Correlation between the protein and carbohydrate supplement and anthropometric and strength variables in individuals submitted to a resistance training program

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ABSTRACT

The majority of individuals following regular resistance exercise trainings have a major esthetic concern that may be summarized through the increase in the strength and muscular mass under the training associated to the supplement. The purpose of this paper was to verify if the intake of a high protein diet (4 $g.kg^{-1}.d^{-1}$) associated to the training causes a higher increase in the muscular mass and strength compared to the normo protein dietetic pattern. **Methodology:** Sixteen volunteers were divided in two groups according to the supplement pattern: a total of 4 $g.kg^{-1}.d^{-1}$ protein (HP), and carbohydrate (NP) intake following the caloric quantity of the protein supplement (225 $g.d^{-1}$). Both groups were submitted to the resistance training protocol to the biceps and triceps muscles three times a week for 8 weeks. It was analyzed the strength, the muscular mass, the muscular cross section area, the cortisol and the insulin. **Results:** The HP group presented higher protein intake, and the NP group presented higher carbohydrate intake. Both groups also presented a difference in the cortisol values. The NP group presented a positive correlation between the higher carbohydrate intake (%) and the increase in the muscle area, and also between the strength to the overhead triceps, and the increase in the muscular mass and the higher carbohydrate intake. **Conclusion:** It is suggested that the correlation between the carbohydrate intake and the increase in the muscular area and strength to the overhead triceps found in the NP group is related to the favorable metabolic situation to the protein synthesis.

Keywords: Protein supplement. Muscular mass. Muscular cross section area. Strength.

INTRODUCTION

The benefits of practicing regular exercises have been proved by many researchers[1]. As to the specific case of the resistance training, scientific evidences confirm that an adequate training program induces several benefits, such as: improvement in the insulin response to the glycosis overload, in the insulin sensitivity, and a lower chance to develop cardiovascular diseases, among others[2]. Nevertheless, the majority of young adults following regular resistance exercise programs have esthetic concerns that can be summarized by an increase in the strength and muscular mass which are not necessarily restricted to the benefic physiological limits to the health. For this, it is yearly launched in the market several diets and protein supplements aiming to have a synergistic action on the muscular mass gain by means of the resistance training.

Justification

Taking into account the indiscriminate way that individuals use to follow their diets and supplements through an undetermined time[3,4] without any prove that such strategies will have such synergistic action on the muscular mass and strength increase, this paper seeks to verify if the protein supplement associated to the practice of the resistance activity is really effective in increasing the muscular mass compared to individuals receiving the same isocaloric supplement as carbohydrate.

Purpose

To verify if the effects of a hyperprotein diet (4 $g.kg^{-1}.d^{-1}$) associated to a high intensity resistance exercise program causes a major increase in the muscular mass and strength compared to the normo-protein dietetic pattern in carbohydrate-supplemented individuals in the same caloric amount than the group receiving protein.

METHODOLOGY

The project started with sixteen individuals and finished with twelve individuals. All volunteers were students from the School of Physical Education of the São Paulo Military Police in a semi-internship regimen, performing four meals at the school (breakfast, snack, lunch and snack) in order to allow an easy food control. Every volunteer was also performing the same physical activities pertinent to the school program.

The project was approved by the Ethics Committee from the Institute of Biomedical Sciences, and every volunteer signed a Free Clarified Consent term.

Analysis of the diet

The nutritional assessment was performed with the fulfillment of the 3-day food inquiring (2 working days and 1 weekend day) every 15 days along the whole interventional period (8 weeks). The Virtual Nutri software (version 2.5) was used to the food intake calculation.

Supplement

All individuals were randomly divided in two groups: half of the group (n = 8) received a protein supplement (HP), and the other half received a carbohydrate supplement (NP). The amount of the supplemented protein was calculated from the protein intake analysis attained by means of the food records. Each individual received a protein supplement equivalent to 4 $g.kg^{-1}.d^{-1}$ added to the proteins ingested in the diet. The protein supplements used were milk vanilla-flavored serum protein (70%) and powdered slim milk (30%). The carbohydrate used was the maltodextrin. The amount of carbohydrate supplemented (225 $g.d^{-1}$) was calculated by the

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caloric equivalence supplied by the protein supplement, and it was adjusted after four weeks.

The supplements were previously tested and homogenized with water, in order to be flavored through the addition of quite similar aromatizing and sweetening agents, dyes, and powder milk in order to gain flavor, color and smell aiming to make difficult the identification of the sampling to the volunteers. Every bag containing the supplements was identified through numbers (1 to 16). All individuals were instructed to homogenize the supplements with 1,000 ml water and to consume in four portions along the day (in the morning, in the lunch, in the afternoon and at night).

