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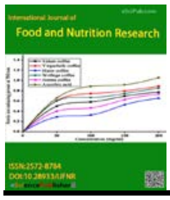

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Comparison between creatine monohydrate and creatine HCl on body composition and performance of the Brazilian Olympic team

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ABSTRACT

Weight-dependent athletes have trouble to balance the energy consumption to the needs of the sport they practice. As performance depends on that balance, it would be ideal to find a supplement that would be ergogenic without promoting weight increase. Monohydrate creatine supplementation is effective to improve strength and power but water retention and weight gain are side effects that avoid its use. An alternative molecule, creatine HCl, proposes the same an ergogenic effects without the undesirable effects. So, this study compared the effects of both creatines on performance and body composition of elite gymnastics athletes. 11 males, 18 to 25 years old took part into the randomized cross-over model: Creatine Monohydrate Supplement (MCG), resistant starch (RS) and HCl Supplement (HClG). Pre and Post all the experimental conditions, body fat percentage, body weight, lean body mass and total water amount were measured, bench press and leg press 1RM test were also carried out. Lean mass increased with both treatments ($p < 0.05$), fat percentage decreased only with HCl ($p < 0.05$) and strength gains were significantly improved for both supplements. We concluded that both creatines improve strength but only HCl allows this effect without retaining water.

Keywords: Creatine monohydrate. Creatine HCl. Artistic Gymnastics. Elite Athletes.

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Introduction

There is no doubt about the importance of an adequate nutritional status for the elite's athlete body composition and performance[1], however many athletes in aesthetic and weight dependent sports are at risk of energy imbalance[2].

Some sports modalities are divided into weight categories, that division is extra important when it comes to the need of a light, lean and highly capable body with no compromise to muscle strength[3].

With that in mind several athletes use nutritional strategies in order to maximize performance with little changes in the body composition. Those nutritional maneuvers or supplements should be individualized and carefully prescribed to avoid side effects of these fine tune strategies.

Two of the most important features of these nutritional supplements are efficacy and safety. Safety meaning not only physiological absence of harm but also no doping substances contamination as described by (Cohen et al., 2017)[4].

One of these supplements that has reached a positive consensus in the scientific literature about its effectiveness and is also safe is Creatine[5,6]. However, there are some authors that reported side effects of creatine supplementation, mainly water retention[6,7,8], but also gastro intestinal distress[6,8,9] with one study pointing out a strong correlation between diarrhea and the ingested doses (5g or 10g) ingested at once[10].

These side effects of the supplement are probably related to the substance mechanism of action and the dose used to assure the efficacy of the supplements. Although recent studies don't report important side effects, water retention and weight gain are unequivocal, and meanwhile this effect is desired by some, such as weightlifting enthusiasts, it is catastrophic to weight dependent athletes.

With this information, although creatine has achieved the status of consensus in the literature, some researchers have proposed improvements to the molecule. The main improvements proposed were to change or add some specific compound to improve bioavailability and absorption of creatine[1].

Creatine HCl brings a modification in the molecule with the formation of hydrochloride creatine salt, and that, according to Miller (2009)[1], would make creatine 40 times more soluble when compared to regular creatine monohydrate.

Greater solubility could change the amount of creatine needed to fill the muscle storage. Beside the fact that if we put creatine HCl in the same amount of water that we put creatine monohidrate it would dissolve easier, this enhanced solubility suggests that creatine HCl would be absorbed and enter the muscle easier than monohidrate[11]. However, the efficacy of creatine HCl in these weight dependent athletes still needs to be tested.

In a recent study, creatine HCl was reported effective in Huntington disease patients after 2 years of chronic use. There was a significant reduction of brain atrophy and better absorption of the molecule when compared to creatine monohydrate treatment[12].

The formation of an elite athlete is a long and constant process. The suppression of any of its phases might become harmful in a medium or long term commitment[13]. Its then important to emphasize the building of a solid nutrition base that might accommodate small but efficient nutrition changes or strategies that might be the difference between gold or silver.

Once gymnastics is a modality that worries excessively about weight and needs outstanding performance and strength, a supplement that might help strength without harming performance or increasing weight seems ideal to these athletes.

So, the objective of this study was to compare the effects of monohydrate creatine to creatine HCl on body composition and performance of elite gymnastics athletes.

Materials and Methods

Ethics

All experimental procedures were approved by the ethical committee of São Judas Tadeu University. This research was recorded under the protocol number CAAE 48447915.2.0000.0089.

Subjects and experimental design

11 healthy elite athletes were selected from the Brazilian Olympic gymnastics team. The athletes were selected from personal contacts and the study was conducted in the São Caetano do Sul Training Center – AGITH.

Experimental design was crossover and double blind.

Supplementation protocol

All subjects ingested creatine monohydrate (MCG), creatine HCl (HClG) and resistant starch (RS) and were tested before (PRE) and after (POST) all three supplement protocols.

MCG received 5g of monohydrate creatine for 30 days, attended to all training sessions and had the diet controlled by the research team nutritionist. Supplement was provided by the nutritionist in the training facility after the training session and it was ingested every day in the same hour with plain water (5g diluted in 100ml).

Resistant starch was offered in the middle of both protocols, at first it served as a washout period between the two creatine protocols. Also, it meant that the athletes would receive a supplement in this period, that would be similar in taste, color and physical aspect (granulation, solubility) to creatine.

It was given in the same way of the other supplements, i.e. it was provided by the nutritionist in the training facility after the training session and ingested every day in the same hour with plain water (5g diluted in 100ml).

HClG received 1.5g of HCl creatine and 3.5g of RS for 30 days, attended to all traning sessions and had the diet controlled by the research team nutritionist. Supplement was provided by the nutritionist in the training facility after the training session and it was ingested every day in the same hour with plain water (1.5g diluted in 100ml).

Both creatine supplements and the resistant starch were given to the subjects in individualized jars withouth any content identification.

The proposed doses were used based on the study published by Hultman et al., (1996). it shows that 5g of creatine, ingested for 20 days are enough to produce the well known ergogenic effects of the supplement.

This study was carried out in accordance to the competitive schedule of the athletes informed by the Brazilian Gymnastics Federation. All the tests were made in the pre competitive period, in order to avoid problems with the athletes diets and to assure the best results of the supplement and training combination. The pre competitive period was a phase where the athletes were training very intense and at the same time, there was still time to make adjustments, with focus on the main competitions.

