 28 days before intramuscular CrP levels return to baseline [6,7]. It is not uncommon to use creatine "cycles", in these cases the athlete uses creatine for 28 days, does a washout for 28 days, and then returns to use, returning to washout and supplementation. Despite having some popularity, the cycle strategy lacks a scientific basis. In addition, many manufacturers and professionals recommend supplementation 30 minutes before training, which is another strategy that is not based on nutritional and pharmacological fundamentals [8].

Efficacy of Creatine as an Ergogenic Aid

It has been widely demonstrated that the loading strategy, as described above, is very effective for significant increases in strength, power, and speed. [9-12]. It is essential to emphasize that gains only happen when accompanied by resistance, strength, or power training. Creatine does not present results per se and must be accompanied by efficient planning in training strategies Branch [13,14]. These outcomes are consistently reported across genders as well as in adolescents [15-33].

In addition, [11] found that a 20g per day for seven days of oral creatine monohydrate supplementation improved results in some cognitive tasks in mountain bikers. These findings show that creatine supplementation could be used for diminished mental fatigue in mountain bikers, potentially contributing to greater reaction times and better decision-making on the track.

Safety of Creatine Use

A growing number of studies are available that support the safety of creatine supplementation, unfortunately, the majority in adults. These studies have been conducted in both athletic and general populations and range from a few days up to to 5 years without any adverse changes in markers of clinical health [34]; [13]; [35,36]. Creatine supplementation has been demonstrated no adverse impact on clinical health markers in competitive athletes [13]; [37-46] and in clinical populations [47-50].

Recently, two studies evaluating over 40 biochemical and hematological health markers have shown that creatine supplementation is safe in young. Both studies revealed no significant changes in adverse outcomes following either 7 days [12] or 28 days [12] of creatine supplementation. The result of increased body mass as a side effect is practically unanimous, however, this increase is notorious for lean mass, not being an undesirable effect for most modalities in which creatine has been recommended (strength athletes, power athletes, bodybuilders, and clinical patients with muscle wasting disorders [1].

In addition, [51] helps us to unravel why many professionals are wrong when giving diagnoses about kidney health. By increasing creatine intake (supplementation), we naturally produce more creatinine, which is used to assess kidney health. In Figure 4 we can see how this happens.

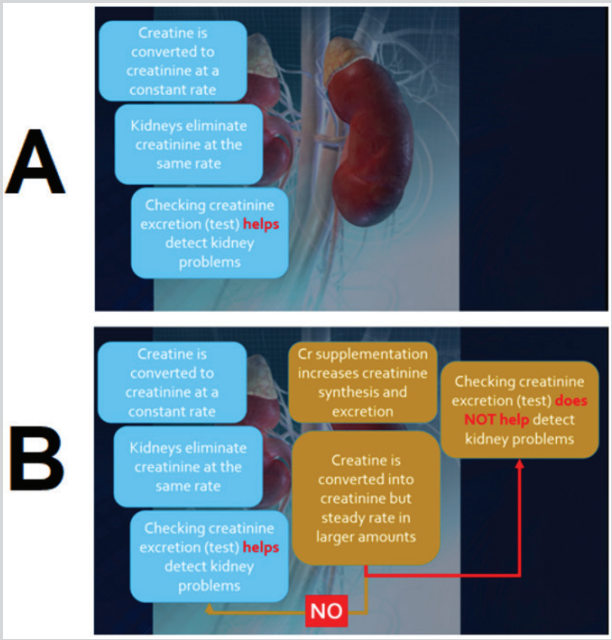

Figure 4: The clinical use of the serum or unitary creatinine test is adequate in situation A, but in situation B the evaluation will return altered values without the kidney is diseased.

Creatine Use In Adolescents

Even though it is one of the most studied supplements by science, the number of studies carried out in children and adolescents is very small. Acordin [52] the main reasons are the fear of authorizing research ethics committees, parents, doctors, and nutritionists. Position stand published by the International Society of Sports Nutrition [53], is careful and prudent describes certain criteria surrounding approval from parents, choosing quality supplements, strictly follow following the dosages, and mainly concerned with optimizing diet before supplementation.

