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Supplementation prevalence and adverse effects in physical exercise practitioners

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Abstract

Introduction: **The use of nutritional supplements is prevalent among physical exercise practitioners and some adverse effects have been reported, however not sufficiently substantial, because they originate from isolated cases.**

Objectives: **Investigate nutritional supplements consumption prevalence and adverse effects of the use of such products.**

Methods: **An epidemiological, representative and transversal study, with 180 physical exercise practitioners in gyms, who answered questionnaires about sports supplementation, associated factors and self-perceived adverse effects. In a subsample of 86 individuals, blood pressure was measured and blood was collected for the evaluation of lipid profile markers, hepatic and renal function.**

Results: **The supplementation prevalence level was 58.3%, whereas the physicians and nutritionists indicated only 21.9%. The reported adverse effects were observed only by supplement users (acne, insomnia, aggressiveness, headaches and tachycardia). Systolic blood pressure was higher in the supplemented group when compared to the control group ($p = 0.04$), as in the subgroup of thermogenic users ($p < 0.0001$) and among those who had consumed any type of supplementation for over 2 years ($p = 0.005$). Serum creatinine levels were higher only in the subgroup of carbohydrates when compared to the control group ($p = 0.03$). Diastolic blood pressure, lipid profile and hepatic function did not present differences between groups.**

Conclusions: **The use of nutritional supplements without specialized orientation was elevated among physical exercise practitioners, being associated to adverse effects both by the users themselves and by clinical diagnosis.**

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PREVALENCIA DE LA SUPLEMENTACIÓN Y EFECTOS ADVERSOS EN PERSONAS QUE PRACTICAN EJERCICIO FÍSICO

Resumen

Introducción: **El uso de suplementos nutricionales por parte de personas que practican ejercicio físico es frecuente y se han notificado efectos adversos; sin embargo, no son suficientemente sustanciales puesto que proceden de casos aislados.**

Objetivos: **Investigar la prevalencia de consumo de suplementos nutricionales y los efectos adversos del consumo de estos productos.**

Métodos: **Estudio epidemiológico transversal y representativo que incluye 180 personas que practican ejercicio físico en gimnasios y que contestaron encuestas acerca de la suplementación para el deporte, los factores asociados y los efectos adversos auto-percibidos. En una submuestra de 86 individuos, se midió la presión sanguínea y se tomó sangre para una evaluación de los marcadores del perfil lipídico y de las funciones hepática y renal.**

Resultados: **La tasa de prevalencia de suplementación fue del 58,3%, mientras que los médicos y nutricionistas sólo lo indicaron en el 21,9%. Los efectos adversos notificados (acné, insomnio, agresividad, cefaleas y taquicardia) sólo fueron observados por los consumidores de suplementos. La presión sanguínea sistólica fue superior en el grupo con suplementos en comparación del grupo control ($p = 0,04$), al igual que en los consumidores de productos termogénicos ($p < 0,0001$) y en las personas que habían consumido cualquier tipo de producto en los dos años previos ($p = 0,005$). Las concentraciones de creatinina sérica fueron superiores sólo en el subgrupo de personas que consumían hidratos de carbono en comparación con el grupo control ($p = 0,03$). La presión sanguínea diastólica, el perfil lipídico y la función hepática no mostraron diferencias entre los grupos.**

Conclusiones: **El empleo de suplementos nutricionales sin una orientación especializada fue alto entre las personas que practican ejercicio físico, asociándose a efectos adversos manifestados por los propios usuarios como por diagnóstico clínico.**

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Palabras clave: *Suplementos dietéticos. Efectos adversos. Ejercicio.*

Abbreviations

SPB: Systolic Blood Pressure.
DBP: Diastolic Blood Pressure.
GOT: Glutamic-Oxaloacetic Transaminase.
GPT: Glutamic-Pyruvic Transaminase.
GGT: Gamma-Glutamyl Transferase.