Nutritional guidance

All athletes had a nutritional follow up to obtain a individualized, normocaloric, normoproteic and normoglycidic diet. Diet was calculated and individualized by a nutritionist specialized in sport nutrition that have been working with this team for approximately 4 years. Supplements use was monitored to avoid competition or any harmful interaction from other supplements with the Creatine provided in this study.

Variables analyzed

1 RM test was carried out according to the described by (Brown & Weir, 2001)[14]. The test was performed in the Bench Press and in the Leg press 45º because these are exercises that are representative of large muscle groups strength for upper and lower limbs.

We evaluated the weight, circunferences and skinfolds in order to obtain the percentage of body fat and we used the same digital scale (Tanita digital) in all evaluations. The nutritionist responsible for making the evaluations was very experienced and knew the subjects very well. We decided to calculate the percentage of body fat of these subjects using the skinfolds method because it gives us the information about the percentage of body fat but it also show the body fat distribution in the specific skinfold areas, and that is an information that is not provided when we use a bioimpedance analyzer.

Circumferences used to keep record of and calculate the body composition parameters were biceps, chest, waist, abdominal, hips, tights and calves. Sknifold sites used were: triceps, biceps, chest, subscapular, iliac crest, abdominal, tights and calves. After that, the predictive equation of Jackson & Pollock (1978)[15] to find body density and body fat percentage was applied.

We used an INBODY bioimpedance analyzer to identify body water changes, one of the main variables of interest of this comparison study. The INBODY equipment is a tetrapolar 8 point electrode device that is described by several authors as a reliable and accurate device to evaluate body water content.

Inclusion and exclusion criteria

Subjects were included in the study when they had at least 1 year of experience with gymnastics, when they were between 15 and 30 years old, male, and had performance indexes similar to the other members of the team.

Subjects were excluded from the study when they would miss 25% or more of the training sessions and skip the supplement ingestion for more than 5 consecutive days. We didn't have any athlete excluded from the study.

Data analysis

Data was organized in a Microsoft excel sheet to be analyzed in the SPSS statistic program. First we did a Shapiro Wilk normality test. With the normal distribution of the data we carried out a repeated measures one way ANOVA with Tukey post test. The effect size was also calculated and the Cohen's D index used. Significance was set to $p<0.05$.

Results

This study aimed to compare the effects of creatine monohydrate and creatine HCl on performance and body composition of weight dependent athletes. Creatine monohidrate was supplied for 30 conscutive days (5g a day), then, after one month of wash out, where the athletes ingested 5g of resistant starch, creatine HCl (1.5g with 3.5g of resistant starch) was supplied for another 30 days period. All results are presented as average ± standard deviation.

The 1 RM results showed significative improvements for both groups in both exercises when compared intragroups. Bench press (MCG 93.09 ± 16.86 PRE and 96.64 ± 16.20 POST; $p = 0.0001$; HClG 96.91 ± 15.35 PRE and 102.00 ± 14.94 POST; $p = 0.0018$; Figure 1).

Leg press 45º (MCG 185.09 ± 50.24 PRE and 193.45 ± 50.80 POST; $p = 0.0005$; HClG 195.82 ± 48.85 PRE and 207.09 ± 48.01 POST; $p = 0.024$; Figure 2), there was no difference between the end of the MC protocol and the start of the HCl protocol, the period where the athletes ingested resistant starch, comparing the values of the 1RM test for both exercises and there was no difference between the groups.

The same result was observed for the weight with the monohidrate creatine supplementation period. The average weight increased significantly (57.96 ± 6.87 PRE; 58.61 ± 6.65 POST; $p=0.006$).

When Creatine HCl was offered it didn't promote weight increase. It actually allowed a significant decrease in body weight (58.03 ± 6.53 PRE and 57.67 ± 6.41 POST; $p = 0.03$).

These results are due to the combination of a controlled diet, heavy training and supplementation protocol since there was no difference between the weights in the beginning of both phases. Once again, there was no difference between the end of the MCG protocol and the start of the HCl protocol regarding the weight of the participants (RS 58.23 ± 6.66 PRE and 57.97 ± 6.27 POST; $p = 0.377$).

Both treatments showed significant reduction in fat percentage when compared to PRE moment

(MCG 7.08 ± 1.74 PRE and 6.18 ± 1.39 POST; p = 0.04) and (HCl 5.28 ± 1.44 PRE and 4.37 ± 1.32 POST; p = 0.04). HClG had a lower fat percentage in the PRE moment when compared to the MCG group, however, it still finished the protocol with a lower value when compared to PRE. No difference was observed for the RS period (RS 5.79 ± 1.30 PRE and 5.58 ± 1.39 POST; p = 0.488).

