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IMPACT OF CREATINE MONOHYDRATE ON BODY MASS OF SWIMMERS

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Abstract: The subject of the research is impact of creatine monohydrate on a mass of swimmers. The test was performed on a sample of 60 swimmers among members of the Academic Swimming Club „22. April“ divided into two groups aged between 21 and 25. All respondents are male and in good health. The respondents belonging to this population are at the zenith of morphological and motor development and are well motivated to advance in swimming. The measurement was carried out at the end of May and half of June 2008 at the premises of the Recreation Center Srpske Toplice (water temperature 28°C). The respondents were measured for body mass at baseline and after 21 days of taking creatine. The main objective of the paper is to determine whether taking creatine for three weeks shows significant differences in a mass gain of swimmers. The results of the research show that the differences in body mass between the two measurements have statistical significance.

Keywords: creatine, nutritional supplement, body mass, swimming, statistical analysis.

1. INTRODUCTION

Ways to take supplements and impact on creatine stores in muscles

Various ways of taking supplements have been suggested to effectively raise a level of creatine stores in muscles. The amount by which the creatine stores in muscles will increase depends on a level of creatine in muscles before taking the supplements. Those who have low levels of creatine stores in muscles, such as people who eat a little meat or fish, are more likely to increase their muscular store by 20-40%, while for those with relatively high stores, creatine growth will range from 10-20% [1]. The amount of the increase in creatine content in skeletal musculature is important because research has shown that changes in results achieved are correlated with this increase [2]. A schedule of taking creatine as a nutritional supplement in the literature is most commonly referred to as the „supplement“ schedule. It is characteristic of this schedule that ß-hydroxy-ß-methylbityrate is taken approximately in the amount of 0.3 g/kg/day for 5 - 7 days (eg ~ 5 g taken four times daily), and subsequently 3-5 g/kg/day. Studies have shown that taking this schedule achieves an increase of 10-40% of creatine in muscles and phosphocreatine in stores. Additional research has shown that it is enough for supplementation schedule to last for 2-3 days so that the beneficial effects can be felt, especially if proteins and/or carbohydrates are added to a diet. Moreover, by adding creatine monohydrate in the amount of 0.25 g/kg-lean mass daily, it may represent an alternative dose sufficient to increase creatine stores in muscles.

Other schedules that are used to take nutritional supplements are schedules that do not predict the supplementation phase or the "cycle". Several studies have shown that there are schedules by which a sufficient increase in creatine in muscles (3 g/day for 28 days) as well as in muscle size and strength (6 g/day for 12 weeks) has been achieved without supplementation. Such schedules appear to be equally effective in increasing the stores of creatine in the muscles, with the increase being more gradual and the ergogenic effect not occurring as quickly. Cyclic schedules assume that „supplementation“ doses should be taken for 3-5 days every 3 to 4 weeks. These cyclical schedules

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appear to be effective in increasing and maintaining a creatine content of the muscles before falling to baseline values which occurs in about 4-6 weeks [3].