Introduction

According to historical records, the human behavior of seeking ergogenic resources to improve physical performance dates back to the Ancient Greece Olympics, in 776 b.C.[1] Substances such as dried figs and strychnine were used as ergogenic resources, obviously without any scientific evidence. Nowadays, despite great scientific advancement, it has been observed indiscriminate use of nutritional supplements as ergogenic resources, still without biological plausibility or scientific evidence of the effectiveness and safety, not only in athletes,[2,3] but also in recreational practitioners of physical exercise.[4,5]

There is a reasonable number of studies on nutritional supplementation prevalence by physical exercise practitioners. Among practitioners of gyms in Brazil, the use of supplementation was observed in 32% of subjects in Rio de Janeiro,[6] 23.9% in São Paulo,[7] 52% in Ribeirão Preto,[8] 61.2% in São Paulo[9] and 36.8% in Belo Horizonte.[10] In the United States, Spain and Lebanon, were found similar numbers to Brazil, with values from 36.3% and 84.7%.[4,5,11] The use of these substances is generally made indiscriminately, without proper orientation from specialized professionals,[10] and with a limited number of studies in animal models or without any grounds for recommendations of usage in humans.[12,13]

Cases have been reported of acute kidney injure and proteinuria from the use of several supplements, including creatine,[14] acute liver dysfunction from the use of herbal supplements,[15-17] acute cholestatic liver injury from the consumption of whey protein and creatine[18] and cardiovascular disorders (elevated blood pressure and heart rate, acute myocardial infarction) from the use of thermogenic supplements.[19] Curiously, all of these adverse effects occurred in subjects who were apparently healthy.

Although such adverse effects are highly relevant, these data are not sufficiently consistent, because they were extracted from case studies. It is not safe to affirm, for instance, that the adverse effect was really a consequence of supplementation or if the individuals presented a predisposition. So being, the data available in literature until the present moment do not allow conclusions about the safety in the usage of the sports supplements commercially available.

Therefore, the aim of this study was to investigate the use of nutritional supplements in a representative sample of a given metropolitan city, evaluating the prevalence of its consumption associated to possible adverse effects.

Methods

Sample: a cross-sectional study was performed with physical exercise practitioners in 15 gyms in João Pessoa- PB, Brazil, a seaside city with 700,000 inhabitants. A cluster sampling was obtained based on the sample calculation with 90% of reliability, 5% of sampling error and a percentage of 80% of gyms goers who make use of nutritional supplements. Based on these criteria, a sample size of 172 subjects would be necessary to constitute a representative sample of the nearly 16.000 physical exercise practitioners, from the 200 gyms registered in the regional council of physical education, located in the five health districts of João Pessoa, PB, Brazil. Three gyms from each health district were randomly selected, and the subjects distributed at random.

The study was developed with 180 subjects, of both genders, older than 18 years of age. From this population, a subsample of 86 individuals was utilized to analyze the potential clinical adverse effects originated from supplement usage.

Ethical aspects: after due consent from the gyms owners, the subjects were invited to participate in the research. All of them signed the term of consent according to Resolution 196/96 of the national health council. The study was previously approved by the human research ethics committee of Lauro Wanderley University Hospital, in the Federal University of Paraíba under number 704/2010.

Research design: an interview was done in order to obtain the data through a questionnaire elaborated by the authors, also approaching the adverse effects self-perceived by the all sample. In the subjects from the subsample, additionally, blood collection and blood pressure measurement were done.

Interview: done by prior appointment, in the gyms, during different moments of the training according to the volunteer's preference to avoid flaws in the register of the collected data. A structured questionnaire was used, contemplating the social profile of the subject, the usage of supplements, the previous usage of anabolic steroids, indication for supplement usage, physical activity practiced and time of practice, adverse effects self-perceived during or after supplement consumption. For such adverse effects, was presented a list containing the effects previously reported in literature (aggressiveness, baldness, change in the tone of voice, acne, insomnia, gynecomastia, tachycardia, renal dysfunction and liver dysfunction).[20] In the "motives for exercise practicing", "supplements consumed", "indication of supplements" and "referred effects" items, the subjects could select more than one option.

Definition of user and classification of the supplements: in order to be considered supplement users the

subjects should have been making use of any type of supplementation for at least four months and not be making use of anabolic steroids in this period. The non-users of supplements or anabolic steroids were considered the control group for comparison purposes concerning the adverse effects of the supplements. In case of previous usage of supplementation, they should not have consumed the product for at least four months.