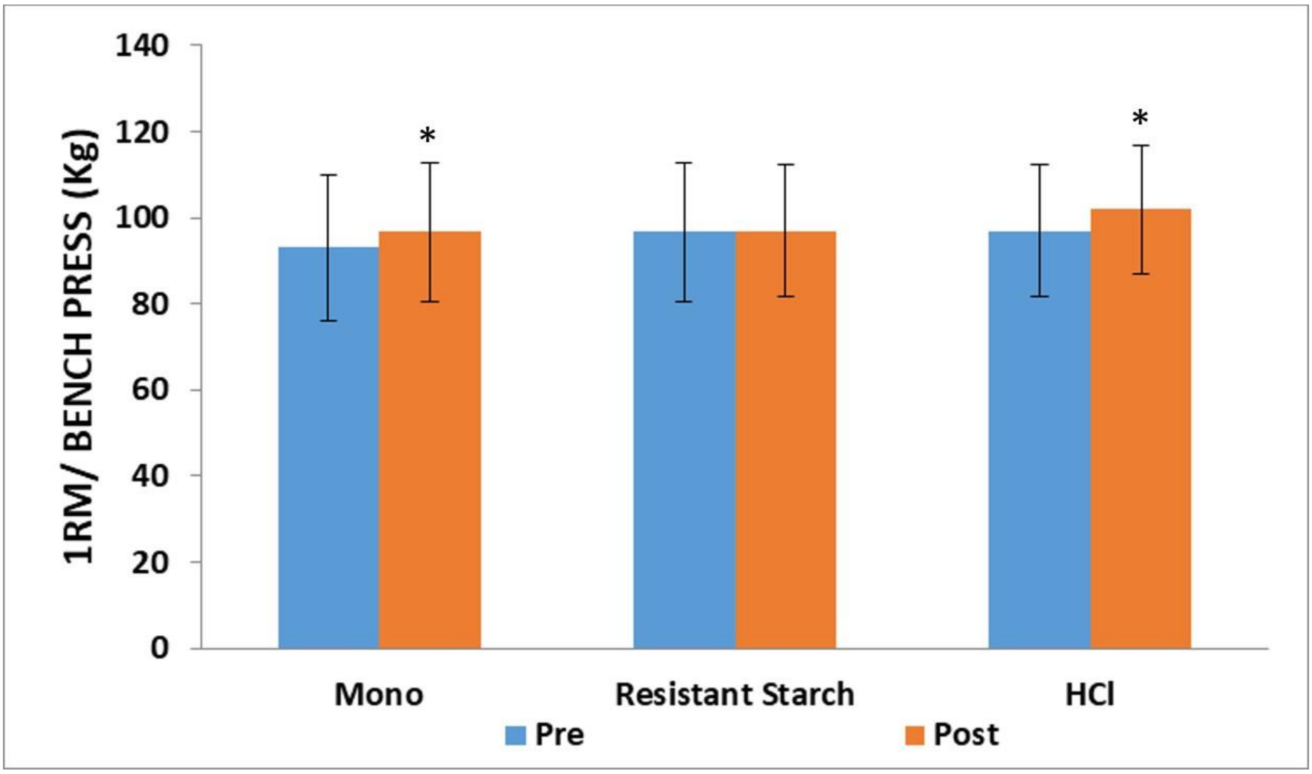

Figure 1 – 1 RM Bench Press test of all experimental moments. * p<0.05 compared to Pre.

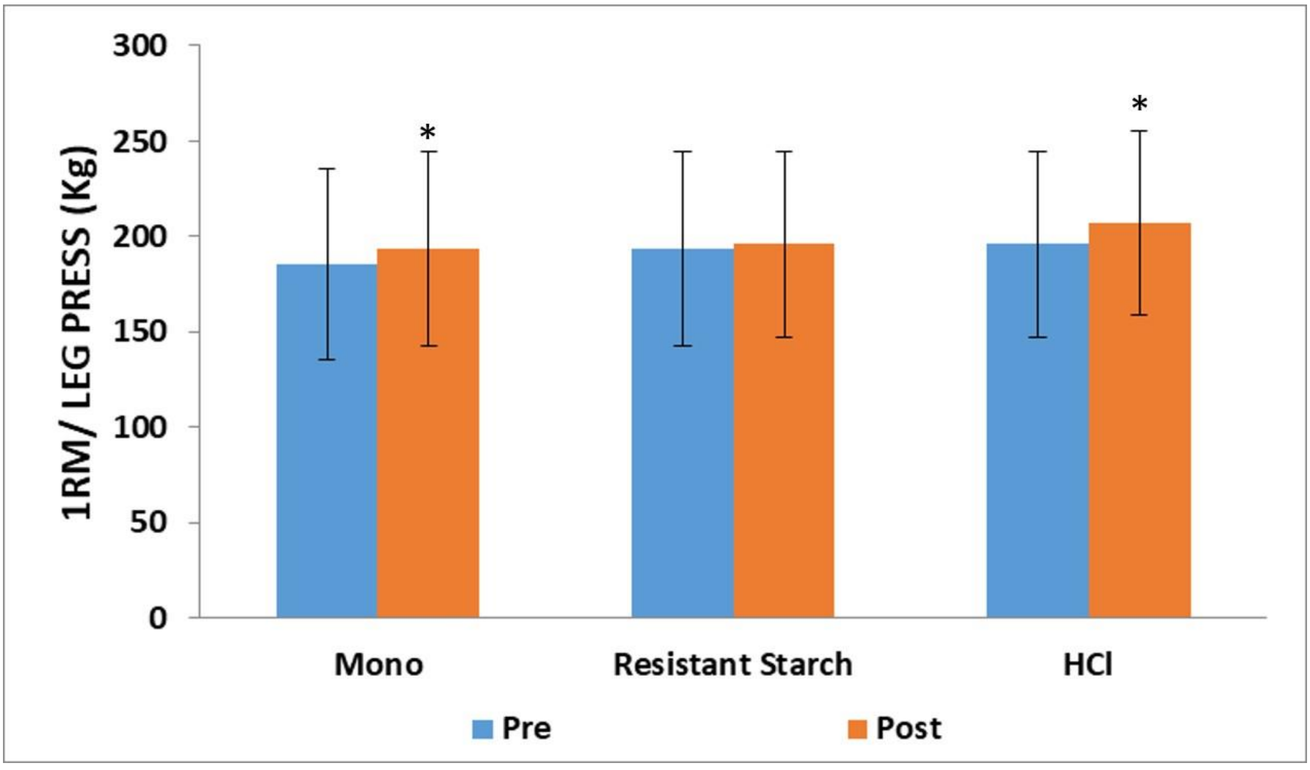

Figure 2 – 1 RM Leg Press 45º test of all experimental moments. * p<0.05 compared to Pre.