On the other hand, [17] examine swimmers (~15y.o.) who were randomly assigned to one of two groups to ingest either 21

g/day of creatine or placebo over 9 days. They found significant improvements in repeat sprint swimming performance after creatine supplementation. Another study, led by [17] tried to replicate these findings in young (~16 y.o.), elite swimmers using 28 days of supplementation (20g/day for 5 days; followed by 5g/day for 22 days). Despite they found improvement in swim bench test performance, the results failed to replicate improvement in single sprint performance as [17,18] examined the effects of creatine supplementation (5 days; 4 times per day × 5g/day) on mechanical power output and swim performance in highly trained junior (~16 y. o.) competitive swimmers. Significant improvements in sprint swimming performance and dynamic strength following creatine supplementation were observed.

In soccer's adolescent athletes we found 3 studies that showed positive results in some outcomes after creatine supplementation. [54] verified significant improvements in specific soccer abilities. Were tested 20 young (~17 y.o) male soccer players (7 days of supplementation; 30g/day). In another study, seven days (20g/day) of creatine supplementation were provided to 17 younger soccer players (~17 y.o.) and significant improvements in repeat sprint performance and dribbling abilities were observed [55]. [19] with elite youth (~17 y,o.) soccer players found significant improvements in power output following a 0.03g/kg/day for 7 days. All these studies were able to demonstrate improvements in many, but not all tests performed, unfortunately, the number of study participants is small and the effect size was not always calculated. Although not an extensive list, a precedent has been set regarding creatine supplementation interventions in adolescent athletes, warranting further research in this area examining both efficacy and safety.

Is Creatine Safe for Youth?

Historically, the concern of creatine supplementation started in 1998 when a young male with focal segmental glomerulosclerosis and relapsing nephrotic syndrome who had kidney disease began creatine supplementation which increased creatinine and was incorrectly presumed to indicate deteriorating kidney function. Two independent experts wrote letters to the journal indicating the error, but speculation surrounding creatine and kidney function has continued [51].

To date, we have not verified studies whose outcomes were directly related to the health of adolescents supplemented with creatine. The studies previously cited in this review provide vague information about some participants who suffered cramps, stomach or intestinal discomfort, and dehydration. None of these findings were investigated to confirm whether the effect was from supplementation or another confounding variable.

Another factor is that these symptoms/signs appeared in young people who used higher dosages (higher and 3.0g/kg per day), but we cannot reliably attribute that there is an association. Based on studies with young people (between 18 and 25 years of age), we can speculate that there is safety in creatine supplementation, but specific studies for these outcomes need to be carried out, whether or not they are safe.

In addition, creatine supplementation has been used for decades as a treatment for diseases with a deficiency of the enzymes that catalyze creatine synthesis. In addition to being successful as a treatment, these children (sometimes as young as 2 years old) do not have any undesirable effects associated with the use of creatine [56-64].

CONCLUSION

The main conclusion of this study is that there is a great deal of misinformation about creatine use by teenagers. If, on the one hand, the number of studies is small to incisively determine that the use of creatine is safe for health, the results of these studies are very promising. It is understandable, but there may be an exaggeration among physicians, nutritionists, and parents regarding the restriction of this supplement. Furthermore, the results related to the improvement of sports performance seem to be much more evident. As a supplement, not a drug, it can benefit young athletes with no side effects and no addiction. Specific studies investigating metabolic and health markers, studies comparing results in boys and girls, and assessments of improvements in cognition are recommendations that the authors give for future studies on the topic.

