Вестник Новосибирского государственного педагогического университета

2017, том 7, № 1 www.vestnik.nspu.ru ISSN 2226-3365

DOI: 10.15293/2226-3365.1701.14

УДК 612

ВЛИЯНИЕ ПИЩЕВЫХ ДОБАВОК ARGI+ И MULTI MACA НА ОРГАНИЗМ СПОРТСМЕНОВ

К. Милашюс (Вильнюс, Литва)

Проблема и цель. *Цель работы – исследовать влияние пищевой добавки аминокислоты аргинин (ARGI+) и ее смеси с корнем растения Маса (Lepidium meyenii) на физическую подготовленность и функциональные возможности спортсменов при выполнении физических нагрузок различной продолжительности.*

Методы. *В исследовании приняли участие 36 студентов по специальности физическая культура, активно занимающиеся различными видами спорта, которые методом случайного отбора были распределены на три группы: экспериментальные ($Э_1$ и $Э_2$) и контрольную (К). Исследуемые группы $Э_1$ (n = 12) 20 дней потребляли пищевую добавку ARGI+, по 10 г в день, а исследуемые группы $Э_2$ (n = 12) в течение этого же времени потребляли пищевую добавку, состоящую из смеси ARGI+ по 10 г и двух капсул Multi Maca. Исследуемые контрольной группы (n = 12) никаких пищевых добавок не употребляли.*

Спортсмены обследовались до начала потребления пищевых добавок (тестирование I) и через 20 дней, сразу после завершения приема пищевых добавок (тестирование II).

Результаты. *Наши исследования показали, что потребление пищевой добавки ARGI+ оказало положительное влияние на мощность мышц при выполнении кратковременной физической нагрузки. За экспериментальный период достоверно повысилась мощность одноразового сокращения мышц (МОСМ) и анаэробная алактатная мощность мышц (ААММ). У представителей группы $Э_2$ эти же показатели повысились меньше. У членов обеих экспериментальных групп абсолютная и относительная мощность мышц при выполнении нагрузки продолжительностью 10 с увеличилась статистически достоверно по сравнению с изменением этих же показателей в контрольной группе.*

Заключение. *Результаты нашего исследования показывают, что функциональные возможности системы крови и показатель аэробных возможностей (VO_2max) больше повысились у представителей группы $Э_2$, которые потребляли комплекс пищевых добавок ARGI+ и Multi Maca.*

Ключевые слова: *спортсмены, пищевые добавки, аргинин, Мульти мака, анаэробная алактатная мощность мышц, аэробные возможности.*

Милашюс Казис – профессор, хабилитированный доктор биологических наук, заведующий кафедрой методики спорта, Литовский педагогический университет, Вильнюс, Литва.
E-mail: kazys.milasius@leu.lt

СПИСОК ЛИТЕРАТУРЫ

1. **Jeukendrup A., Gleeson M.** Sport Nutrition. An introduction to energy production and performance. – Champaign, IL: Human Kinetics, 2010. – 473 p.
2. **Hernandez B., Leon J.** Neglected crops: 1492 from a different perspective. – Rome: Food acid Agriculture Organization (FAO) of the United Nations (UN), 1994. – p. 343.
3. **Zuniga L., Flores D.** Maca (monograph) // Latin Pharma. Lima, Peru, 2003. – P. 8–11.
4. **Omran S., Ashton J., Stathopoulos C.** Effect of Maca (*Lepidium meyenii)* on some physical characteristics of cereal and root starches // International Food Research Journal. – 2010. – Vol. 17. – P. 1085–1094.
5. **Gonzales G., Cordova A., Vega K., Chung A., Villena A., Gonez C., Castillo S.** Effect of *Lepidium meyenii* (Maca) on sexual desire and its absent relationship with serum testosterone levels in adult healthy men // Andrology. – 2002. – Vol. 34. – P. 367–372. DOI: http://dx.doi.org/10.1046/j.1439-0272.2002.00519.x
6. **Gonzales G., Cordova A., Vega K., Chung A., Villena A., Gonez C.** Effect of *Lepidium meyenii* (Maca), a root with aphrodisiac and fertility-enhancing properties, on serum reproductive hormone levels in adult healthy men // Journal of Endocrinology. – 2003. – Vol. 176, № 1. – P. 163–168. DOI: http://dx.doi.org/10.1677/joe.0.1760163
7. **Stone M., Ibarra A., Roller M., Zangara A., Stevenson E.** A pilot investigation into the effect of Maca supplementation on physical activity and sexual desire in sportsmen // Journal of Ethnopharmacology. – 2009. – Vol. 126, № 3. – P. 574–576. DOI: http://dx.doi.org/10.1016/j.jep.2009.09.012
8. **Zenico T., Cicero A., Valmorri L., Mercuriali M., Bercovich E.** Subjective effects of *Lepidium meyenii* (Maca**)** extract on well-being and sexual performances in patients with mild erectile dysfunction: a randomized, double-blind clinical trial // Andrologia. – 2009. – Vol. 41, Is. 2. – P. 95–99. DOI: http://dx.doi.org/10.1111/j.1439-0272.2008.00892.x
9. **Gonzales G.** Ethnobiology and ethnopharmacology of Lepidium meyenii (Maca), a plant from the Peruvian highlands // Evidence-Based Complementary and Alternative Medicine. – 2012. – Vol. 2012. – Article ID 193496. – 10 p. DOI: http://dx.doi.org/10.1155/2012/193496
10. **Gonzales G.** "Biological effects of *Lepidium meyenii*, maca, a plant from the highlands of Peru," in Natural Products, Eds V. K. Singh R. Bhardwaj J. N. Govil and R. K. Sharma // Recent Progress in Medicinal Plants. – 2006. – Vol. 15. – P. 209–234.
11. **Milašius K., Dadelienė R., Pečiukonienė M., Skernevičius J.** Effects of Maca booster food supplement on athletes' bodily adaptation to physical loads // Ugdymas. Kūno kultūra. Sportas. – 2008. – Vol. 4 (71). – P. 69–75 (In Lithuanian).
12. **Milašius K., Pečiukonienė M., Dadelienė R.** The impact of food supplement Black Devil on athletes' organism's adaptation to physical loads // Sporto mokslas. – 2010. – Vol. 1 (59). – P. 51–57. (In Lithuanian).
13. **Imanipour V., Naderi A., Mahdi F., Sadeghi M., Shahedi V.** The effects of supplementary L-arginine dietary on metabolism and performance in anaerobic exercise // Journal of Basic and Applied Scientific Research. – 2012. – Vol. 2 № (1). – P. 759–762.
14. **Cynober L.** Can argnine and ornithine support gut functions? // Gut. – 1994. – Vol. 35. – P. 42–45.
15. **Elam R., Hardin D., Sutton R. et al.** Effects of argnine and ornithine on strength, lean body mass and urinary hydroxyproline in adult males // Journal of Sports Medicine. – 1989. – Vol. 29. – P. 52–56.
16. **Lambert M. I., Hefer J. A., Millar R. P. et al.** Failure of commercial amino acid supplements to increase serum growth hormone concentrations in male body-builders // International Journal of Sport Nutrition. – 1993. – Vol. 3. – P. 298–305.