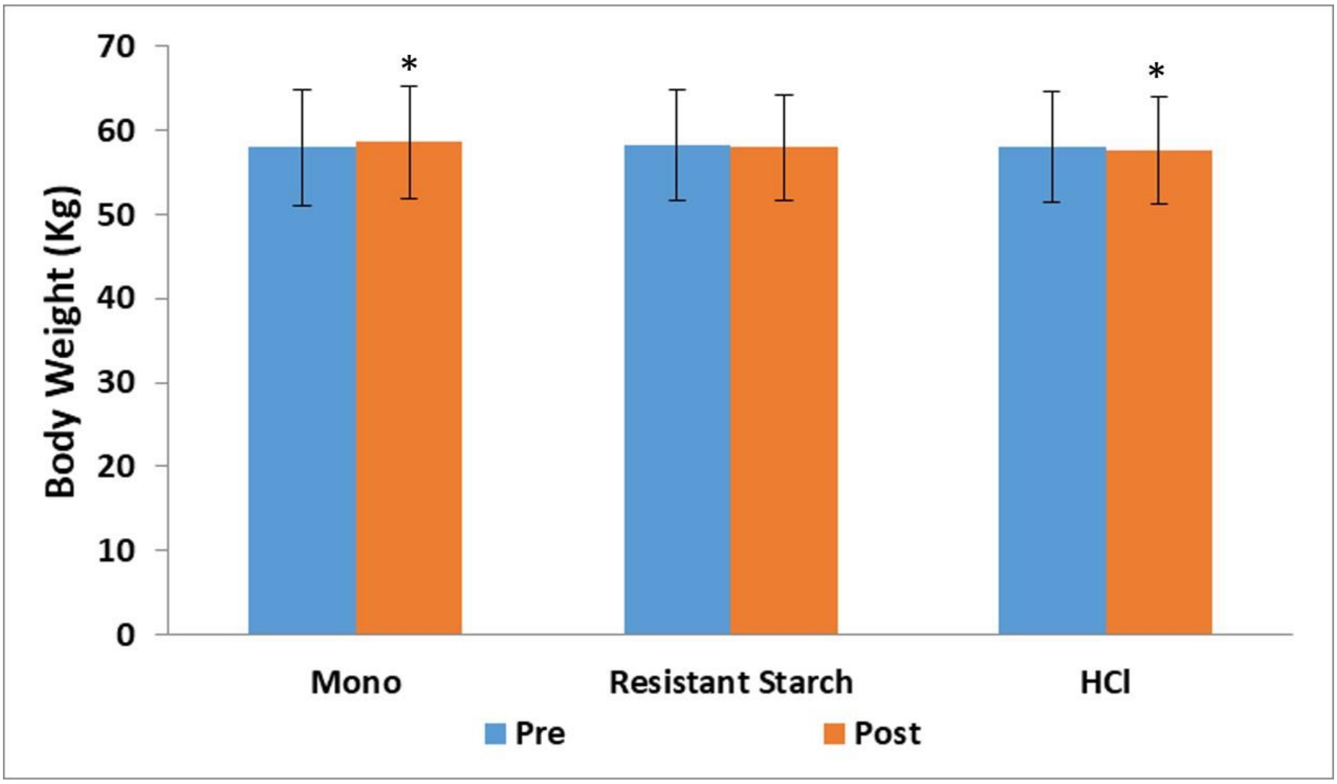

Figure 3 – Body Weight of all experimental moments. * p<0.05 compared to Pre.

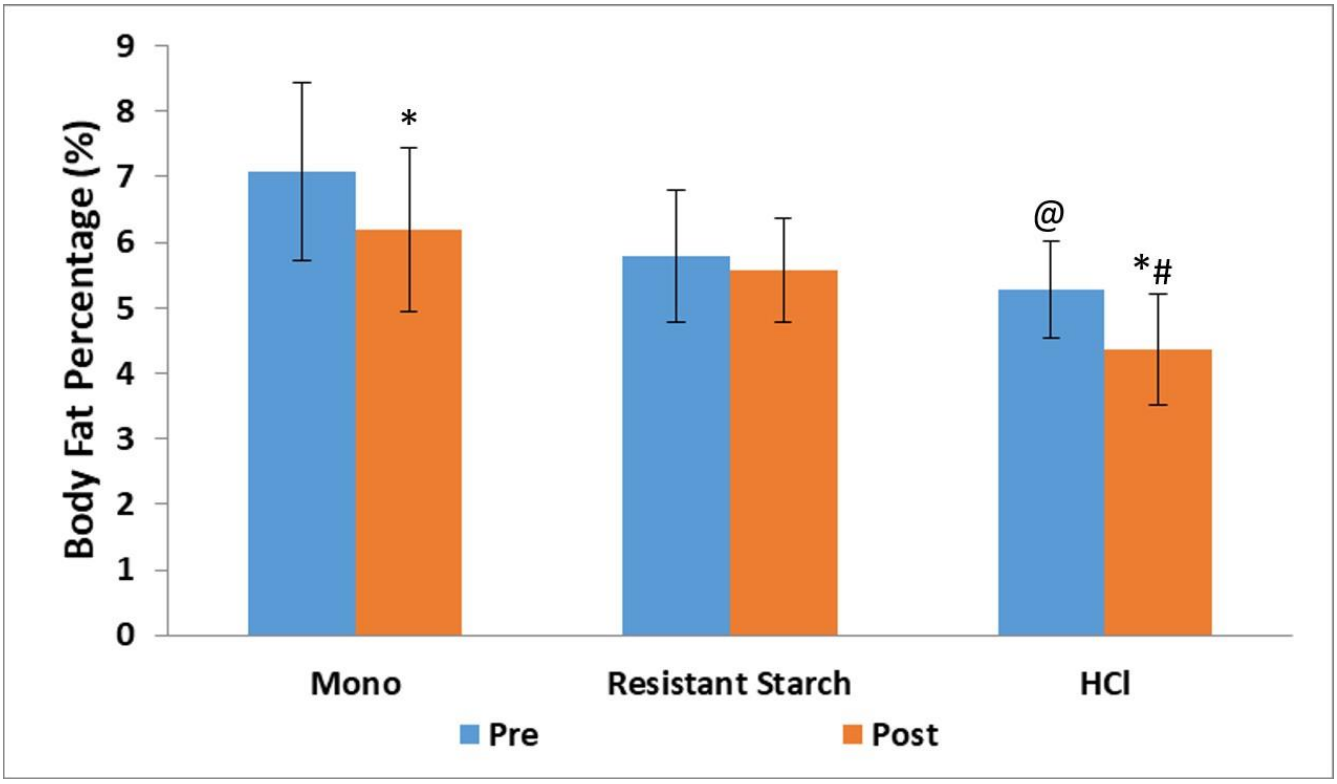

Figure 4 – Body fat percentage of all experimental moments. * p<0.05 compared to Pre; @ p<0.05 compared to Pre Mono; # p<0.05 compared to Post Mono.

Both groups showed significant increases in muscle mass when compared to PRE (MCG 53.81 ± 6.67 PRE and 54.98 ± 6.28 POST; p = 0.00002; HClG 54.81 ± 5.96 PRE and 55.29 ± 6.07 POST; p = 0.0024), although there was no significant changes in the POST results when the groups were compared (MCG 54.98 ± 6.28 POST and HClG 55.29 ± 6.07 POST; p = 0.174). No difference was noted during the resistant starch period, between the two treatments (RS 54.98 ± 6.37 PRE and 54.68 ± 5.96 POST; p = 0.119).