1-MR Test and prescription of the activity

Prior to the test, every individual performed a stretching and warm up: 10 repetitions for every exercise (7 kg bar). All of them performed an average of four tries to attain the maximal load of every exercise (the load was estimated through the Borg Scale[5]. The training consisted of four exercises: arm curl (AC), preacher curl (PC), overhead triceps (OT) and lying down triceps extention (LDTE) performed in five series with eight repetitions, three times a week (1 day interval between trainings). The intervals consisted in 3 minutes between series, and five minutes between exercises.

One week before the beginning of the intervention process, every individual was familiarized to every movement with a 80% load, when it was performed every necessary correction in the movements and posture. The intervention period had a eight week endurance. Every volunteer had a record to the frequency controlling, and they were instructed to not be absent to none of the training sessions (in an amount of 24 sessions). Whenever it would be necessary to be absent for more than one training session, they would be excluded from the project. After four weeks, every load was readjusted (1-MR test). All the training sessions were supervised.

Assessment of the body composition

Cutaneous folds and circumference: a Harpenden compass was used to measure the cutaneous folds, as well as a tape measure to the circumferences. The cutaneous folds assessed were: triceps, biceps, subscapular, suprailiac, supraspinal, abdomen, thigh, and leg. The measurement of the circumferences were performed using a tape measure in the thorax, waist, hips, relaxed and contracted biceps, forearm, thigh, and leg. The measurements were performed three consecutive times each, and the value used was the average of the three measures. Every measurement was performed using the same device and it was made by the same researcher. The protocol used to calculate the density was the Durnin and Womwersley[6], and to calculate the percentage of fat (pre-intervention = % fat1, and post-intervention = % fat 2) and the muscular mass (pre-intervention = Mm1, and post-intervention = Mm2) it was used the Siri equation[7]. Every volunteer was weighted in an electronic scale, and the height was measured in a board stadiometer.

Strength test (isokinetic)

Every volunteer performed a stretching and warm up of the upper limbs. The warm up was composed by three series of fifteen repetitions with thera band, an elastic stripe fastened in a fixed unit in which the participants performed their flexion and extension movements of the both arms' elbows. The strength test in the isokinetic stadiometer was performed in a CYBEX NORM device, having the athlete in supine position with his upper limb stabilized trying to reproduce the extension and flexion movements of the elbow. Five repetitions (60%/sec.) were performed, adapted from Neu[6]. The torque peak (TP) was analyzed to the right and left flexor and extensor muscles.

Cortisol and insulin analysis

It was collected 10 ml of the anticubital vein blood from all individuals after a 12 hours starvation period 8am. The blood was centrifuged and frozen (–10ºC) to the later cortisol and insulin analysis. The serum cortisol and insulin were analyzed through the radio-immuno-assay technique (Coat-A-Count Cortisol kit and insulin kit).

Computed tomography

The image acquisitions were accomplished in a SIEMENS – SOMATION PLUS 4 device, at the Center of Computerized Tomography of the Nove de Julho Hospital, and every analysis was accomplished using the software of the own device. The protocol used to the image acquisition was adapted from MacDougal[9]. Before entering into the room, individuals had their dominant arm marked at the higher circumference spot of the flexed biceps. Next, a tape measure was placed in the distance between the acromion and olecranon bones, and the reference spot was recorded in the tape measure where the pen mark was previously done. That procedure was followed in order to mark the exact cut spot where it would be attained the tomographic images in the two moments, pre- and post-intervention. The images were accomplished having the volunteers in supine position with their arms relaxed aside their bodies, having the palm of their hands up. It was attained two tomographic images through 10 mm with axial cuts at the preciously marked reference spot. The first image attained was used to adjust the field of sight of the biceps muscle, and it was despised and not analyzed. The second image attained was analyzed assisted by the mouse of the device, drawing the circumference of the arm muscles, and applying the value of the muscular density between 30 and 100 hounsfield units (HU) to calculate the area of the muscle in the 10 mm width predefined by Goodpaster *et al.* (1997). The values of the muscular area in the pre- and post-intervention (M1 and M2 areas, respectively) were compared.

The timetable of every test performed is presented on table 1.