17. **Burtscher M., Brunner F., Faulhaber M., Hotter B., Likar R.** The prolonged intake of L -arginine-l-aspartate reduces blood lactate accumulation and oxygen consumption during submaximal exercise // Journal of Sports Science and Medicine. – 2005. – Vol. 4. – P. 314–322.
18. **Muazzezzaneh A., Keshavarz S., Sabour Yaraghi A., Djalali M., Rahimi A.** Effect of L-arginine supplementation on blood lactate level and VO_{2max} at anaerobic threshold performance // Feyz Journal of Kashan University of Medical Sciences. – 2010. – Vol. 14, № 3. – P. 24–32.
19. **Álvares T., Meirelles C., Bhambhani Y., Paschoalin V., Gomes P.** L-arginine as a potential ergogenic aid in healthy subjects // Sports Medicine. – 2011. – Vol. 41, № 3. – P. 233–248. DOI: http://dx.doi.org/10.2165/11538590-000000000-00000
20. **Bescós R., Gonzalez-Haro C., Pujol P., Drobnic F., Alonso E., Santolaria M., Ruiz O., Esteve M., Galilea P.** Effects of dietary L-arginine intake on cardiorespiratory and metabolic adaptation in athletes // International Journal of Sport Nutrition & Exercise Metabolism. – 2009. – Vol. 19, № 4. – P. 355–365.
21. **Knechtle B., Bosch A.** The influence of arginine supplementation on performance and metabolism in athletes // International Journal of Sports Medicine. – 2008. – Vol. 9, № 1. – P. 22–31.
22. **Bosco C., Luchtanen P., Komi P.** A simple method for measurement of mechanical power in jumping // European Journal of Applied Physiology. – 1983. – Vol. 50. – P. 273–282.
23. **Margaria R., Aghemo P., Roveli E.** Measurement of muscular power (anaerobic) in man // Journal of Applied Physiology. – 1966. – Vol. 21. – P. 1662–1664.
24. **Kalamen J.** Measurement of maximum muscle power in man. – Columbus: Ohio State University, 1968.
25. **Skernevičius J., Raslanas A., Dadelienė R.** The methodology of sport science. – Vilnius: LSIC, 2004. – 222 p. (In Lithuanian).
26. **Gonestas E., Strielčiūnas R.** Applied statistics. – Kaunas: LKKA, 2003. – 302 p. (In Lithuanian).
27. **Colombani P., Bitzi R., Frey-Rindova P., Frey W., Arnold M., Langhans W., Wenk C.** Chronic arginine aspartate supplementation in runners reduces total plasma amino acid level at rest and during a marathon run // European Journal of Nutrition. – 1999. – Vol. 38, № 6. – P. 263–270.
28. **Abel T., Knechtle B., Perret C., Eser P., von Arx P., Knecht H.** Influence of chronic supplementation of arginine aspartate in endurance athletes on performance and substrate metabolism. A randomized, double-blind, placebo-controlled study // International Journal of Sports Medicine. – 2005. – Vol. 26. – P. 344–349.
29. **Bailey S., Winyard P., Vanhatalo A., Blackwell J., DiMenna F., Wilkerson D., Jones A.** Acute L-arginine supplementation reduces O_2 cost of moderate intensity exercise and enhances high-intensity exercise tolerance // Journal of Applied Physiology. – 2010. – Vol. 109, № 5. – P. 1394–1403. DOI: http://dx.doi.org/10.1152/japplphysiol.00503.2010
30. **Fahs C., Heffernan K., Fernhall B.** Hemodynamic and vascular response to resistance exercise with L-arginine // Medicine and Science in Sports and Exercise. – 2009. – Vol. 41, № 4. – P. 773–779. DOI: https://dx.doi.org/10.1249/MSS.0b013e3181909d9d
31. **Forbes S., Harber V., Bell G.** Oral L-arginine before resistance exercise blunts growth hormone in strength trained males // International Journal of Sport Nutrition and Exercise Metabolism. – 2014. – Vol. 24, № 2. – P. 236–244. DOI: https://dx.doi.org/10.1123/ijsnem.2013-0106
32. **Yang Q., Jin W. Lv X.** Effects of macamides on endurance capacity and anti-fatigue property in prolonged swimming mice // Pharmaceutical Biology. – 2016. – Vol. 54, № 5. – P. 827–834. DOI: https://dx.doi.org/10.3109/13880209.2015.1087036
33. **Chen J., Zhao Q., Wang L. et al.** Physicochemical and functional properties of dietary fiber from maca (Lepidium meyenii Walp.) liquor residue // Carbohydrate Polymers. – 2015. – Vol. 132. – P. 509–512. DOI: https://dx.doi.org/10.1016/j.carbpol.2015.06.079