For the purpose of analyses, the supplements were assorted according to their major compounds, categorized as follows: Amino acids: all containing protein concentrates and isolated amino acids; Carbohydrates: considered those constituting only carbohydrates and not enriched with other substances; Thermogenics: those presenting substances that mimetize catecholamines and Blends: those which contained a mixture of proteins, amino acids, antioxidants, vitamins, minerals and other substances associated.

Clinical evaluation of the adverse effects: in order to evaluate the possible clinical adverse effects originated from the use of supplements, blood biochemical variables (liver function, kidney function and lipid profile) and blood pressure measurements. Eight mililiters of blood were collected from antecubital vein by an experienced, properly trained nurse. The blood was immediately placed into tubes without anticoagulant, and centrifuged at 3,000 RPM for 15 minutes, and then refrigerated at -20º C. After 48 hours, the collected serum was utilized for a biochemical analysis of the Glutamic-Oxaloacetic Transaminase (GOT), Glutamic-Pyruvic Transaminase (GPT), Gamma-Glutamyl Transferase (GGT), creatinine, total cholesterol and cholesterol HDL levels. All the biochemical tests were performed using specific comercial kits from the Labtest brand (Lagoa Santa, MG, Brazil) in a spectrophotometer from the Biospectro brand, model SP-220/Brazil.

Blood pressure was measured after a 10-minute rest and before the volunteers executed any physical activity on that day. The measurement was made following the orientations of the VI Brazilian Guidelines on Hypertension (2010) as for the standardization of preparation, precautions and measurement techniques. An aneroid sphygmomanometer from the Missouri brand (São Paulo, SP, Brazil) was used, being previously calibrated, against a mercury column sphygmomanometer.

Statistical analysis: the data are presented as mean and standard deviation. The analyses of normality were performed using the Kolmogorov-Smirnov test. When normality was not found, the data went through a logarithmic transformation in order to utilize parametric statistics. The T-test for independent samples was utilized to analyze blood pressure benchmarking, levels of GOT, GPT, GGT, creatinine, total cholesterol and cholesterol HDL and to evaluate significative differences between supplement and control groups. The data were analyzed using of the GraphPad InStat 3.0 software (San Diego, CA, USA). Differences were considered statistically significant at $P < 0.05$.

Results

The groups of users and non-users of nutritional supplements presented similar mean age (25 ± 5 years and 26 ± 6 years, respectively). The subjects were predominantly men, being 82% (n = 87) in the supplemented group and 56% (n = 42) in the non-supplemented group. Only 4% among the supplement users and 8% of the non-users had not completed high school, whereas 61% of the supplement users and 53% of the non-users had a university degree of an ongoing major. The most commonly reported motives for exercise practicing were esthetics (61% of supplement users and 8% of non-users) and health (60% of users and 82% of non-users), followed by hypertrophy (38% of users and 31% of non-users), leasure (19% of users and 21% of non-users) and sports performance (11% of users and 10% of non-users).

The prevalence found for the use of at least one type of nutritional supplement was 58.3%. Proteins, carbohydrates, and creatine were the most consumed supplements by the sample of this research. The prevalence of use for each of these supplements, as well as the indication of other less used products is presented in table I. In

Table I
Prevalence of the use of supplements and associated factors

Variables	*General*	*Men*	*Women*
Prevalence of supplementation (%)	58,3 (n = 105)	82,8 (n = 87)	17,1 (n = 18)
Most used supplements (%)			
Proteins	74,3	72,4	83,3
Carbohydrates	31,4	36,8	5,5
Creatine	25,7	26,4	22,2
Thermogenics	18,0	17,2	22,2
Blends	6,7	7,0	5,5
Prohormones	4,8	4,6	5,5
Associated (two or more)	52,4	54,0	44,4
Supplements used isolatedly (%)			
Proteines	27,6	25,3	38,9
Thermogenics	7,6	8,0	5,5
Carbohydrates	3,8	4,6	–
Creatine	1,9	2,3	–
Blends	1,9	2,3	–
Prohormones	–	–	–
Indication for supplement usage (%)			
Friends	41,9	47,1	16,7
Self indication	35,2	34,5	38,9
Physical Educators	27,6	25,3	38,9
Nutricionist	20	18,4	27,8
Others	6,7	8,0	–
Family	2,8	2,3	5,5
Physicians	1,9	2,3	–
Salespeople	1,9	2,3	–