TABLE 1
Test timetable

	Period weeks			
	0	**2**	**4**	**8**
3-day food record	x	x	x	x
Body composition	x			x
Dynamometry	x			x
1-MR test	x		x	x
Tomography	x			x
Blood collection	x			x

Statistical analysis

A descriptive analysis was performed presenting the mean and the standard deviations. In order to verify if the sampling had a normal distribution, the Kolmogorov-Smirnov test was performed. To verify if there was any difference between the assessed variables between the HP and NP groups, the t-Student test for independent samplings was used, and to check the difference within each group between the first and second measurements, the paired t-Student test was used. To assess the correlation between variables, it was used the R. Pearson linear correlation coefficient. The significance level adopted was $p < 0.05$. The software used was the SPSS version 10.0.

RESULTS

The descriptive data of that population is found on tables 2, 3, and 4. The strength data are presented on table 5.

TABLE 2
Age, height, and body weight data

	HP		NP	
	Pre	**Post**	**Pre**	**Post**
Age	30.2 ± 1.9		27.5 ± 1.8	
Height (cm)	176 ± 4.4		172.9 ± 6.7	
Weight (kg)	73.3 ± 8.9	72.6 ± 5.0	68.7 ± 5.7	70.4 ± 4.8

TABLE 3
Cortisol, insulin and nutritional assessment data

	HP		NP	
	Pre	**Post**	**Pre**	**Post**
Cortisol (μg/dl)	15.9 ± 6.4	19 ± 5.4*	16.4 ± 2.7	13.1 ± 2*^
Insulin (UI/ml)	2.1 ± 0.7	1.7 ± 0.5	1.8 ± 0.4	2.0 ± 0.5
kcal	3,108 ± 491	3,710 ± 216*	3,193 ± 496	3,767 ± 493*
P (g)	133.5 ± 32.5	296.8 ± 31.3*	127.8 ± 20	129.9 ± 14.4*^
P (%)	17.3 ± 2.8	32.1 ± 3.4*	16.3 ± 2	14 ± 1.3*^
C (g)	362.1 ± 48.6	337.8 ± 48.3*	418.7 ± 81	580.7 ± 72*^
C (%)	47.1 ± 3.2	37.4 ± 3.5*	52.9 ± 9.2	63 ± 2.5*^
L (g)	120.5 ± 25.9	112.4 ± 12.6	104.3 ± 36	100 ± 21.4
L (%)	32.7 ± 5	32.5 ± 3.2	29.5 ± 7.5	29.6 ± 6.3

* p < 0.01 pre- and post-significant difference within the same group; ^ p < 0.01 upon the comparison of both groups; P(g) = protein intake in grams; P(%) = protein intake related to the caloric intake; C(g) = carbohydrate intake in grams; C(%) = carbohydrate intake related to the caloric intake; L(g) = lipid intake in gram; L(%) = lipid intake related to the caloric intake.

TABLE 4
Anthropometric data of the assessed population

	HP		NP	
	Pre	**Post**	**Pre**	**Post**
Mm (kg)	61.2 ± 6.2	61.5 ± 3.3	58.3 ± 4.4	61.4 ± 6.2*
% of fat	16.2 ± 2.3	15.2 ± 2.3*	15.2 ± 3.2	12.7 ± 2.7*
Area M (cm^2)	46.5 ± 11.4	51.7 ± 12.5*	48.1 ± 9.0	54.6 ± 11.7*

* p < 0.05 indicates a significant difference within the same group.
Mm = muscular mass; Area M = muscular cross section; % of fat = percentage of fat.

TABLE 5
Strength variables

	HP		NP	
	Pre	**Post**	**Pre**	**Post**
AC (kg)	36.2 ± 4.9	44.7 ± 5.2*	37.2 ± 4.4	44.1 ± 1.9*
PC (kg)	33.7 ± 7.0	46.8 ± 5.1*	32.2 ± 5.1	47.6 ± 4.3*
LDTE (kg)	37.6 ± 8.6	47.3 ± 9.5*	33.9 ± 7.9	45.1 ± 8.2*
OT (kg)	28.5 ± 6.5	42.3 ± 8.4*	31.6 ± 7.9	43.8 ± 6.5*
TPRFD (N/m)	48.1 ± 8.7	57.8 ± 11.8*	49.9 ± 9.1	58.7 ± 6.2*
TPLF (N/m)	50 ± 7.9	52.4 ± 10.8*	50.5 ± 5.7	52.1 ± 7.9*
TPRE (N/m)	56.6 ± 12.8	61.5 ± 3.3*	54.5 ± 12.8	50.2 ± 10.9*
TPLE (N/m)	61.9 ± 14.6	63.2 ± 15.6*	57 ± 11.0	50 ± 6.5*

* p < 0.05 indicates a significant difference within the same group.
AC = arm curl; PC = preacher curl; LDTE = Lying down triceps extension; OT = overhead triceps; TPRF = torque peak to right flexors; TPLF = torque peak to left flexors; TPRE = torque peak to right extensors; TPLE = torque peak to left extensors.