1.1. Creatine compositions and combinations

There are many forms of creatine on the market which can be very confusing for a consumer. A composition and combinations of some of these products include creatine phosphate, creatine plus ß-hydroxy-ß-methlyibityrate (HMB), bicarbonate of soda creatine, magnesium-celate creatine, creatine plus glycerol, creatine plus glutaminate, creatine plus ß-alanine, creatine ethyl ester, creatine with cinulin extract, as well as effervescent tablets and serums. For most of these forms of creatine, reports show that they are no better than traditional creatine monohydrate in terms of strength gain or results achieved. [4] Reliable studies have yet to publish reports for creatine ethyl ester and creatine with cinnulin extract. However, recent research does suggest that adding it to β-alanine creatine monohydrate can produce greater effects than when taken creatine monohydrate alone. These studies suggest that such a combination can have greater effects on a percentage of body fat, lean masses and body fat, and in addition slows a neuromuscular fatigue. The three alternative compositions of creatine have shown to be promising, but so far there is insufficient evidence to guarantee that they can be recommended instead of creatine monohydrate. For example, creatine phosphate is reported to be just as effective as creatine monohydrate in improving lean body mass and strength, however, this is still related to just one study. In addition, it is currently far more difficult and expensive to produce creatine phosphate than creatine monohydrate. A combination of creatine monohydrate and sodium phosphate, which reports say increases endurance in high-intensity exercise, may be a financially more affordable alternative than creatine phosphate. Moreover, for the creatine/HMB combination, reports say that it is more effective for improving muscle body mass and strength than creatine alone. However, other data suggest that this combination offers no advantages in terms of increasing aerobic or anaerobic capacity. Thus, conflicting data such as this cannot be a guarantee for a recommendation to replace creatine monohydrate with the combination of creatine/ß-hydroxy-ß-methylbityrate=HMB. Finally, for a combination of creatine plus glycerol, reports have shown that, as a method of hyper-hydration for high-temperature exercise, it increases a total amount of water in a body, but this is also the first study of this kind. In addition, this combination failed to enhance thermal and cardiovascular responses to a greater extent than when creatine monohydrate was used alone [5]. The addition of nutrients that increase insulin levels and/or improve insulin sensitivity has been a major area of interest in recent years for those scientists who have sought to obtain optimal ergogenic effects of creatine. Adding certain macronutrient ingredients seems to significantly increase a muscle retention of creatine.

By adding 93 g of carbohydrate to 5 g of creatine monohydrate, total creatine in muscle increased by 60% [2]. Likewise, the addition of 47 g of carbohydrate and 50 g of protein to creatine monohydrate was as effective in increasing the retention of creatine in muscles as adding 96 g of carbohydrate [6]. Additional studies have shown that creatine retention is increased by addition of dextrose or small amounts of Dpinitol (a herbal extract with insulin-like properties). While these nutritional supplements have proven to increase creatine retention in muscles, several recent studies show that these combinations are no more effective than creatine monohydrate to increase muscle strength and endurance or improve athletic performance [4]. Some other recent studies, however, point to potential positive effects on anaerobic strength, muscle hypertrophy, and muscle strength when combined with creatine protein [7]. Combining creatine monohydrate with carbohydrates or carbohydrate and protein seems to give optimal results. Studies suggest that increased levels of creatine in skeletal musculature may increase positive aspects of training [8].

2. METHOD

2.1. Sample of respondents

The test was performed on a sample of 60 swimmers from the members of the Academic Swimming Club "22. april" divided into three groups and aged 21-25. The test was conducted on a voluntary basis. All respondents were male and in good health. Respondents belonging to this population are at the zenith of morphological and motor development and are well motivated to advance in swimming. Respondents had engaged in recreational swimming until the start of this research.

The measurement was performed at the building of the Recreational Center Srpske Toplice (water temperature 28°C), twice, at the end of May and middle of June 2008, respectively, ie. before and after taking the creatine monohydrate supplement.

All respondents were weighed at the beginning and end of taking creatine monohydrate.

The respondents of the first group took creatine monohydrate, the respondents of the third group had fitness, and the respondents of the second group had no additional therapies or trainings.

After three weeks (21 days), all respondents were re-measured for body mass.

In addition to the variables mentioned, changes in body mass were subsequently calculated.

On the basis of the subject, goal and tasks of the research, as well as on the results of previous research, it is possible to make the following hypotheses:

1. H1 - there are statistically significant changes in body mass,
2. H2 – there are no statistically significant changes in body mass.

2.2. Test description

The amount of the increase in creatine content in skeletal musculature is important because studies have shown that changes in results achieved are correlated with this increase. The schedule of taking creatine as a nutritional supplement in the literature is most commonly referred to as the "supplement" schedule. It is characteristic of this schedule that creatine monohydrate is taken at approximately 0.3 g/kg/day for 5 - 7 days (eg ~ 5 g four times a day) and later at 3-5 g/day. Studies have shown that taking according to this schedule results in an increase of 10-40% of creatine in muscles and phosphocreatine in stores.

Regarding statistical processing, descriptive statistics indicators (arithmetic mean, median, mode, extreme values, rank, quartiles, variance, standard deviation, coefficient of variation) were used to represent body masses (on the first measurement, on the second measurement, and differences in mass).