Table II
Adverse effects reported from the use of supplements

Reported effects	*General*	*Supplement group*		*Control group*
		Men	*Women*	
Acne (%)	21,9	21,8	22,2	0
Insomnia (%)	19	19,5	16,7	0
Aggressiveness (%)	16,2	18,4	5,5	0
Headaches (%)	14,3	16	5,5	0
Tachycardia (%)	13,3	14,9	5,5	0
Kidney Dysfunction (%)	6,7	6,9	5,5	0
Hypertension (%)	4,8	5,7	–	0
Gynecomastia (%)	4,8	5,7	–	0
Grown hair (%)	3,8	–	22,2	0
Irregularities in menstrual cycles (%)	3,8	–	22,2	0
Hepatic Dysfunction (%)	2,8	2,3	5,5	0
Reduced breast size (%)	1,9	–	11,1	0
Baldness (%)	0,9	1,1	–	0
Change in voice tone (%)	0,9	–	5,5	0
Sexual impotence (%)	0,9	1,1	–	0

the same table, it is observed that over half of the men and over one third of the women consumed at least two supplements simultaneously. Regarding people who used only one supplement, protein was the most consumed supplement, with 27.6%. After that, prevalence between 1.9 and 7.6% was observed for carbohydrates, creatine, thermogenics, prohormones and blends.

As for the recommendation for the use of supplements, stands out the fact that between 35.2 and 41.9% of the sample supplemented themselves or followed indication from friends, whereas 27.6% were supplemented following indication from physical education instructors. On the other hand, only 20% followed indication from nutritionists and 1.9%, from physicians. Variations between genders are presented in table I.

The self-perceived adverse effects from the use of supplements included acne, insomnia, aggressiveness, headaches and tachycardia, which present values between 13.3 and 21.9% in the analysis considering men and women together, whereas the results sorted by gender can be observed in table II. The subjects who did not utilize supplementation did not refer adverse effects.

The clinical data evaluated are available in table III. When comparing the control group and the supplemented group independently of the supplement used, the time of use and the amount of supplement ingested, it was observed that the systolic blood pressure of the supplemented group was significantly higher than the control group, finding no differences in the diastolic pressure. For the biochemical variables, indicators of lipid profile, liver and kidney functions, no differences were found between the two groups.

When such clinical data were evaluated according to time of supplementation, it was observed a significant

Table III
Clinical adverse effects among supplement users

Variables	*Supplemented group*				*Control*
	General	*Up to 1 year*	*1-2 years*	*Over 2 years*	
SBP (mmHg)	128 ± 18	124 ± 14	123 ± 22	145 ± 20 *	121 ± 13
DBP (mmHg)	82 ± 10	80 ± 10	82 ± 13	86 ± 9	80 ± 11
Total Cholesterol (mg/dl)	164 ± 59	155 ± 62	171 ± 36	178 ± 57	159 ± 70
HDL Colesterol (mg/dl)	39 ± 13	41 ± 14	40 ± 10	37 ± 9	43 ± 15
GOT (U/l)	3 ± 1	3 ± 1	3 ± 1	3 ± 1	3 ± 1
GPT (U/l)	3 ± 1	3 ± 1	3 ± 1	3 ± 2	3 ± 1
GGT (U/l)	336 ± 80	337 ± 63	305 ± 52	377 ± 70	344 ± 57
Creatinine (mg/dl)	1 ± 0	1 ± 0	1 ± 1	1 ± 0	1 ± 0

The data are mean ± standard deviation.
*Difference from the control ($p < 0.05$). The term General represents the data disregarding time of use.