Novosibirsk State Pedagogical University Bulletin

2017, Vol. 7, No. 1 http://en.vestnik.nspu.ru ISSN 2226-3365

DOI: 10.15293/2226-3365.1701.14

Kazys Milašius, Professor, Habilitated Doctor of Biomedical Sciences,
Head of Department of Sport Teaching Methods, Lithuanian University of Educational Sciences, Vilnius, Lithuania.
ORCID ID: http://orcid.org/0000-0002-1109-7421
E-mail: kazys.milasius@leu.lt

EFFECT OF ARGI+ AND MULTI MACA FOOD SUPPLEMENTS ON SPORTSMEN'S PHYSICAL AND FUNCTIONAL CAPACITY

Abstract

Introduction. *The aim of the present study is to determine the effect of food supplement ARGI+ and ARGI+ in combination with Multi Maca on physical and functional capacity of athletes to work in various energy production zones.*

Materials and Methods. *Thirty-six apparently healthy, injury-free in, at least, one season and physically active men volunteered and were randomly divided into three groups, as well as participated in the double-blind study. There were no significant differences between groups for any of physical development variables, indicating homogeneity between groups.*

First group E_1 subjects (n = 12) took the supplement ARGI+ 10g/day for 20 days. Second group E_2 subjects (n = 12) took the supplement ARGI+ 10g/day and Multi Maca 2 tablets/day for 20 days. Third group K subjects consumed lactose as a placebo (PL) daily. Subjects performed the first testing session T1 one day before the intake of dietary supplements for a period of twenty days. One day after the second testing session T2 performed.

Results. *Therefore, based on our collective data, we conclude that 20 days use of ARGI+ and ARGI+ in combination with Multi Maca supplementation has influence on athletes' physical capacity in short-term exercise. Results of our study demonstrate significant increases of single muscle capacity power and anaerobic alactic muscle power in group E1 subjects, who took the supplement ARGI+ 10g/day. These data of the second group E2 subjects, who took the supplement ARGI+ 10g/day and Multi Maca 2 tablets/day for twenty days period increased less. Absolute and relative maximal moment muscle capacity, using 10 s maximal effort ergometry works in both experimental groups increased.*

Conclusions. *Supplementation of ARGI+ in combination with Multi Maca for a period of twenty days more effectively influenced cardiovascular system capacity and aerobic capacity than supplementation ARGI+.*

Keywords

Sportsmen; food supplements; arginine; Multi Maca; anaerobic alactatic muscle power; aerobic capacity.

Introduction

Preparing high-performance athletes it is very important to have scientifically based recommendation about consumption possibilities of concrete nutrition and food supplement considering sportsmen's age, gender, sportsmanship and sports specifies [1]. Therefore, natural food supplements from plants are becoming more and more popular in sports practice. One of these is a food supplement made of root of plant Maca (*Lepidium meyenii)* which is cultivated in the Peruvian central highlands. It is classified as one of the cleanest and environmentally safe products of

natural origin and is a staple food for the local population. They use it for recovery and wellness [2–4]. Maca, like ginger, is a powerful adaptogene, which improves the body ability to adapt to complicated and stressful situations. Scientific studies have shown that Maca improves memory and neurotransmitter function, increases the amount of oxygen in the blood and enhances libido [5–8]. Maca alkaloids positively effect hypothalamus and adrenal glands, and this provides energy, and increases vitality [7; 9]. Recently, Maca has become more popular among athletes. It is a great source of energy [10]. Our earlier studies [11–12] show that a dietary supplement Maca booster, containing only Maca powder, has a positive impact on athletes' muscle power capacities in different energy production zones. It increases a single muscle, anaerobic alactic muscle and anaerobic alactic glycolytic muscle power, as well as aerobic capacity. Lately the production of food supplements which contain more active ingredients has been started. One of these supplements is Multi Maca.

Another important component of the nutrient of athletes is the amino acid – arginine. Arginine exists in the body as a free amino acid, constituent of most proteins and as a precursor to several non-proteins such as nitrogen compounds. This amino acid also functions as an intermediate mediator in urea formation cycle in the production of adenosine tri-phosphate, cell proliferation, vascular dilation, neural transmission, calcium release and the immune system: Imanipour et al. (2012) [13]. Arginine is essential for human growth, as it stimulates growth hormone and insulin secretion of anabolic [14]. Moreover, it effects muscles mass and strength, enhance body immunity system and promote healing after injuries [15]. It is an important nutritional component in heart and vascular system disorders.