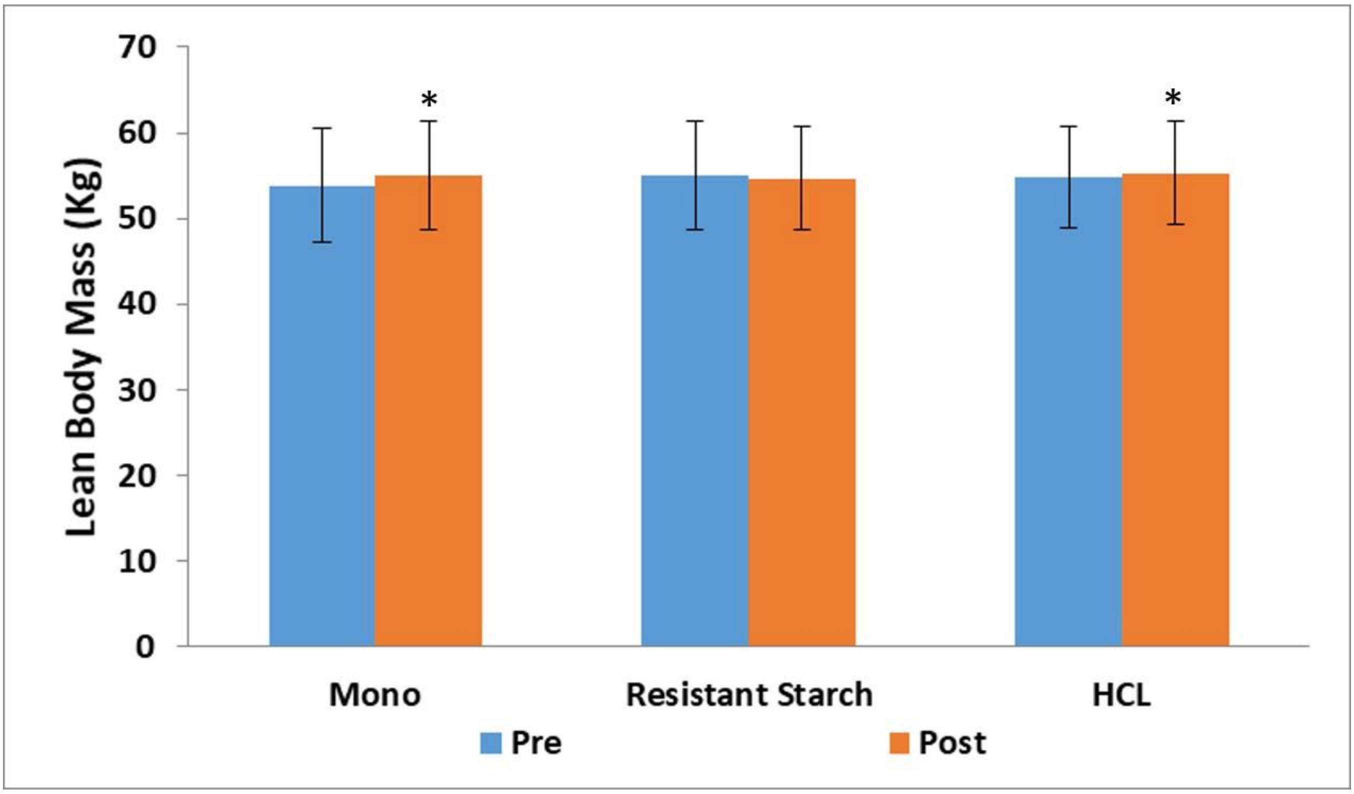

Figure 5 – Lean body mass of all experimental moments. * p<0.05 compared to Pre.