Qualitative data (general changes in mass) are presented through a frequency of occurrence and percentage representation.

Student's t -tests for paired samples (within one group) and for independent samples (between different groups) were used to compare mean values of the characteristics.

A $\chi 2$ (chi square test) contingency test was used to compare a frequency of features between different groups.

Pearson's correlation parameter was used to determine a degree of correlation between various variables for mass.

For statistical processing, preparation and presentation of results the following were used: statistical software *SPSS 16.0 for Windows; Microsoft Office Excel 2007* and *Microsoft Office Word 2007.*

3. RESULTS WITH DISCUSSION

Table 1 shows that the average mass of all subjects at the first measurement was 80.97 kg. The most frequent mass, as well as the median, was 80 kg and the mass range was 39 kg (from 67 to 106 kg). It is also noticeable that at least 50% of the respondents on the first measurement weighed between 75 and 84.5 kg.

At the second measurement, the average mass was increased to 81.39 kg. The most frequent mass at the second measurement was 84 kg and the median was 81 kg. The mass range was reduced to 38 kg (from 66 to 104 kg) at the second measurement, with at least 50% of the respondents weighing between 76 and 85.5 kg.

Thus, on average, respondents received 430 g each. The highest number of respondents did not change their body mass between the two measurements. The mass change range is from 4 kg gained to 2 kg lost. At least half of all respondents did not change their body mass or gained 1 kg each.

Table 1. Basic indicators of descriptive statistics for mass of the whole sample

Total	Mass (before)	Mass (after)	Mass (difference)
Arithmetic mean	80.97	81.39	0.43
Maximum	106.00	104.00	4.00
Third quartile	84.50	85.50	1.00
Median	80.00	81.00	0.00
First quartile	75.00	76.00	0.00
Minimum	67.00	66.00	-2.00
Range	39.00	38.00	6.00
Mode	80.00	84.00	0.00
Variance	65.83	62.00	1.92
Standard deviation	8.11	7.87	1.39
Coefficient of variation	10.02	9.67	326.22

T-test (Table 2) shows that a difference in mass of the respondents at the first and second measurements is statistically significant.

Table 2. T-test (paired sample)

Total	t	df	p
Mass (before) - Mass (after)	-2.374	59	*0.021*

The parameters in Table 3 represent the Pearson correlation coefficient showing a linear relationship between variables.

Based on the results shown in Table 3, it is concluded that the mass at the first and second measurements is in a very strong positive correlation.

The mass at the first measurement is slightly negatively correlated with the change in mass between the two measurements.

Therefore, in a very large number of cases, respondents who had a higher body mass at the first measurement also had a higher mass at the second measurement.

Also, less regularity was observed that respondents who had higher mass at the first measurement lost more mass between the two measurements.

Table 3. Pearson correlation coefficient between observed variables for the whole sample

Total		Mass	Total	Mass
Mass (before)	r	1.000	*0.985*	*-0.256*
	p		*0.000*	*0.049*
Mass (after)	r	*0.985*	1.000	-0.087
	p	*0.000*		0.507
Mass (difference)	r	*-0.256*	-0.087	1.000
	p	*0.049*	0.507	

Table 4 shows that the average body mass of respondents who used creatine at the first measurement was 80.70 kg. The most frequent mass was 80 kg and the median was 81 kg. Half of the respondents in the first group weighed between 76.5 and 83.5 kg on the first measurement. The mass range at first measurement was 27 kg (68 to 95 kg).

Table 4. Basic indicators of descriptive statistics for mass of the first group

Group 1 + creatine	Mass (before)	Mass (after)	Mass (difference)
Arithmetic mean	80.70	82.33	1.63
Maximum	95.00	95.00	4.00
Third quartile	83.50	85.50	2.00
Median	81.00	83.50	2.00
First quartile	76.50	78.00	1.00
Minimum	68.00	70.00	-2.00
Range	27.00	25.00	6.00
Mode	80.00	84.00	2.00
Variance	41.38	37.01	1.60
Standard deviation	6.43	6.08	1.27
Coefficient of variation	7.97	7.39	77.89

After taking creatine, the first group respondents averaged 82.33 kg at the second measurement, the most frequent mass increased to 84 kg, and at least half of the respondents had 83.5 kg or more. The mass range at the second measurement was 25 kg (70 to 95 kg). At least 50% of the respondents weighed between 78 and 85.5 kg at the second measurement.