While exerting and using Arginine, the body forms and accumulates less urea. The claim that L-arginine supplementation supposedly modulates nitric oxide (NO) production and consequently increases blood perfusion to the tissues is of great interest to those who participate in aerobic- and resistance-type exercise. Therefore, Arginine has become one of the most popular ergogenic supplements for endurance and resistance athletes, and especially for body builders [16].

M. Burtscher et al. (2005) [17], A. Muazzezzaneh et al. (2010) [18] studies present that long-lasting L-arginine intake increases fat oxidation and, at the some time, decreases blood lactate level, and heart rate, as well as and increases pulmonary ventilation and oxygen consumption during maximum intensity exercise. It allows to increase the maximum work capacity and it is easier tolerated. However, A. Muazzezzaneh et al. (2010) [18] found that L-arginine had no influence on VO_2 max at anaerobic threshold. V. Imanipour et al. [13] (2012) notes, that consumption of L-arginine supplements reduces the amount of ammonium, and that is why alienates fatigue. T. Alvares et al. (2011) [19] concludes, that the intake of L-arginine improves the blood flow, so the muscles are better supplied with the necessary substances. Moreover it also promotes greater removal of metabolities, such as lactate and ammonia Study data showed, that L-arginine intake improves metabolic process, stimulates muscles cells and inhibits fat cells proliferation, which increases muscle mass, improves muscular recovery and decreases fat mass.

Most studies have focused on the effect of L-arginine supplementation on physical performance and blood lactate level. However, the obtained results are contradictory. R. Bescos et al. (2009) [20] did not find this supplement to have beneficial effect on the cardiovascular system and data of changing of metabolic adaptation. Likewise, B. Knechtle, A. Bosch (2008) [21] did not find the effect of Arginine Aspartate to athletes' capacity and metabolic changes.

Although the effect of these food supplements on human body has been extensively researched, there is not enough evidence to prove the effect of each supplement to athletes' body. There is always pressure for optimal performance, especially on the world stage. Providing insight into this line of research may provide an opportunity for athletes to implement a new nutritional strategy that improves their performance.

We hypothesed that the amino acid Arginine powder ARGI+ and vegetarian dietary supplement Maca with ARGI+ consumption will improve the athletes' physical and functional abilities.

The aim of the present study is to determine the effect of food supplement ARGI+ and ARGI+ in combination with Multi Maca on physical and functional capacity of athletes to work in various energy production zones.

Methods

Thirty-six apparently healthy, injury-free in, at least, one season and physically active men volunteered and were randomly divided into three groups (Table 1), as well as participated in the double-blind study. There were no significant differences between groups for any of physical development variables, indicating homogeneity between groups.

Table 1

Physical development participants of study (X ± SD)

Groups	Body mass, kg	BMI, kg/m^2	Muscle mass, kg	Fat mass, kg
E_1	76,44 ± 8,37	23,02 ± 1,59	41,86 ± 5,17	8,42 ± 1,77
E_2	76,76 ± 8,84	23,25 ± 2,67	41,75 ± 4,89	8,49 ± 2,54
K	80,18 ± 9,02	23,79 ± 2,50	45,68 ± 4,70	9,23 ± 2,70

First group E_1 subjects (n = 12) took the supplement ARGI+ 10g/day in the morning for 20 days. Second group E_2 subjects (n = 12) took the supplement ARGI+ 10g/day and Multi Maca 2 tablets/day in the morning and in the afternoon for 20 days. Third group K subjects consumed lactose as a placebo (PL) daily for 20 days. To get more objective evidence about the supplement effect, participants were instructed not to change their normal dietary intake and their habitual physical activity during the course of the study. Subjects had 2 hours of training a day. All participants had to sing a written informative consent and were cleared for participation by passing a mandatory medical screening. They were familiarized with the testing protocol before data collection. All experimental procedures, involved in the study, were conformed by Lithuanian Ethical Committee.

One dose of 10g ARGI+ contains 5gr of L-arginin, 80 mg of vitamin C, 5 μg of vitamin D_3, 75 μg of vitamin K_2, 1,4 mg of vitamin B_6, 2,5 μg of vitamin B_{12}, 200 μg of folic acid. The rest part is grape skin, pomegranate and red grape extract; black currant juice, elderberry juice, raspberry juice, Morello cherry juice, blackberry juice and blueberry juice powder.

In two tablets per serving, Multi Maca contains: 500 mg of Maca (root), 200 mg of Tribulus terrestris (fruit), 200 mg of Muira Puama (root), 200 mg of Catuaba (bark), 150 mg of L-Arginine, 150 mg of Saw Palmetto (fruit), 50 mg of Pygeum africanum (bark), 10 mg of Co Enzyme Q-10 and 10 mg of Soy extract,

Subjects performed the first testing session (T1) one day before the intake of ARGI+ and

ARGI+ in combination with Multi Maca for a period of twenty days. One day after the second testing session (T2) performed. Testing was performed between 11 a.m. and 2 p.m. and at the same time of day, as T1 for each participant in the same location. It can be noted, that the procedures involved for T1 and T2 were identical.

After 20 days of supplementation, in the second testing session, participants reported in the questionnaire, whether they had tolerated the supplement and reported any medical problems or symptoms they might have encountered.

Single muscle capacity power (SMCP) was measured using jumping platform BSM-1. The jump height and take-of time were recorded. The obtained data were calculated applying Bosco et al. (1983) [22] method.