Figure 1 represents the cortisol variation comparing both groups.

The correlations are represented on table 6. The NP group presented a significant correlation between the increased carbohydrate intake % and the increase in the muscular area (M2 area), r = 0.9; p = 0.001, figure 2. There was no significant correlation to them in the HP group (r = 0.13; p = 0.8). Related to the strength, the NP group presented a positive correlation between the increase in the strength to the overhead triceps (OT) and the increase in the muscular mass (Mm2), r = 0.8; p = 0.01. The HP group did not present a significant correlation between the same variables (r = 0.01; p = 0.8).

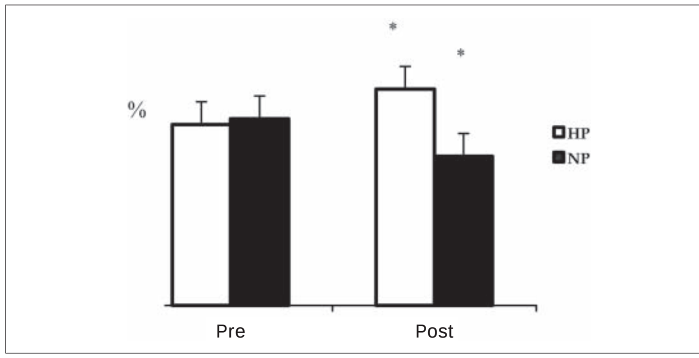

Fig. 1 – *Analysis of the cortisol variation in the pre- and post-comparing the HP and NP groups*

TABLE 6
Correlation between nutritional, anthropometric and strength variables

	r					
	Area M^2		D (%) area M		OT2	
	HP	**NP**	**HP**	**NP**	**HP**	**NP**
C(%)2	–0.5	–0.32	–0.37	–0.2	0.4	**0.85***
D% C(%)	0.13	**0.9***	–0.3	0.58	0.28	0.82
Mm2	0.73	**0.9****	0.37	0.28	0.01	**0.8***

* P = 0.01; ** p = 0.02. The software used was the SPSS (version 10.0).
Area M2 = Muscular cross section area after the intervention; D (%) area M = delta percentual of the muscular cross section area; OT2 = overhead triceps exercise post intervention. C (%)2 = Carbohydrate intake (g); D%C (%) = delta percentual of the consumed carbohydrate (%).

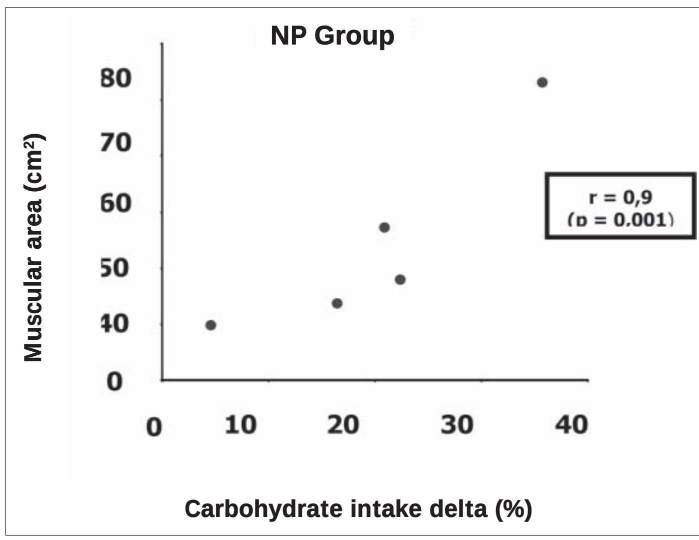

Fig. 2 – *Correlation between the delta of the C intake (%) and the post-intervention muscular cross section area*

The NP group also presented a positive correlation between the increase in the carbohydrate intake (C2%) and the increase in the strength to the overhead triceps (OT) exercise, r = 0.85; p = 0.04, it was observed no significant correlation between both variables in the HP group (r = 0.4; p = 0.3).

There was a positive correlation between the increase in the muscular mass (Mm2) and the increase in the M2 area (r = 0.9; p = 0.02) in the NP group; the HP group did not present a significant correlation between both variables (0.73; p = 0.09).