CONFLICTS OF INTEREST

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

REFERENCES

1. Kreider RB, Kalman DS, Antonio J, Ziegenfuss TN, Wildman R, Collins R, et al. (2017) International society of sports nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport, and medicine. J Int Soc Sports Nutr 14(1):18.
2. Wyss M, Kaddurah-Daouk R (2000) Creatine and creatinine metabolism. Physiol Rev 80(3): 1107-213.
3. Jager R, Purpura M, Shao A, Inoue T, Kreider RB (2011) Analysis of the efficacy, safety, and regulatory status of novel forms of creatine. Amino Acids 40(5): 1369-1383.
4. Gastin PB (2001) Energy system interaction and relative contribution during maximal exercise. Sports Med 31(10): 725-741.
5. Mesa JL, Ruiz JR, Gonzalez-Gross MM, Gutierrez Sainz A, Castillo Garzon MJ (2002) Oral creatine supplementation and skeletal muscle metabolism in physical exercise. Sports Med 32(14): 903-944.
6. Greenhaff PL, Casey A, Short AH, Harris R, Soderlund K, et al. (1993) Influence of oral creatine supplementation of muscle torque during repeated bouts of maximal voluntary exercise in man. Clin Sci 84(5): 565-571.
7. Vandenberghe K, Goris M, Van HP, Van LM, Vangerven L, et al. (1997) Long-term creatine intake is beneficial to muscle performance during resistance training. J Appl Physiol 83(6): 2055-2063.
8. Deldicque L, Decombaz J, Foncea HZ, Vuichoud J, Poortmans JR, et al. (2008) Kinetics of creatine ingested as a food ingrediente. Eur J Appl Physiol 102(2): 133-143.
9. Bemben MG, Bemben DA, Loftiss DD, Knehans AW (2001) Creatine supplementation during resistance training in college football athletes. Med Sci Sports Exerc 33(10): 1667-1673.
10. Cooper R, Naclerio F, Allgrove J, Jimenez A (2012) Creatine supplementation with specific view to exercise/sports performance: an update. J Int Soc Sports Nutr 9: 33.
11. Borchio L, Machek SB, Machado M (2020) Supplemental creatine monohydrate loading improves cognitive function in experienced mountain bikers. J Sports Med Phys Fit 60(8): 1168-1170.
12. Almeida D, Pereira R, Borges EQ, Rawson ES, Rocha LS, et al. (2022) Creatine supplementation improves physical performance, without negative effects on health markers, in young weightlifters. J Sci Sport Exerc.
13. Branch JD (2003) Effect of creatine supplementation on body composition and performance: a meta-analysis. Int J Sport Nutr Exerc Metab 13(2): 198-226.

14. Rawson ES, Clarkson PM (2000) Acute creatine supplementation in older men. Int J Sports Med 21(1): 71-75.

15. Cornish SM, Chilibeck PD, Burke DG (2006) The effect of creatine monohydrate supplementation on sprint skating in ice-hockey players. J Sports Med Phys Fitness 46(1): 90-98.

16. Dawson B, Vladich T, Blanksby BA (2002) Effects of 4 weeks of creatine supplementation in junior swimmers on freestyle sprint and swim bench performance. J Strength Cond Res 16(4): 485-490.

17. Grindstaff PD, Kreider R, Bishop R, Wilson M, Wood L, Alexander C, et al. (1997) Effects of creatine supplementation on repetitive sprint performance and body composition in competitive swimmers. Int J Sport Nutr 7(4): 330-346.

18. Juhasz I, Gyore I, Csende Z, Racz L, Tihanyi J (2009) Creatine supplementation improves the anaerobic performance of elite junior fin swimmers. Acta Physiol Hung, 96(3): 325-336.

19. Silva AJ, Machado RV, Guidetti L, Bessone AF, Mota P, et al. (2007) Effect of creatine on swimming velocity, body composition and hydrodynamic variables. J Sports Med Phys Fitness 47(1): 58-64.

20. Machado M, Guimarães P, Forbes SC (2022) Safety of creatine supplementation: where are we now? Gazzetta Medica Italiana Archivio per le Scienze Mediche, Itlay.

21. Kreider RB, Ferreira M, Wilson M, Grindstaff P, Plisk S, et al. (1998) Effects of creatine supplementation on body composition, strength, and sprint performance. Med Sci Sports Exerc 30(1): 73-82.

22. Bemben MG, Lamont HS (2005) Creatine supplementation and exercise performance: recent findings. Sports Med 35(2): 107-125.

23. Chilibeck PD, Magnus C, Anderson M (2007) Effect of in-season creatine supplementation on body composition and performance in rugby union football players. Appl Physiol Nutr Metab 32(6): 1052-1057.

24. Kerksick CM, Rasmussen C, Lancaster S, Starks M, Smith P, et al. (2007) Impact of differing protein sources and a creatine containing nutritional formula after 12 weeks of resistance training. Nutrition 23(9): 647-656.

25. Kerksick CM, Wilborn CD, Campbell WI, Harvey TM, Marcello BM, et al. (2009) The effects of creatine monohydrate supplementation with and without D-pinitol on resistance training adaptations. J Strength Cond Res 23(9): 2673-2682.

26. Volek JS, Mazzetti SA, Farquhar WB, Barnes BR, Gomez AL, et al. (2001) Physiological responses to short-term exercise in the heat after creatine loading. Med. Sci Sports Exerc. 33(7): 1101-1108.