Anaerobic alactic muscle power (AAMP) was measured using step ergometry. The running speed and the height of rise there were recorded according Margaria et al. (1966) [23] modified Kalamen (1968) [24] test. Anaerobic alactic muscle power was also measured using 10 s maximal effort ergometry work.

For evaluation of aerobic capacity, submaximal ergometry test using gas analyzer Oxycon Mobile (Germany).

Resting heart rate (beats/min) was assessed in supine position with Polar FS1 (Finland), after standard physical load and after 60s recovery period. The Roufier index was also calculated [25].

Haemoglobin concentretion (HB) (g/l) was collected with analyzer HEMOCUE, taking blood from finger. To determine haematocrit (HCT) in percentage minifotometre MF5020 was used.

Data were analyzed by methods of mathematical statistics. The arithmetical mean ($\bar{X}$), Standard deviation (SD) were calculated. Student's criterion was applied to determine differences between groups and testing sessions ($p \leq 0,05$) [26].

Results

All 36 participants, who had begun the study, finished it successfully. Overall participant compliance with supplement ingestion was 100 %. In addition, none of the participants reported any negative side effects associated with ingesting either of the supplements.

Results of our study demonstrate significant increases of single muscle capacity power in group E_1 subjects, who took the supplement ARGI+ 10g/day. They showed the shorter time of jump take-of time on average from 196,3 to 180,3 ms, and relative single muscle capacity power increased on average from 24,6 ± 3,5 to 27,5 ± 3,8 W/kg ($p = 0,043$). These data of the second group E_2 subjects, who took the supplement ARGI+ 10g/day and Multi Maca 2 tablets/day for twenty days period, did not have significant changes statistically (Table 2).

Within 20 days of study period relevant anaerobic alactic muscle power, which was measured using step ergometry, significantly increased in group E_1 subjects from 16,2 ± 0,6 to 16,8 ± 0,9 W/kg, ($p = 0,041$), but had no significant changes in group E_2 subjects ($p = 0,419$).

From the 10 s maximal effort ergometer test at T1 and T2 changes were observed in absolute and relative maximal moment muscle capacity. Athletes achieved maximal moment muscle capacity at 4-5s of using 10 s maximal effort ergometry works. Absolute maximal moment muscle capacity of subjects, who took the supplement ARGI+, increased in average 96,64 W ($p = 0,048$), and relate maximal moment muscle capacity increased in average 1,1 W/kg ($p = 0,042$). The data of subjects who took the supplement ARGI+ in combination with Multi Maca, increased to 28,2 W and 0,1 W/kg ($p = 0,379$, $p = 0,313$). In the placebo group the data did not increase. Changes in 10 s maximal effort average absolute and relate data

during 20 days of study period of group E_1 and E_2 subjects are similar (Table 2).

Table 2

Changes of muscle power and oxygen consumption before (T1) after (T2) 20 days of intake ARGI+ and ARGI+ in combination with Multi Maca or plascebo

Groups	Variable	SMCP, W/kg	AAMP, W/kg	10 s work capacity, W				VO_{2max}	
				Max, W	W/kg	Average, W	W/kg	l/min	ml/kg/min
1st testing									
E_1	**X**	24,6	16,2	1 355,.5	17,7	944,5	12,3	3,44	45,2
	SD	3,5	0,6	280,7	2,1	196,8	1,4	0,66	7,5
E_2	**X**	26,0	17,0	1 431,4	18,7	1 000,1	13,0	3,85	51,0
	SD	2,4	0,8	199,1	1,8	151,8	0,8	0,57	10,2
K	**X**	24,5	15,4	1 367,3	16,8	954,6	11,8	3,21	40,2
	SD	5,1	1,3	206,7	2,1	131,5	1,1	0,78	10,3
2nd testing									
E_1	**X**	27,5	16,8	1 452,1	18,8	960,6	12,4	3,70	48,5
	SD	3,8	0,9	314,4	2,6	197,5	1,7	0,50	6,4
E_2	**X**	25,6	16,9	1 459,6	19,1	1 029,5	13,4	4,14	55,4
	SD	2,6	1,4	223,3	1,4	164,3	0,9	0,59	11,5
K	**X**	24,4	15,4	1 370,9	16,8	951,2	11,6	3,40	42,6
	SD	4,6	1,4	208,2	2,1	123,5	0,9	0,65	8,8
Reliability of diferencines p									
E_1 I-II		**0,043**	**0,041**	**0,048**	**0,042**	0,425	0,460	0,153	0,140
E_2 I-II		0,348	0,419	0,379	0,313	0,334	0,142	**0,047**	**0,048**
E_1-K 2nd testing		**0,049**	**0,005**	**0,05**	**0,047**	0,892	0,167	**0,041**	**0,038**
E_2-K 2nd testing		0,497	**0,012**	**0,047**	**0,006**	0,208	**0,001**	**0,024**	**0,011**

Note: * – $p < 0,05$.

The research, based on our data obtained, showed the increases in absolute and relate date of VO_2max in group E_1 subjects, from 3,44 ± 0,66 to 3,70 ± 0,50 l/min, and from 45,2 ± 7,5 to 48,5 ± 6,4 ml/min/kg. Aerobic capacity in group E_2 subjects increased more than in group E_1 subjects. Absolute data of VO_2max increased on average from 3,85 ± 0,57 to 4,14 ± 0,59 l/min ($p = 0,047$) and relative data of VO_2max increased on average from 51,0 ± 10,2 to 55,4 ± 11,5 ml/min/kg ($p = 0,048$). No significant changes were found in group K subjects (Table 2).