Thus, after a creatine therapy, the respondents gained an average of 1.63 kg. The largest number of respondents gained 2 kg, and at least half of them gained mass by 2 kg or more. The respondent who lost the most mass was „lighter" for 2 kg, and the largest mass increase in one respondent was 4 kg. Half of the respondents had increased mass by 1 to 2 kg.

T-test (Table 5) shows that the difference in mass of the first group of respondents between the two measurements is extremely statistically significant.

Table 5. T-test (paired sample) - Group 1

Group 1	t	df	p
Mass (before) - Mass (after)	-5.742	19	*0.000*

Table 6 shows that the masses at the first and second measurements are in very strong positive correlation. Thus, respondents who had higher mass values at the first measurement also had higher mass values at the second measurement.

Table 6. Pearson correlation coefficient between observed variables for the first group

Group 1		Mass (before)	Mass (after)	Mass (difference)
Mass (before)	r	1.000	*0.981*	*-0.367*
	p		*0.000*	*0.112*
Mass (after)	r	*0.981*	1.000	-0.180
	p	*0.000*		0.448
Mass (difference)	r	-0.367	-0.180	1.000
	p	0.112	0.448	

Table 7 shows the basic indicators of descriptive statistics for body mass of the respondents in the second group. The average mass of the respondents in the second group was 82.90 kg at the first measurement, the most frequent mass was 80 kg, and at least half of the respondents had 81 kg or less at the first measurement. The mass range was 39 kg (from 67 to 106 kg). 50% of the respondents weighed between 79 and 90.5 kg at the first measurement.

The average mass at the second measurement was 82.20 kg and the mode and median remained unchanged compared to the first measurement. The mass range has been reduced to 38 kg (66 to 104 kg). Half of the respondents weighed between 79 and 88.5 kg.

Thus, respondents in the second group lost an average of 700 g between the two measurements. The majority of respondents did not change their body mass, and at least half of the respondents did not gain any mass. The respondents gained a maximum of 1 kg and lost a maximum of 2 kg.

Table 7. Basic indicators of descriptive statistics for mass of the second group

Group 2	Mass (before)	Mass (after)	Mass (difference)
Arithmetic mean	82.90	82.20	-0.70
Maximum	106.00	104.00	1.00
Third quartile	90.50	88.50	0.00
Median	81.00	81.00	0.00
First quartile	79.00	79.00	-2.00
Minimum	67.00	66.00	-2.00
Range	39.00	38.00	3.00
Mode	80.00	80.00	0.00
Variance	85.36	79.12	0.96
Standard deviation	9.24	8.89	0.98
Coefficient of variation	11.14	10.82	-139.82

T-test (Table 8) shows that the difference in mass of the second group of respondents between the two measurements is still very statistically significant.

Table 8. T-test (paired sample) - Group 2

Group 2	t	df	p
Mass (before) - Mass (after)	3.199	19	*0.005*

Table 9 shows that mass at the first and mass at the second measurement are in very strong positive correlation. Thus, respondents who had higher mass values at the first measurement also had larger mass values at the second measurement.

Table 9. Pearson correlation coefficient between observed variables for the second group

Group 2		Mass (before)	Mass (after)	Mass (difference)
Mass (before)	r	1.000	*0.995*	-0.398
	p		*0.000*	0.082
Mass (after)	r	*0.995*	1.000	-0.304
	p	*0.000*		0.193
Mass (difference)	r	-0.398	-0.304	1.000
	p	0.082	0.193	

The average mass of the third group of respondents (Table 10) at the first measurement was 79.30 kg, the most frequent mass was 76 kg, and the median was 76.5 kg. The mass range at the first measurement was 34 kg (68 to 102 kg). Half of the respondents weighed between 74.5 and 83.5 kg at the first measurement.