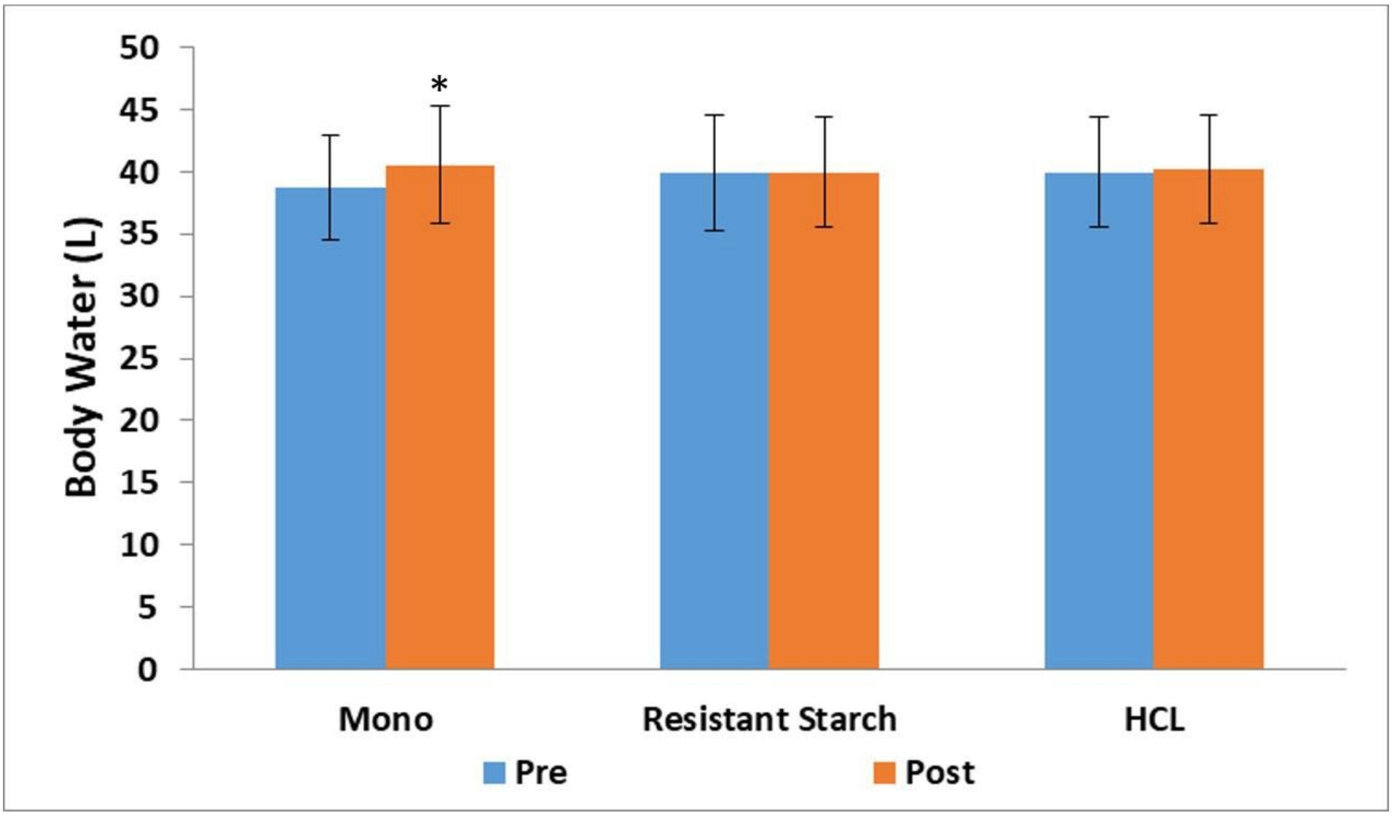

Figure 6 – Body water content of all experimental moments. * p<0.05 compared to Pre.

The results of body composition are in accordance with the functional evaluation (1RM test) as described above. This test showed an increase in both treatments compared to the PRE moment.

One important evaluation of this study was water retention measured with a segmental tetrapolar eletric bioimpedance scale (Inbody 120). It is important to emphasize that all subjects were instructed to maintain normal hydration according to the needs of the this modality and the prescribed diet.

Our bioimpedance results showed that the MCG had a higher amount of body water when compared to PRE (MCG 38.71 ± 4.21 PRE and 40.52 ± 4.74 POST; p = 0.000018), this result is not the same to the HClG, or even to the resistant starch period (HClG 39.98 ± 4.42 PRE and 40.22 ± 4.31 POST; p = 0.169); (RS 39.93 ± 4.62 PRE and 39.92 ± 4.38 POST; p = 0.957). There was no difference between the groups.

Discussion

The study was carried out in pre competitive periods, aligned with the athletes main competitions calendar, similar to the study published by Malina et al.(2013)[16] that analyzed gymnastics athletes maturation stage according to the training periodization proposed by their trainer.

The diet prescribed for the athletes in this study was thought to fulfill the needs of the athletes and to allow the observation of the supplement effects along with the competitive calendar. Our results might be of little statistic magnitude but in a practical approach, those results meant significant differences in the athlete performance and ranking. Usually the calculation of the diets is made based on the energy need of each modality and Achten & Jeukendrup, (2004)[17] suggest that energy compensation should be used to improve performance. In our study these needs were determined for each athlete individually and the group was supervised by the same nutritionist for at least 4 years.

Creatine is an already tested and prescribed supplement with known results, but with its use not indicated to weight restricted subjects. With the proposal of a molecule that was more soluble, better absorbed and retained less water, a process described by Gufford et al. (2010)[18], we expected better results, especially in a fine-tuned sample of elite athletes such as the ones used in the study.

The direct interaction between the diet, the supplement and the results is stronger when the main dietary needs of the athletes are identified and the supplements used are supported by information available in the literature (Knapik et al., 2015)[19].

Our results showed weight increase for the MCG comparing PRE and POST moments. This result is important when we put it in the context of the weight dependent athletes.

Although creatine monohydrate is commonly known to increase weight, there are some other studies that show different results, mainly because of different metabolic states or demands, for instance, studies with other exercise protocols instead of the typical strength training exercises where creatine is usually used or studied. Consumption of creatine monohydrate by runners showed no significant weight gain[20] (Santana et al., 2018). Jatoi et al., (2017)[21]also supplemented creatine for cancer patients, in order to promote muscle mass and weight gain, with no positive results.

Although there was no differences between the groups in the end of the protocol, once again, if we put the results in context and understand that the protocols were developed in very similar conditions, the lack of increase in the weight of the HClG is in accordance with other studies of our group[20,22] and contributes to the hypothesis that this type of creatine might have less impact on the weight of athletes due to less water retention.

After the HCl protocol, the athletes showed significant less body fat percentage when compared to the MCG. Although the protocols were very similar with a strict diet control in both moments, because the HCl protocol was the second protocol and the athletes were training for the most important competition in their year, we understand that this result might be influenced by these elements. However, we believe that one aspect of the HCl creatine supplement that is not explored in the literature is that it promotes the same effects of the monohydrate creatine but at the same time it allows changes in body composition that creatine monohydrate impairs.

Our results showed significative increase in muscle mass after both protocols. Although these results are typical for monohydrate creatine, they have been poorly evaluated for other types of creatine. These increases, especially the monohydrate one, are supported by review articles that state that resistance training associated to creatine result in muscle mass increase[23,24]. The muscle mass increases are directly connected to the maximum strength increases that were observed in our study, for both types of creatines.

Gymnastic athletes are directly influenced by their weight, therefore we understand that sometimes, dehydration techniques are used, like in other weight dependent modalities. In our study, also because of the competitive level of the athletes that participated in the study, they were instructed and supervised to keep the normal hydration status through the entire experimental period, so performance would not be affected and nutrients absorption would not be negatively influenced.

The literature has several published papers about the weight gain effect of monohydrate creatine. This effect can be attributed mainly to water retention[25, 26,27,28]. This water retention is associated to the traditional loading supplementation protocol that is considered an effective dosage to fill the muscle storages but at the same time it is considered excessive, resulting in this water unbalance with consequent water retention[29].

One classic study published by Powers et al., (2003)[27] investigated the effects of creatine supplementation and the extracellular and intracellular water volume during the supplement period. The study verifies the creatine loading hypothesis, showing muscle creatine increase and muscle mass increase but it also showed total body water increase in the supplemented group. Another interesting variable presented on this study is the excretion, absorption and maintenance that happens in a different way than the placebo group. In a 28 days cycle there is a 12% increase and stabilization until the last day. The intracellular water increase happens in both cases but is more significant in the monohydrate-supplemented group.