In addition, we observed increases in functional capacity of cardiovascular system. Rufje index in the L-arginine supplementation group (E1) increased from 4,10 ± 1,96 to 3,00 ± 1,17 ($p = 0,047$), and resting heart rate decreased from 59,5 ± 8,1 to 53,5 ± 6,7 b/min ($p = 0,065$). After 20 days supplementation pulse rate after standard physical load decreased from 106,2 ± 10,9 to 104,0 ± 8,8 b/min. Pulse rate after 60s recovery period decreased from 77,0 ± 10,0 to 74,0 ± 4,8 b/min (Table 3).

Table 3

Changes of cardiovascular system before (T1) and after (T2) 20 days of intake ARGI+ and ARGI+ in combination with Multi Maca or plascebo

Groups	Variable	Resting HR, b/min	HR after physical load, b/min	HR after 60s restitution, b/min	RI	Hb, g/l	Ht, %
1st testing							
E_1	**X**	59,5	106,2	77,0	4,10	156,1	45,0
	SD	8,1	10,9	10,0	1,96	9,9	2,6
E_2	**X**	49,4	100,0	74,0	2,88	158,2	47,1
	SD	15,8	12,5	7,8	1,98	10,4	3,5
K	**X**	60,8	114,3	87,0	6,20	157,6	46,1
	SD	6,8	14,1	11,5	2,84	9,3	3,3
2nd testing							
E_1	**X**	53,5	104,0	74,0	3,00	158,2	43,3
	SD	6,7	8,8	4,8	1,17	6,4	2,8
E_2	**X**	54,4	98,8	76,0	2,96	163,6	43,8
	SD	5,4	13,3	11,5	2,29	8,0	2,5
K	**X**	61,7	113,5	88,8	6,13	157,4	45,5
	SD	9,4	15,0	13,2	3,52	8,2	2,1
Reliability of diferencines p							
E_1 I-II		0,065	0,785	0,228	**0,047**	0,282	0,076
E_2 I-II		0,180	0,419	0,245	0,467	**0,045**	**0,01**
E_1-K 2nd testing		**0,027**	0,573	**0,031**	**0,044**	0,730	**0,042**
E_2-K 2nd testing		**0,023**	0,144	**0,042**	0,067	0,546	0,091

Note: * – $p < 0,05$.

Results of our study demonstrate that the supplements have an influence on Haemoglobin concentration and Haematocrit. After 20 days of supplementation in experimental group E1, we observed increases in Haemoglobin concentration on average from 156,1 ± 9,9 to 158,2 ± 6,4 g/l, but these changes were not significant, and in group E2 – on average from 158,2 ± 10,4 to 163,6 ± 8,0 g/l ($p = 0,045$) . Blood viscosity had tendency to decrease in E1 and E2 groups' subjects, but for subjects who took the supplement ARGI+ this tendency was more visible ($p = 0,01$) (Table 3).

Discussion

In the current study, we observed that 20 days ARGI+ in combination with Multi Maca supplementation, has an effect on athletes muscle capacity to work in various energy production zones. This confirms our earlier study results [11], and demonstrate that the supplement Multi Maca (*Lepidium meyenii)* have an influence on muscle capacity. However, our current study focuses on the question, which supplement has more influence on muscle capacity. We have found that food supplement ARGI+ has more appreciable influence on increasing single muscle capacity power and anaerobic alactic muscle power than using 20 days ARGI+ in combination with Multi Maca. As

reported by T. Álvares et al. (2011) [19] dietary supplements, containing L-arginine, helps to increase muscle strength, their recovery after anaerobic and aerobic exercise, removing metabolic products. Reasonable results were obtained by V. Imanipour et al. (2012) [13], who studied the effects of L-arginine on methabolism and anaerobic capacity. They stated that dietary supplement L-arginine reduces amonium (NH4) production and it contributes to increased muscle power during short-lasting physical load. Our study data confirm this statement, because we have fixed the increases in jump take-of time in group E_1 subjects, who took the supplement ARGI+ 10g/day for twenty days, and significant differences in the second testing session T2 between group E_1 subjects and group K subjects.

The observed beneficial effect of 20 days supplementation on athletes' absolute maximal moment muscle power. Although relative maximal moment muscle power in group E_1 subjects increased, only at the second testing session T2 it significantly changed ($p = 0,049$) and in group E2 changes were not significant ($p = 0,497$) in comparison with group K subjects. Significant, changes in comparison with placebo group were on average of 10s absolute maximal ($p = 0,05$ and $p = 0,047$) and relative ($p = 0,047$ and 0,006) capacity ergometry work.

Aerobic capacity is determined by two main factors: muscles ability to use oxygen for ATP resintesis and cardiovascular system functional capacity. The results of this study show the influence of dietary supplements ARGI+ and ARGI+ in combination with Multi Maca to aerobic capacity of young sportsmen. Our results generally comply with the results of previous studies [17–18; 27–28], although, in a study S. Bailey et al. (2010) [29] found, that consumption of L-arginin less increase oxygen consumption cost of moderate-intensity cycle exercise and significantly increased maximal oxygen consumption during high-intensity cycle exercise.