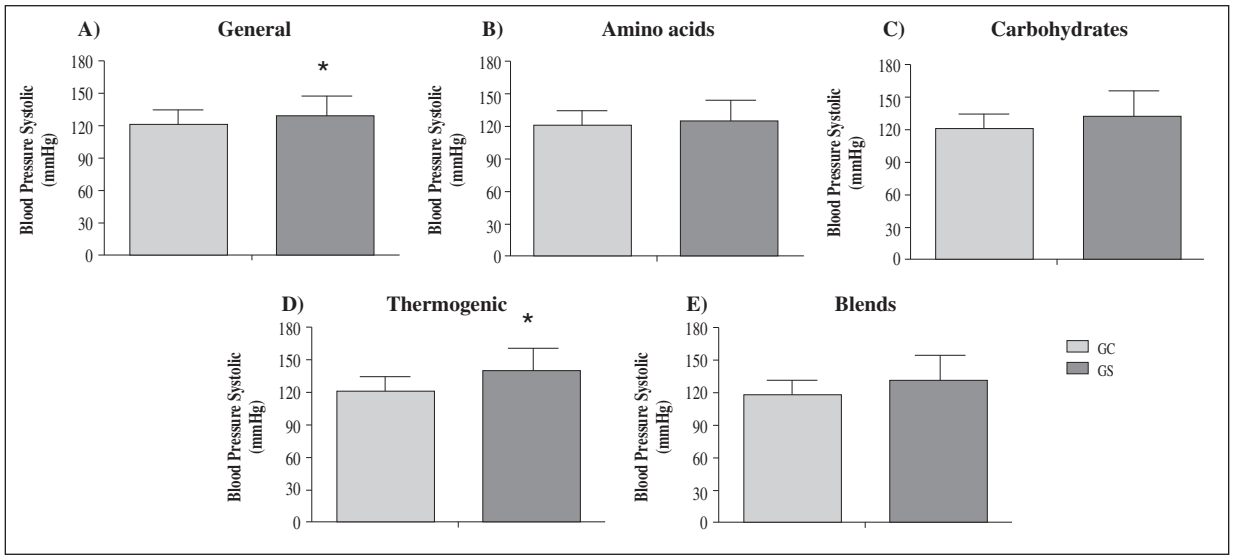

*Fig. 1.—Comparison between the Sistolic Blood Pressure in the control group (GC) and supplemented group (GS) in (A) and subgroups of users of amino acids (B), carbohydrates (C), thermogenics (D) and blends (E). The data are mean and standard deviation. *p < 0.05.*

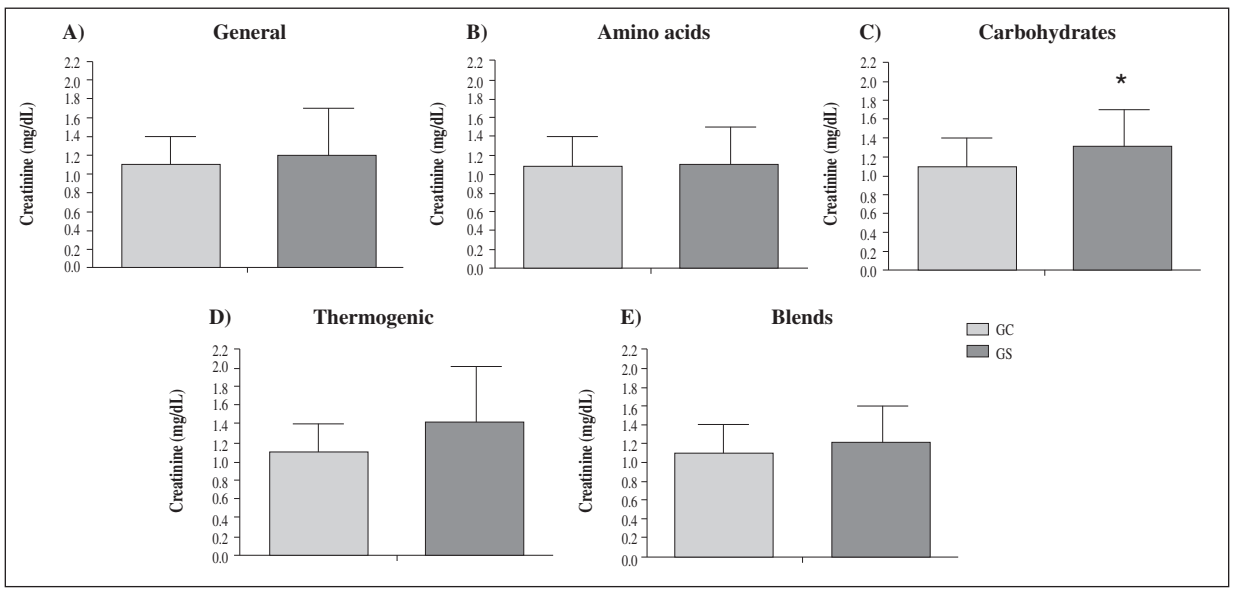

*Fig. 2.—Comparison between creatinine serum concentration in subjects from the control group (GC) and supplemented group (GS) in (A) and subgroups of users of amino acids (B), carbohydrates (C), thermogenics (D) and blends (E). The data are mean and standard deviation. *p < 0.05.*