Schoeller et al., (1980)[30] makes a detailed evaluation of the water flux in the body. It shows, through the measuring of Deuterium oxide dilution (also known as Heavy water) the water flux on the organic tissues. This method is based on the ingestion of a determined dosage of Deuterium and the consequent determination of it in the body fluids samples, like blood, saliva or urine. The samples are evaluated before and after some hours after the Deuterium ingestion. This method, despite expensive and sophisticated, determines the amount of body water, lean mass and fat mass precisely.

Deminice et al., (2013)[31], showed in a study with young soccer players, an increase in the water amount and and weight gain when supplemented with a dosage of 0.3g/kg of bodyweight for 14 days. These authors used the technique of the Deuterium dilution evaluation. The study published by (Powers et al., 2003)[27] evaluated men and women involved in strength training for at least 3 times a week. These individuals followed the classic creatine supplementation protocol, with a 25g dose daily in the first week (loading phase) and one 5g dose for maintenance for the next 21 days. These authors also used the heavy water technique and found increase in the water and body weight in the creatine group when compared to placebo both in the end of the loading week and in the end of the maintenance phase.

The association between the increase in intramuscular creatine and the changes in osmotic pressure is expected. It results in water entering the cells, remaining there (water retention) and therefore, weight increase. When the organism needs to lose water because of sweat, temperature increase or both combined, these changes can be harmful since intracellular water does not help thermoregulation effectively[27].

Deminice et al., (2013)[31] reports an increase in the intracellular water of 5% (1.6L), increase that is already observed in other studies such as (Bemben & Lamont, 2005)[5] and (Francaux & Poortmans, 2006)[32].

All these features are directly connected to the weight gain, which is the main side effect of monohydrate creatine supplementation. So, it seems that the association of the amount of creatine ingested, increase in the body water content and consequently in the weight is already established. However, all the studies we quoted, as well as others, report performance improvement of the supplemented individuals.

That performance improvement, a literature consensus, made creatine a good target to molecular improvements. Some attempts, despite of the changes on the molecule, yielded no effective improvements when compared to regular monohydrate creatine[33], but the addition of a HCl radical to it, making it a more soluble salt seems to be an effective process[22].

This strategy is not exactly a new idea, the pharmaceutical companies used it for several years. There are more than 200 molecules with this type of adaptation on the European Pharmacopea. Compared to the free bases, these molecules are more soluble in the gastrointestinal tract and are absorbed faster to the blood stream[34].

What we observed in this study is that even if the supplement is already a consensus in the literature it can be improved and, depending on the context, the new features can be the difference that would get the elite athlete from second place to winning.

Study Limitations

The competition schedules were different for different athletes and eventually for some of them, that would influence training intensity. A more sophisticated body composition equipment such as a DEXA would be appropriated in order to properly evaluate water rettention.

We can conclude that both creatines are effective regarding muscle mass and strentgh gains according to the results of 1RM and body composition.

As to body water we could conclude that creatine monohydrate retains water when compared to creatine HCl, and that is even more important when we work with atheltes where weight can be a determinant variable.

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Declaration of Interest

We declare that there are no conflict of interests in this study.

References

1. Miller, D. W. (2009). Oral bioavailability of creatine supplements: Is there room for improvement. . . Annual Meeting of the International Society of Sports Nutrition. Retrieved from http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L34037775
2. Brown, M. A., Howatson, G., Quin, E., Redding, E., & Stevenson, E. J. (2017). Energy intake and energy expenditure of preprofessional female contemporary dancers. PLoS ONE, 12(2), 1–13. https://doi.org/10.1371/journal.pone.0171998
3. Kiningham, R. B., & Gorenflo, D. W. (2001). Weight loss methods of high school wrestlers. Medicine and Science in Sports and Exercise, 33(5), 810–813.
4. Cohen, P. A., Avula, B., Venhuis, B., Travis, J. C., Wang, Y. H., & Khan, I. A. (2017). Pharmaceutical doses of the banned stimulant oxilofrine found in dietary supplements sold in the USA. Drug