The average mass of the third group of respondents at the second measurement was not significantly changed - 79.65 kg, and also the mode and median remained unchanged. The range increased to 35 kg (from 68 to 103 kg), and half of the „medium“ mass respondents at the second measurement had between 74.5 and 83.5 kg. Thus, the respondents of the third group gained on average 350 g between the two measurements, and the largest number did not change the mass. The highest mass gain was at respondents who, after the second measurement, had mass higher by 2 kg, and the ones who lost the most were those who had lower mass by 1 kg.

Table 10. Basic indicators of descriptive statistics for mass of the third group

Group 3 + Fitness	Mass (before)	Mass (after)	Mass (difference)
Arithmetic mean	79.30	79.65	0.35
Maximum	102.00	103.00	2.00
Third quartile	83.00	83.50	1.00
Median	76.50	76.50	0.00
First quartile	74.50	74.50	0.00
Minimum	68.00	68.00	-1.00
Range	34.00	35.00	3.00
Mode	76.00	76.00	0.00
Variance	70.75	71.61	0.56
Standard deviation	8.41	8.46	0.75
Coefficient of variation	10.61	10.62	212.90

T-test (Table 11) shows that the difference in the mass of the third group respondents between the two measurements, although at the limit of significance, is still statistically significant.

Table 11 - T-test (paired sample) - Group 3

Group 3	t	df	p
Mass (before) - Mass (after)	-2.101	19	*0.049*

Table 12 shows that for the third group subjects the body mass at the first and second measurements is in very strong positive correlation. Thus, the respondents who weighed more at the first measurement, generally had more than the others at the second measurement, too.

Table 12. Pearson correlation coefficient between observed variables for the third group

Group 3		Mass (before)	Mass (after)	Mass (difference)
Mass (before)	r	1.000	*0.996*	0.024
	p		*0.000*	0.919
Mass (after)	r	*0.996*	1.000	0.112
	p	*0.000*		0.637
Mass (difference)	r	0.024	0.112	1.000
	p	0.919	0.637	

Comparison of differences between groups by T-test for independent samples showed that there were no statistically significant differences between the different groups in the masses of the respondents at the first measurement, as well as in the masses of the respondents at the second measurement (Tables 13, 14 and 15).

In contrast, the mass differences between the two measurements differ statistically extremely significantly for each of the two observed groups.

Thus, the respondents in the second group lost on average 700 g between the two measurements.

The respondents in the third group gained 350 g on average, which is statistically significantly more than the second group, but also statistically much less than the first group, whose respondents gained on average 1630 g.

Table 13. T-test (independent samples) for the first and second group

Group 1 / Group 2	t	df	p
Mass (before)	-0.874	38	0.388
Mass (after)	0.052	38	0.959
Mass (difference)	6.499	38	*0.000*

Table 14. T-test (independent samples) for the first and third group

Group 1 / Group 3	t	df	p
Mass (before)	0.591	38	0.558
Mass (after)	1.148	38	0.258
Mass (difference)	3.882	38	*0.000*

Table 15. T-test (independent samples) for the second and third group

Group 2 / Group 3	t	df	p
Mass (before)	1.289	38	0.205
Mass (after)	0.929	38	0.359
Mass (difference)	-3.817	38	*0.000*