difference only in the systolic blood pressure (SBP) variable, which presented higher values for those who have made use of supplements for over two years when compared to the control group ($p < 0.0001$).

In the evaluation according to the type of supplementation consumed, the thermogenic users presented higher systolic blood pressure ($p = 0.005$) comparing to the others supplement users and the control group. This analysis is presented in figure 1.

Although no difference was found in the serum creatinine between the supplemented group and the control group, when this variable was analyzed according to the type of supplement, the carbohydrate based supplements users, associated to other supplements or not, presented significantly higher levels of serum creatinine comparing to the control group ($p = 0.03$), as observed in figure 2.

Discussion

This study demonstrated a high prevalence of supplementation (58.3%) among exercise practitioners of the gyms from João Pessoa, PB, Brazil. This prevalence comes along an important phenomenon: health professionals specializing in nutrition are among those

who least frequently prescribe supplements. Supplement users reported some adverse effects which are not referred by a non-user control group. Concomitantly, clinical evaluations pointed to a medium elevation in the systolic blood pressure among supplement users, which was also observed in the subgroup of thermogenic users. Serum creatinine levels were elevated among carbohydrate users, associated to other supplements or not.

Previous studies show lower prevalence rates than those found in our research, with values between 23.9 and 56.1%.[4,7,8,10,11] These studies also had samples that were appropriate for investigations of epidemiological character, with sample populations lower (102 subjects) and higher in number (1,102 subjects) than our research and all the studies were done in gyms, as well as ours.

Higher prevalence was found by Morisson et al.[5] and Hirschbruch et al.[9] (rates of 84.7 and 61.2%, respectively). However, the Morrison et al. study[5] does not possess representativeness, for the convenience sampling was adopted and the study was conducted in only one gym. On the other hand, Hirschbruch et al.[9] used a very embracing criterion for the inclusion of the subjects in the supplemented group, which allowed a larger number of supplement users, given that it considered the use of any supplement at least once in a lifetime. Therefore, these matters may explain the higher prevalence found in these studies when compared to the presented research.

Interestingly, the prevalence of supplementation among men (82.8%) was much higher than among women (17.1%). This could be due to the manner of distribution of the sample between genders, being composed by a majority of men (71.7%) and a minority of women (28.3%). Nevertheless, the number of women does not weaken the data on prevalence for this subgroup. In fact, in some studies,[4,6,11] the sampling sizes varied from 160 to 512, and in the latter the subgroup of women was also smaller and varied from 37.3% to 45%. In these as well as in other studies,[7,9,10] the prevalence of supplementation was also higher among men. However, supplementation studies with university athletes showed a higher consumption of supplements, mainly vitaminic and/or mineral, by women.[21,22]

The most consumed supplements were proteins (74.3%), carbohydrates (31.4%) and creatine (25.7%), respectively. Previous studies corroborate the findings of the presented study, verifying that the most used supplements by physical exercise practitioners are proteins and amino acids,[4,7,8,10,11] which does not corroborate the results found by other study,[9] where sports drinks were reported as the most consumed supplement.

One datum of great concern in terms of health is that the people who have minor technical and scientifical knowledge on sports supplementation are among the ones who most prescribe supplements. This concern is justified by considering that our data corroborate previous literature very strongly. In fact, studies show that self-prescription is a very common practice among supplement users, and among professionals, physical educators are most responsible for the indication of such products,[4,7-9] which points to a necessity for better enlightenment among professional and graduation students of this area.