Our study did not show any significant increases in cardiovascular system functional capacity. However, in comparison of E_2 group subjects and group K subjects after supplements consumption (T2), all data of cardiovascular system had significant difference. In addition, in comparison of group E1 subjects and group K subjects after supplements consumption (T2) relative data of VO_{2max}, heart rate after 60s recovery period, the Roufier index, Haematocrit had significant differences. R. Bescos et al. (2009) [20] did not find that ingestion of range of doze L-arginin (5,5; 9,0 and 15,0 g per day) has an influence on cardiovascular system. Similarly, no changes in data of cardiovascular system were noticed after L-arginine supplementation [30].

Research has demonstrated that ARGI+ supplementation influences muscle capacity in short-term exercise. Analogical data indicates S Forbes.et al (2014) [31], they state that usage bigger amounts of L-arginine increases the concentration of growth hormone in strength trained males. However, ARGI+ in combination with Multi Maca supplementation more influences aerobic capacity ($p = 0,047$ and $p = 0,048$). According toYang Q et al (2016) [32] compared with the control group of mice, exhaustive swimming time was significantly prolonged in group which used a high-dose of Maca. Very important information about the effect of Maca influence indicates J. Chen et al (2015) [33], in their opinion the consumption of Maca improves the quality of assimilation of various food products.

Conclusions

Therefore, based on our collective data, we conclude that 20 days use of ARGI+ and ARGI+ in combination with Multi Maca supplementation has influence on atletes' physical capacity in

short-term exercise. Results of our study demonstrate significant increases of single muscle capacity power and anaerobic alactic muscle power in group E_1 subjects, who took the supplement ARGI+ 10g/day. These data of the second group E_2 subjects, who took the supplement ARGI+ 10g/day and Multi Maca 2 tablets/day for twenty days period increased less. Absolute and relative maximal moment muscle capacity, using 10 s maximal effort ergometry works in both experimental groups increased.

Supplementation of ARGI+ in combination with Multi Maca for a period of twenty days more effectively influenced cardiovascular system capacity and aerobic capacity than supplementation ARGI+.

REFERENCES

1. Jeukendrup A., Gleeson M. *Sport Nutrition. An introduction to energy production and performance.* Champaign, IL, Human Kinetics Publ., 2010, 473 p.
2. Hernandez B., Leon J. Maca. *Neglected crops: 1492 from a different perspective*. Rome, Food acid Agriculture Organization (FAO) of the United Nations (UN) Publ., 1994, p. 343
3. Zuniga L., Flores D. Maca (monograph). *Latin Pharma*. 2003, pp. 8–11.
4. Omran S., Ashton J., Stathopoulos C. Effect of Maca (*Lepidium meyenii)* on some physical characteristics of cereal and root starches. *International Food Research Journal*. 2010, vol. 17, pp. 1085–1094.
5. Gonzales G., Cordova A., Vega K., Chung A., Villena A., Gonez C., Castillo S. Effect of *Lepidium meyenii* (Maca) on sexual desire and its absent relationship with serum testosterone levels in adult healthy men. *Andrology*. 2002, 34, pp. 367–372. DOI: https://dx.doi.org/10.1186/1472-6882-6-23.
6. Gonzales G., Cordova A., Vega K., Chung A., Villena A., Gonez C. Effect of *Lepidium meyenii* (Maca), a root with aphrodisiac and fertility-enhancing properties, on serum reproductive hormone levels in adult healthy men. *Journal of Endocrinology*. 2003, vol. 176, no. 1, pp. 163–168. DOI: https://dx.doi.org/10.1677/joe.0.1760163
7. Stone M., Ibarra A., Roller M., Zangara A., Stevenson E. A pilot investigation into the effect of Maca supplementation on physical activity and sexual desire in sportsmen. *Journal of Ethnopharmacology*. 2009, vol. 126, no. 3, pp. 574–576. DOI: http://dx.doi.org/10.1016/j.jep.2009.09.012
8. Zenico T., Cicero A., Valmorri L., Mercuriali M., Bercovich E. Subjective effects of *Lepidium meyenii* (Maca) extract on well-being and sexual performances in patients with mild erectile dysfunction: a randomized, double-blind clinical trial. *Andrologia*. 2009, vol. 41, no. 2, pp. 95–99. DOI: http://dx.doi.org/10.1111/j.1439-0272.2008.00892.x
9. Gonzales G. Ethnobiology and ethnopharmacology of Lepidium meyenii (Maca), a plant from the Peruvian highlands. *Evidence-Based Complementary and Alternative Medicine*. 2012, vol. 2012, article ID 193496, 10 p. DOI: http://dx.doi.org/10.1155/2012/193496
10. Gonzales G. "Biological effects of *Lepidium meyenii*, maca, a plant from the highlands of Peru," in Natural Products, Eds V. K. Singh R. Bhardwaj J. N. Govil and R. K. Sharma. *Recent Progress in Medicinal Plants*. 2006, vol. 15, pp. 209–234.
11. Milašius K., Dadelienė R., Pečiukonienė M., Skernevičius J. Effects of Maca booster food supplement on athletes' bodily adaptation to physical loads. *Ugdymas. Kūno kultūra. Sportas.* 2008, vol. 4 (71), pp. 69–75 (In Lithuanian).
12. Milašius K., Pečiukonienė M., Dadelienė R. The impact of food supplement Black Devil on athletes' organism's adaptation to physical loads. *Sporto mokslas*. 2010, vol. 59, pp. 51–57 (In Lithuanian).