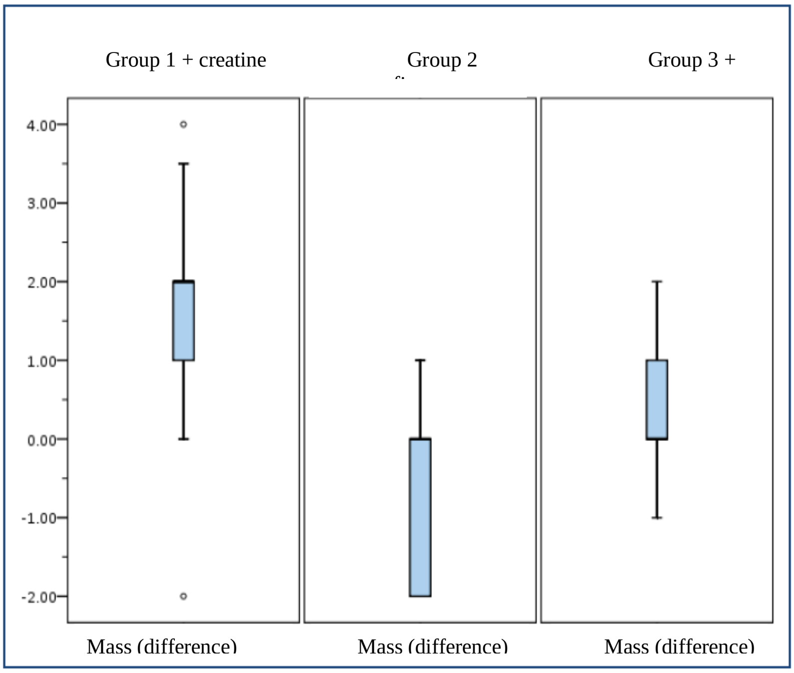

Chart 1. Box-plot diagrams of differences in mass between two measurements

These differences between groups are particularly noticeable in the box-plot diagram (Chart 1).

In order to confirm differences in body mass between the groups, a new variable was created which generally observes changes in the respondents' masses (same mass, lost mass and gained mass).

Table 16 shows a frequency and percentage of general changes in mass by groups. It is observed that in the first group as much as 90% of the respondents gained mass, in the second group half of the respondents retained the same mass, and 45% lost mass, while in the third group half of the respondents also retained the same mass, but also 40% of the respondents gained mass.

Table 16. Frequency of general change in mass between two measurements per group

	Mass (general)							
	Same mass		Lost mass		Gained mass		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Group 1 + Creatine	1	5.0	1	5.0	18	90.0	20	100.0
Group 2	10	50.0	9	45.0	1	5.0	20	100.0
Group 3 + Fitness	10	50.0	2	10.0	8	40.0	20	100.0
Total	21	35.0	12	20.0	27	45.0	60	100.0

The χ^2 contingency test was used to compare differences between groups (Table 17).

This test confirmed the existence of statistically extremely significant differences in general mass change between each two groups.

Table 17. χ^2-test

	χ^2	df	p
Total	33.437	4	0.000
Group 1 - Group 2	28.974	2	0.000
Group 1- Group 3	11.543	2	0.003
Group 2 - Group 3	9.899	2	0.007

The differences in general mass changes between the different groups are even more evident in Chart 2.

This confirms results from some other studies.

Following an adaptation to a long-term intake of creatine monohydrate when combined with training, there is an increase in creatine and phosphocreatine content in musculature, lean body mass, strength, sprint results, driving power, speed of power development, and muscle diameter [9].