It is important to look for the reasons why nutritionists are the professional who least prescribe supplementation. A study revealed that 78% of the individuals who utilized sports supplements never received orientation from a nutritionist, whereas 70% of them wish they would have the orientation of a qualified professional.[6] Perhaps the lack of sport specialized nutritionists and presents in gyms explains this counterintuitive displayed by these authors. Another possible explanation is that the nutrition curricula are still poorly adjusted to this new market trend of sports supplementation.[23]

Until the present moment, qualified studies in the sports supplementation area were valuable for being of epidemiological character, and with considerable sampling size. However, all of these studies evaluated prevalence, prescription and aims without considering possible adverse effects from the use of nutritional supplements. In literature, when adverse effects are mentioned, all of the data are prevenient from case studies or only symptoms referred by users. As far as is known, this is the first study of epidemiological character which sought to evaluate the prevalence of adverse effects in the use of supplements both in character referred and in clinical character.

Adverse effects found in case studies were cardiovascular[19,24] and brainvascular[25] events kidney and liver overload,[14,16,18] dermatological changes,[26] hormonal and psychological disorders.[27,28] However, effects such as kidney and liver dysfunctions, decrease in sexual performance, sicknesses, irritation, acne and insomnia have been previously reported,[6] although the percentage of these effects has not been quantified. Besides, one of the studies found increased somnolence in only 17% of supplement users, but this symptom was not associated to a specific supplement.[29]

Insomnia, aggressiveness, acne and tachycardia were the most reported adverse effects in our research. Insomnia and tachycardia are particular of those who make use of thermogenics, according to case studies,[24,30] whereas acne and aggressiveness are more commonly associated to the use of anabolic steroids.[31,32] Although we ruled anabolic steroid users out of our study, it must be pointed out that there are data in literature indicating that about 14.8 to 25.8% of supplements are contaminated with these substances,[33,34] which may justify the adverse effects reported by the subjects in this study.

As for the clinical adverse effects, in the presented study, variables such as blood pressure, lipid profile, liver and kidney function were evaluated. The systolic component of blood pressure was the most adversely modified clinical change among supplement users.

Differences in blood pressure were not observed in the stratifications by amino acids, carbohydrates and blends users, but remained among thermogenic users.

This phenomenon can be explained by the fact that thermogenic supplements contain adrenergic analogs that may induce an increase in the activation of the sympathetic nervous system, thus influencing the hemodynamic responses.[35,36] In fact, studies show that the consumption of ephedrine based and/or sympathomimetic based supplements leads to in elevation in heart rate and blood pressure,[37,38] as well as changes in the central nervous system.[25,30] Besides, the use of these supplements is associated to more damaging cardiovascular events, as myocardial infarction[24,38] and coronary thrombosis.[19] As well as in our study, interventions performed in ten healthy young adults showed higher mean values for systolic blood pressure without significant changes in the diastolic component by the use of thermogenic supplements.[36,39] However, no significant changes were found in pressure values after thermogenic supplement consumption by apparently healthy young adults.[35,40]

Supplement usage has also been associated to adverse effects on liver and kidney functions of the individuals. The development of acute kidney dysfunction, acute liver dysfunction, cholestasis with ductular proliferation and jaundice have been demonstrated, through case studies, after the simultaneous use of several supplements.[14,18,41,42]

In the presented study, serum creatinine was also elevated, but only in the subgroup of individuals who used carbohydrate based supplements. This would be expected among amino acid users, according to previous literature.[14,28,43] This phenomenon can be attributed to a greater frequency and carbohydrate amount used amond supplement users.[44,45]

Finally, the time of supplement usage could be a triggering factor for adverse effects. In fact, studies reveal that the use of elevated doses of creatine for a long period of time could cause kidney disfunction and hepatotoxicity.[28,46] However, our study showed a elevation only in blood pressure, with no injure to kidney and liver functions due to the time of use of amino acids, known for exercising an overload in the renal system activity.[14]

Conclusions

The rate of sports supplements consumption without specialized orientation is elevated among physical exercise practitioners in gyms, being associated to adverse effects perceived both by the users themselves, and by diagnoses from clinical tests. Such adverse effects were found from a representative sample of a population of physical exercise practitioners, a fact that reinforces previous reports in the literature of adverse effects in isolated groups or case reports. So, the presented study can be utilized as subsidy for regulatory agencies to guide their positions related to prescription, commercialization and administration of supplements for physical activity practitioners.

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