13. Imanipour V., Naderi A., Mahdi F., Sadeghi M., Shahedi V. The effects of supplementary L-arginine dietary on metabolism and performance in anaerobic exercise. *Journal of Basic and Applied Scientific Research*. 2012, vol. 2, no. 1, pp. 759–762.
14. Cynober L. Can argnine and ornithine support gut functions? *Gut*. 1994, vol. 35, pp. 42–45.
15. Elam R., Hardin D., Sutton R. et al. Effects of argnine and ornithine on strength, lean body mass and urinary hydroxyproline in adult males. *Journal of Sports Medicine*. 1989, vol. 29, pp. 52–56.
16. Lambert M. I., Hefer J. A., Millar R. P. et al. Failure of commercial amino acid supplements to increase serum growth hormone concentrations in male body-builders. *International Journal of Sport Nutrition*. 1993, vol. 3, pp. 298–305.
17. Burtscher M., Brunner F., Faulhaber M., Hotter B., Likar R. The prolonged intake of L -arginine-l-aspartate reduces blood lactate accumulation and oxygen consumption during submaximal exercise. *Journal of Sports Science and Medicine*. 2005, vol. 4, pp. 314–322.
18. Muazzezzaneh A., Keshavarz S., Sabour Yaraghi A., Djalali M., Rahimi A. Effect of L-arginine supplementation on blood lactate level and VO_{2max} at anaerobic threshold performance. *Feyz Journal of Kashan University of Medical Sciences*. 2010, vol. 14, no. 3, pp. 24–32.
19. Álvares T., Meirelles C., Bhambhani Y., Paschoalin V., Gomes P. L-arginine as a potential ergogenic aid in healthy subjects. *Sports Medicine*. 2011, vol. 41, no. 3, pp. 233–248. DOI: http://dx.doi.org/10.2165/11538590-000000000-00000
20. Bescós R., Gonzalez-Haro C., Pujol P., Drobnic F., Alonso E., Santolaria M., Ruiz O., Esteve M., Galilea P. Effects of dietary L-arginine intake on cardiorespiratory and metabolic adaptation in athletes. *International Journal of Sport Nutrition & Exercise Metabolism*. 2009, vol. 19, no. 4, pp. 355–365.
21. Knechtle B., Bosch A. The influence of arginine supplementation on performance and metabolism in athletes. *International Journal of Sports Medicine*. 2008, vol. 9, no. 1, pp. 22–31.
22. Bosco C., Luchtanen P., Komi P. A simple method for measurement of mechanical power in jumping. *European Journal of Applied Physiology*. 1983, vol. 50, pp. 273–282.
23. Margaria R., Aghemo P., Roveli E. Measurement of muscular power (anaerobic) in man. *Journal of Applied Physiology*. 1966, vol. 21, pp. 1662–1664.
24. Kalamen J. *Measurement of maximum muscle power in man*. Columbus, Ohio State University Publ., 1968.
25. Skernevičius J., Raslanas A., Dadelienė R. *The methodology of sport science*. Vilnius, LSIC Publ., 2004, 222 p. (In Lithuanian).
26. Gonestas E., Strielčiūnas R. *Applied statistics*. Kaunas, LKKA Publ., 2003, 302 p. (In Lithuanian).
27. Colombani P., Bitzi R., Frey-Rindova P., Frey W., Arnold M., Langhans W., Wenk C. Chronic arginine aspartate supplementation in runners reduces total plasma amino acid level at rest and during a marathon run. *European Journal of Nutrition*. 1999, vol. 38, no. 6, pp. 263–270.
28. Abel T., Knechtle B., Perret C., Eser P., von Arx P., Knecht H. Influence of chronic supplementation of arginine aspartate in endurance athletes on performance and substrate metabolism. A randomized, double-blind, placebo-controlled study. *International Journal of Sports Medicine*. 2005, vol. 26, pp. 344–349.
29. Bailey S., Winyard P., Vanhatalo A., Blackwell J., DiMenna F., Wilkerson D., Jones A. Acute L-arginine supplementation reduces O_2 cost of moderate intensity exercise and enhances high-intensity exercise tolerance. *Journal of Applied Physiology*. 2010, vol. 109, no. 5, pp. 1394–1403. DOI: http://dx.doi.org/10.1152/japplphysiol.00503.2010

30. Fahs C., Heffernan K., Fernhall B. Hemodynamic and vascular response to resistance exercise with L-arginine. *Medicine and Science in Sports and Exercise*. 2009, vol. 41, no. 4, pp. 773–779. DOI: https://dx.doi.org/10.1249/MSS.0b013e3181909d9d.
31. Forbes S., Harber V., Bell G. Oral L-arginine before resistance exercise blunts growth hormone in strength trained males. *International Journal of Sport Nutrition and Exercise Metabolism*. 2014, vol. 24, no. 2, pp. 236–244. DOI: https://dx.doi.org/10.1123/ijsnem.2013-0106.
32. Yang Q., Jin W. Lv X. Effects of macamides on endurance capacity and anti-fatigue property in prolonged swimming mice. *Pharmaceutical Biology*. 2016, vol. 54, no. 5, pp. 827–834. DOI: https://dx.doi.org/10.3109/13880209.2015.1087036.
33. Chen J., Zhao Q., Wang L. et al. Physicochemical and functional properties of dietary fiber from maca (*Lepidium meyenii Walp*.) liquor residue. *Carbohydrate Polymers*. 2015, vol. 132, pp. 509–512. DOI: https://dx.doi.org/10.1016/j.carbpol.2015.06.079