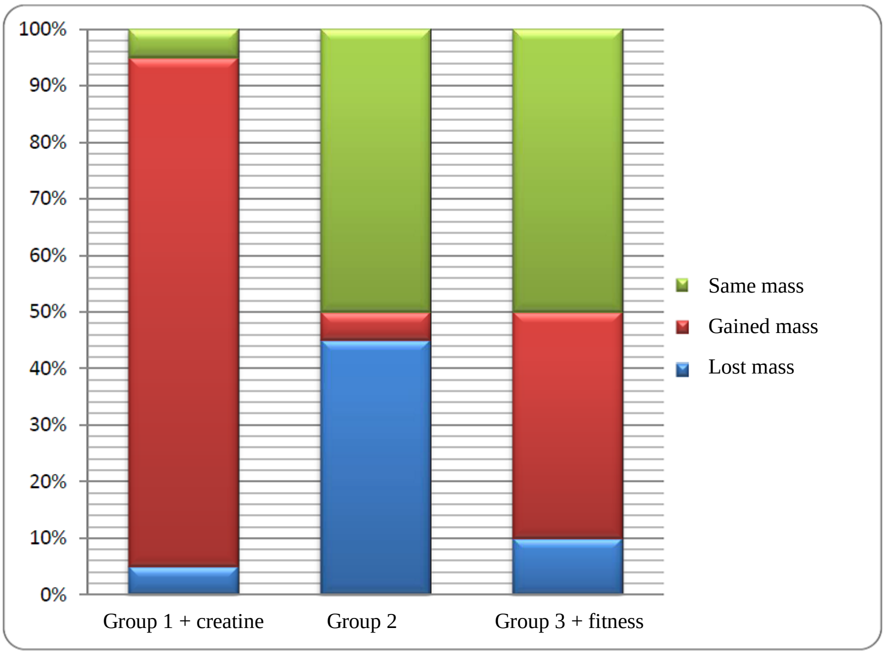

Chart 2 - General changes in mass between two measurements per group

In long-term studies, it was typical that respondents taking creatine monohydrate gained almost twice their body mass and/or lean mass (i.e., additional 2 to 4 pounds of muscle mass during 4 to 12 weeks of training) compared to persons who were taking a placebo. Increased muscle mass appears to have been the result of an improved ability to perform high-intensity exercises via increased available phosphocreatine and enhanced ATP (adenosine triphosphate) synthesis, allowing an athlete to train harder and further increase muscular hypertrophy via an increase in severe myosin heavy chain, probably due to an increase in myogenic regulatory factors of myogenin MRF [10].

4. CONCLUSIONS

The primary objective of the paper was to determine whether creatine intake for three weeks led to a significant increase in swimmer body mass.

Analysing the results of the conducted research and their comparative statistical comparison, we can conclude:

– Masses of the respondents differ statistically significantly in each of the observed groups, as well as in the total sample, at the first and second measurements. Mass was increased in the first and third group after the second measurement;

– Body masses at the first and second measurements are in very strong positive correlation.

– There are no statistically significant differences between different groups in masses of the respondents at the first measurement, as well as in masses of the respondents at the second measurement. In contrast, the differences in masses between the two measurements differ statistically extremely significantly for each two observed groups (the highest mass was gained by the subjects from the first group, and the most mass was lost by the respondents from the second group).

– The $\chi 2$-contingency test confirmed the existence of statistically extremely significant differences in general mass change between each two groups.

The hypothesis H1 (there are statistically significant changes in body mass) is fully confirmed, and the hypothesis two H2 (there are no statistically significant changes in body mass) is rejected.

Based on the above, we can conclude that supplementation with creatine monohydrate at a total dose of 15g daily, for three consecutive weeks at swimmers, leads to an increase in muscle mass and, consequently, an increase in body mass. And that the increase in mass in this group was significantly greater than the increase in the control group, as well as the group that in addition to swimming training had a fitness training.

A large number of studies, which have shown positive results in taking creatine monohydrate as a nutritional supplement, suggest that it is the most effective nutritional supplement available today to increase ability to perform high-intensity exercises and build lean body mass [4, 6, 7, 8. 9,10].

5. LITERATURE

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УТИЦАЈ КРЕТАИН-МОНОХИДРАТА НА ТЈЕЛЕСНУ МАСУ ПЛИВАЧА

Сажетак: Предмет истраживања је утицај креатин-монохидрата на масу пливача. Испитивање је извршено на узорку од 60 пливача чланова Академског пливачког клуба „22. април“ подијељених у двије групе и узраста од 21 до 25 године. Сви испитаници су мушког пола и доброг здравственог стања. Испитаници који припадају овој популацији налазе се у зениту морфолошког и моторичког развоја и добро су мотивисани за напредовање у пливању. Мјерење је извршено крајем маја и половином јуна 2008. године, на објекту Рекреативног центра Српске топлице (температура воде 28 °C). Испитаницима је извршено мјерење тјелесне масе на почетку истраживања и након 21 дан узимања креатина. Основни циљ рада је утврдити да ли узимањем креатина у трајању од три седмице, има значајних разлика у повећању тјелесне масе пливача. Резултати истраживања показују да разлике у тјелесној маси између мјерених имају статистичку значајност.

Кључне ријечи: креатин, додатак исхрани, тјелесна маса, пливање, статистичка анализа.

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