27. Volek JS, Ratamess NA, Rubin MR, Gomez AL, French DN, et al. (2004) The effects of creatine supplementation on muscular performance and body composition responses to short-term resistance training overreaching. Eur J Appl Physiol 91(5-6): 628-637.

28. Tarnopolsky MA (2000) Potential benefits of creatine monohydrate supplementation in the elderly. Curr Opin Clin Nutr Metab Care 3(6): 497-502

29. Rawson ES, Venezia AC (2011) Use of creatine in the elderly and evidence for effects on cognitive function in young and old. Amino acids 40(5): 1349-1362.

30. Devries MC, Phillips SM (2014) Creatine supplementation during resistance training in older adults-a meta-analysis. Med Sci Sports Exerc 46(6): 1194-1203.

31. Wiroth JB, Bermon S, Andrei S, Dalloz E, Hebuterne X, et al. (2001) Effects of oral creatine supplementation on maximal pedalling performance in older adults. Eur J Appl Physiol 84: 533-539.

32. McMorris T, Mielcarz G, Harris RC, Swain JP, Howard A (2007) Creatine supplementation and cognitive performance in elderly individuals. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn 14(5): 517-528.

33. Branch JD. Effect of creatine supplementation on body composition and performance: a meta-analysis. *Int J Sport Nutr Exerc Metab*. (2003) 13(2):198–226.

34. Lanhers C, Pereira B, Naughton G, Trousselard M, Lesage FX, et al. (2015) Creatine Supplementation and lower limb strength performance: a systematic review and meta-analyses. Sports Med 45(9): 1285-1294.

35. Almeida, D, Colombini A, Machado M (2020) Creatine supplementation improves performance, but is it safe? double-blind placebo-controlled study. J Sports Med Phys Fit 60(7): 1034-1039.

36. Kreider RB, Kalman DS, Antonio J, Ziegenfuss TN, Wildman R, et al. (2017) International society of sports nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport and medicine. J Int Soc Sports Nutr 14(1): 18.

37. Poortmans JR, Francaux M (1999) Long-term oral creatine supplementation does not impair renal function in healthy athletes. Med Sci Sports Exerc 31(8): 1108-1110.

38. Poortmans JR, Auquier H, Renaut V, Durussel A, Saugy M, et al. (1997) Effect of short-term creatine supplementation on renal responses in men. Eur J Appl Physiol Occup Physiol 76: 566-567.

39. Cancela P, Ohanian C, Cuitino E, Hackney A (2008) Creatine supplementation does not affect clinical health markers in football players. Br J Sports Med 42(9): 731-735.

40. Greenwood M, Kreider RB, Greenwood L, Byars A (2003) Cramping and injury incidence in collegiate football players are reduced by creatine supplementation. J Athlet Train 38(3): 216-219.

41. Greenwood M, Kreider RB, Melton C, Rasmussen C, Lancaster S, et al. (2003) Creatine supplementation during college football training does not increase the incidence of cramping or injury. Mol Cell Biochem 244(1-2): 83-88.

42. Gualano B, de Salles Painelli V, Roschel H, Lugaresi R, Dorea E, et al. (2011) Creatine supplementation does not impair kidney function in type 2 diabetic patients: a randomized, double-blind, placebo-controlled, clinical trial. Eur J Appl Physiol 111(5): 749-756.

43. Joy JM, Lowery RP, Falcone PH, Mosman MM, Vogel RM, et al. (2014) 28 days of creatine nitrate supplementation is apparently safe in healthy individuals. J Int Soc Sports Nutr 11: 60

44. Lobo DM, Tritto AC, da Silva LR, de Oliveira PB, Benatti FB, et al. (2015) Effects of long-term low-dose dietary creatine supplementation in older women. Exp Gerontol 70: 97-104.

45. Mihic S, MacDonald JR, McKenzie S, Tarnopolsky MA (2000) Acute creatine loading increases fat-free mass, but does not affect blood pressure, plasma creatinine or CK activity in men and women. Med Sci Sports Exerc 32(2): 291-296.

46. Neves M, Gualano B, Roschel H, Lima FR, Lucia de Sa-Pinto A, et al. (2011) Effect of creatine supplementation on measured glomerular filtration rate in postmenopausal women. Appl Physiol Nutr Metab 36(3): 419-422.

47. Ropero-Miller JD, Paget-Wilkes H, Doering PL, Goldberger BA (2000). Effect of oral creatine supplementation on random urine creatinine, pH, and specific gravity measurements. Clin Chem 46(2): 295-297.