Testing and Analysis, 9(1), 135–142. https://doi.org/10.1002/dta.1976

5. Bemben, M. G., & Lamont, H. S. (2005). Creatine supplementation and exercise performance: recent findings. Sports Medicine (Auckland, N.Z.), 35(2), 107–125.
6. Terjung, R. L., Clarkson, P., Eichner, E. R., Greenhaff, P. L., Hespel, P. J., Israel, R. G., … Williams, M. H. (2000). American College of Sports Medicine roundtable. The physiological and health effects of oral creatine supplementation. Medicine and Science in Sports and Exercise, 32(3), 706–717.
7. Benzi, G. (2000). Is there a rationale for the use of creatine either as nutritional supplementation or drug administration in humans participating in a sport? Pharmacological Research, 41(3), 255–264. https://doi.org/10.1006/phrs.1999.0618
8. Groeneveld, G. J., Beijer, C., Veldink, J. H., Kalmijn, S., Wokke, J. H. J., & van den Berg, L. H. (2005). Few adverse effects of long-term creatine supplementation in a placebo-controlled trial. International Journal of Sports Medicine, 26(4), 307–313. https://doi.org/10.1055/s-2004-817917
9. Graham, A. S., & Hatton, R. C. (1999). Creatine: a review of efficacy and safety. Journal of the American Pharmaceutical Association (Washington,D.C. : 1996), 39(6), 803–807.
10. Ostojic, S. M., & Ahmetovic, Z. (2008). Gastrointestinal distress after creatine supplementation in athletes: are side effects dose dependent? Research in Sports Medicine (Print), 16(1), 15–22. https://doi.org/10.1080/15438620701693280
11. Dash, A. K., Miller, D. W., Huai-Yan, H., Carnazzo, J., & Stout, J. R. (2001). Evaluation of creatine transport using Caco-2 monolayers as an in vitro model for intestinal absorption. Journal of Pharmaceutical Sciences, 90(10), 1593–1598. https://doi.org/10.1002/jps.1109
12. Tuckfield, C. (2015). First use of creatine hydrochloride in premanifest huntington disease. Medical Journal of Australia, 202(7), 378–381. https://doi.org/10.5694/mja14.01070
13. Nunomura, M., & Oliveira, M. S. (2011). PARENTS ' SUPPORT IN THE SPORTS CAREER OF YOUNG GYMNASTS. Science of Gymnastics Journal, 5(1), 5–17.
14. Brown, L., & Weir, J. P. (2001). Procedures Recommendation I: Accurate Assessment Of Muscular Strength And Power. Journal of Exercise Physiology, 4(3), 1–21.
15. Jackson, A.S; Pollock, M. . (1978). Generalized equations for predicting body density of men. British Journal of Nutrition, 40(3), 497–504.
16. R. Malina, A. Baxter-Jones, N. Armstrong, Beunen, G. P., Caine, D., Daly, R. M., Lewis, R. D., Rogol, A. D., & Russell, K. (2013). Role of Intensive Training in the Growth and Maturation of Artistic Gymnasts. Sports Medicine, 43(9), 783–802. https://doi.org/10.1007/s40279-013-0058-5
17. Achten, J., & Jeukendrup, A. E. (2004). Optimizing Fat Oxidation Through Exercise and Diet. Nutrition, 20(7–8), 716–727. https://doi.org/10.1016/j.nut.2004.04.005
18. Gufford, B. T., Miller, N. J., Miller, D. W., Vennerstrom, J. L., & Robinson, D. H. (2010). Physicochemical Characterization of Creatine N - Methylguanidinium Salts. Journal of Dietary Supplements, 7(3), 240–252. https://doi.org/10.3109/19390211.2010.491507
19. Knapik, J. J., Steelman, R. A., Hoedebecke, S. S., Austin, K. G., Farina, E. K., & Lieberman, H. R. (2015). Prevalence of Dietary Supplement Use by Athletes : Systematic Review and Meta-Analysis. Sports Medicine, 46(1), 103–123. https://doi.org/10.1007/s40279-015-0387-7
20. Santana, J.O; França, E; Madureira, D; Rodrigues, B; Caperuto, E. C. (2018). Combined Effect of Creatine Monohydrate or Creatine Hydrochloride and Caffeine Supplementation in Runners'Performance and Body Composition. Revista Brasileira de Prescrição e Fisiologia Do Exercício, 11(70), 844–854.
21. Jatoi, A., Steen, P. D., Atherton, P. J., Moore, D. F., Rowland, K. M., Adonizio, C. S., … Loprinzi, C. (2017). A double-blind, placebo-controlled randomized trial of creatine for the cancer anorexia/weight loss syndrome (N02C4): an Alliance trial. Annals of Oncology, 28(8), 1957–1963. https://doi.org/10.1093/annonc/mdx232
22. França, E. De, Avelar, B., Yoshioka, C., Santana, J. O., Madureira, D., Rocha, L. Y., … Caperuto, É. C. (2015). Creatine HCl and Creatine Monohydrate Improve Strength but Only Creatine HCl Induced Changes on Body Composition in Recreational Weightlifters. Food and Nutrition Sciences, 6(December), 1624–1630. https://doi.org/10.4236/fns.2015.617167
23. Buford, T. W., Kreider, R. B., Stout, J. R., Greenwood, M., Campbell, B., Spano, M., … Antonio, J. (2007). Journal of the International Society International Society of Sports Nutrition position stand : creatine supplementation and exercise. Journal of the International Society of

Sports Nutrition, 8, 1–8. https://doi.org/10.1186/1550-2783-4-Received

24. Cooper, R., Naclerio, F., Allgrove, J., & Jimenez, A. (2012). Creatine supplementation with specific view to exercise / sports performance : an update. Journal of the International Society of Sports Nutrition, 9(1), 1. https://doi.org/10.1186/1550-2783-9-33
25. Brilla, L. R., Giroux, M. S., Taylor, A., & Knutzen, K. M. (2003). Magnesium-Creatine Supplementation Effects on Body Water. Metabolism, 52(9), 1136–1140. https://doi.org/10.1016/S0026-0495(03)00188-4
26. Easton, C., Turner, S., & Pitsiladis, Y. P. (2007). Creatine and Glycerol Hyperhydration in Trained Subjects Before Exercise in the Heat. International Journal of Sport Nutrition and Exercise Metabolism, 17(1), 70–91.
27. Powers, M. E., Arnold, B. L., Weltman, A. L., Perrin, D. H., Mistry, D., Kahler, D. M., … Volek, J. (2003). Creatine Supplementation Increases Total Body Water Without Altering Fluid Distribution. Journal of Athletic Training, 38(1), 44–50.
28. Volek, J. S., Mazzetti, S. A., Farquhar, W. B., Barnes, B. R., Omez, A. N. A. L. G., & Kraemer, W. J. (2001). Physiological responses to short-term exercise in the heat after creatine loading. Medicine and Science in Sports and Exercise, 33(7), 1101–1108
29. Gann, J. J., Mckinley-barnard, S. K., Andre, T. L., Schoch, R. D., & Willoughby, D. S. (2015). Effects of a traditionally-dosed creatine supplementation protocol and resistance training on the skeletal muscle uptake and whole-body metabolism and retention of creatine in males. Journal of International Society of Sports Nutrition, 12(Suppl 1), 1–2. https://doi.org/10.1186/1550-2783-12-S1-P2
30. Schoeller, D. A., van Santen, E., Peterson, D. W., Dietz, W., Jaspan, J., & Klein, P. D. (1980). Total body water measurement in humans with 180 and 2H labeled water. The American Journal of Clinical Nutrition, 33(12), 2686–2693.
31. Deminice, R., Rosa, F. T., Franco, G. S., Jordao, A. A., & de Freitas, E. C. (2013). Effects of creatine supplementation on oxidative stress and in fl ammatory markers after repeated-sprint exercise in humans. Nutrition, 29(9), 1127–1132. https://doi.org/10.1016/j.nut.2013.03.003
32. Francaux, M., & Poortmans, J. R. (2006). Side Effects of Creatine Supplementation in Athletes. International Journal of Sports Physiology and Performance, 1(4), 311–323.
33. Jäger, R., Harris, R. C., Purpura, M., & Francaux, M. (2007). Comparison of new forms of creatine in raising plasma creatine levels. Journal of the International Society of Sports Nutrition, 4(1), 1–5. https://doi.org/10.1186/1550-2783-4-Received
34. European Pharmacopea. (2011), acessed to 06/01/2017. Retrieved from http://www.edqm.eu/en/background-50.html