DISCUSSION

It was verified that the HP group presented a 32.1% intake (4 $g.kg^{-1}.d^{-1}$) of protein, and 37.4% carbohydrate, and the NP group had a 14% intake of protein (1.8 $g.kg^{-1}.d^{-1}$), and 63% carbohydrate. According to Lemon[10], 0.89 $g.kg^{-1}.d^{-1}$ of protein are required to keep a positive nitrogenous balance in sedentary individuals, but for endurance athletes and individuals practicing resistance exercises, such positive balance occurs with a 1.2-1.5 $g.kg^{-1}.d^{-1}$ intake, respectively.

Results attained in the paired t-test show that the supplement and the physical activity were effective within each group in promoting the increase in the mass, in the muscular cross section area and the strength increase after the eight week period.

Tarnopolsky[11] verified that whenever the protein intake in the diet increases from 0.86 to 1.4 $g.kg^{-1}.d^{-1}$, the protein synthesis increases in men submitted to the resistance training, but when the intake is higher than 2.4 $g.kg^{-1}.d^{-1}$, no significant difference was found. Nevertheless, the authors did not use the carbohydrate supplement in order to allow some comparison. It was found no significant differences as to the anthropometric data to the strength variables and to the insulin analysis.

It is important to point out that the collection was performed after a 12 hour of starvation period, and so, it did not represent the acute effect which is provoked right after a training session same as it is done by other authors.

In this paper, it was verified significant differences in the cortisol concentrations, the NP group presented a –18.1% decrease, and the HP group a 33.6% increase. Thyfault[12] verified the acute effect with liquid carbohydrate supplement (1 $g.kg^{-1}.d^{-}1$) before and after the activity) or the placebo supplement associated to the resistance exercise (2-day training). It was analyzed the cortisol, insulin, ammonia, and glycosis concentrations, and it was verified an increase in the insulin concentrations after the exercise and one and a half hour after the activity ended. There was no significant difference to other hormones upon the comparison ob both groups.

According to the correlation analysis, it is believed that the strength increase to the seated triceps extension is directly associated to the increase in the muscular mass and the carbohydrate intake in the HP group. By means of the analysis, it was shown that the NP group presented a higher increase in the muscular cross section area compared to the HP group.

Rozenek[13] submitted two groups to the resistance training (four series of eight repetitions at 70% 1-MR, 10 exercises for eight weeks) and supplement. A group received 356 g of glycosis and 1.7 $g.kg^{-1}.d^{-1}$ of protein (placebo group) in an amount equivalent to a surplus of 2,020 kcal per day. There was no significant difference between both groups. The authors raised the hypothesis that there must be an optimization limit of the consumed protein, and when such limit is surpassed, probably there are no benefits as to the strength and muscular mass gain.

Despite it was not performed certain dosages which could verify the accuracy of this fact, it is believed that the high protein concentration (4 $g.kg^{-1}.d^{-1}$) should provoke an unbalance in the Krebs cycle to the energetic production due to the lack of the carbohydrate substrate, thus increasing the ketonic bodies concentrations, an increase in the cortisol concentrations compromising the protein synthesis. On the other hand, it was verified a decrease in the cortisol concentrations in the NP group followed by a positive correlation between the carbohydrate intake and the increase in the muscular cross section area, suggesting that the carbohydrate supplement (225 $g.d^{-1}$) associated to the 1.8 $g.kg^{-1}.d^{-1}$ protein intake and to the resistance training is favorable to the increase in the protein synthesis. It is believed that the positive correlation between the anthropometric variables and only the carbohydrate intake is a consequence of the increase in the insulin concentrations after the consumption, resulting in a decrease in the chronic cortisol concentrations, promoting a better environment for anabolism.

CONCLUSION

The NP group presented a positive correlation between the carbohydrate intake and the increase in the muscular mass and strength to the seated triceps extension. According to the results presented in this study, carbohydrate supplemented individuals (225 $g.d^{-1}$) associated to the protein intake of 1.8 $g.kg^{-1}.d^{-1}$ when submitted to the resistance training presented a higher increase in the muscular mass compared to individuals submitted to the same supplemented training with 4 $g.kg^{-1}.d^{-1}$. It will be required further studies in order to clarify the role of the protein and the carbohydrate in the promotion of the protein synthesis in resistance exercise practitioners. It is not known for sure the mechanism involving the high protein supplement in the muscular and strength gain process.

All the authors declared there is not any potential conflict of interests regarding this article.

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