48. Bender A, Samtleben W, Elstner M, Klopstock T (2008) Long-term creatine supplementation is safe in aged patients with parkinson's disease. Nutr Res 28(3): 172-178.

49. Gualano B, Ugrinowitsch C, Novaes RB, Artioli GG, Shimizu MH, et al. (2008) Effects of creatine supplementation on renal function: a randomized, double-blind, placebo-controlled clinical trial. Eur J Appl Physiol 103(1): 33-40.

50. Solis MY, Artioli GG, Otaduy MCG, Leite CDC, Arruda W, et al. (2017) Effect of age, diet, and tissue type on PCr response to creatine supplementation. J Appl Physiol 123(2): 407-414.

51. Vannas-Sulonen K, Sipila I, Vannas A, Simell O, Rapola J (1985) Gyrate atrophy of the choroid and retina. A five-year follow-up of creatine supplementation. Ophthalmology 92(12): 1719-1727.

52. Machado M, Pereira R, Sampaio JF, Knifis FW, Hackney AC(2009) Creatine supplementation: effects on blood creatine kinase activity responses to resistance exercise and creatine kinase activity measurement. Braz J Pharm Sci 45(4): 751-757.

53. Jagim AR, Stecker RA, Harty PS, Erickson JL, Kerksick CM (2018) Safety

of Creatine Supplementation in Active Adolescents and Youth: A Brief Review. Frontiers in nutrition 5:115.

54. Kreider RB, Melton C, Rasmussen CJ, Greenwood M, Lancaster S (2003) Long-term creatine supplementation does not significantly affect clinical markers of health in athletes. Mol Cell Biochem 244(1-2): 95-104.

55. Ostojic SM (2004) Creatine supplementation in young soccer players. Int J Sport Nutr Exerc Metab, 14(1): 95-103.

56. Mohebbi H, Rahnama N, Moghadassi M, Ranjbar K (2012) Effect of creatine supplementation on sprint and skill performance in Young Soccer Players. MiddleEast J Sci Res 12(3): 397-401.

57. Machado M, Pereira R, Sampaio-Jorge F, Knifis FW, et al. (2009 Creatine supplementation: effects on blood creatine kinase activity responses to resistance exercise and creatine kinase activity measurement. *Braz J Pharm Sci* (2009) 45(5): 751-757.

58. Sykut-Cegielska J, Gradowska W, Mercimek-Mahmutoglu S, Stockler-Ipsiroglu S (2004) Biochemical and clinical characteristics of creatine deficiency syndromes. Acta Biochim Pol 51(4): 875-882.

59. Braissant O, Henry H, Beard E, Uldry J (2011) Creatine deficiency syndromes and the importance of creatine synthesis in the brain. Amino acids 40(5): 1315-1324.

60. Stockler-Ipsiroglu S, van Karnebeek CD (2014) Cerebral creatine deficiencies: a group of treatable intellectual developmental disorders. Semin Neurol 34(3): 350-356.

61. Harris RC, Soderlund K, Hultman E (1992) Elevation of creatine in resting and exercised muscle of normal subjects by creatine supplementation. Clin Sci 83(3): 367-374.

62. Merege-Filho CA, Otaduy MC, de Sa-Pinto AL, de Oliveira MO, de Souza Goncalves L, et al. (2017) Does brain creatine content rely on exogenous creatine in healthy youth? a proof-of-principle study. Appl Physiol Nutr Metab 42(2): 128-134.

63. Rawson ES, Volek JS (2003) Effects of creatine supplementation and resistance training on muscle strength and weightlifting performance. J Strength Cond Res 17(4): 822-831.

64. Solis MY, Hayashi AP, Artioli GG, Roschel H, Sapienza MT, et al. (2016) Efficacy and safety of creatine supplementation in juvenile dermatomyositis: a randomized, double-blind, placebo-controlled crossover trial. Muscle Nerve 53(1): 58-66.

65. Theodorou AS, Cooke B, King RFGJ, Hood C, Denison T, et al. (1999) The effect of longer-term creatine supplementation on elite swimming performance after an acute creatine loading. J Sports Sci 17(11): 853-859.

66. Yanez-Silva A, Buzzachera CF, Picarro IDC, Januario RSB, Ferreira LHB, et al. (2017) Effect of low dose, short-term creatine supplementation on muscle power output in elite youth soccer players. J Int Soc Sports Nutr 14:5