IMPACT OF DIFFERENT DIET REGIMES AT RESULTS OF ENDURANCE PERFORMANCES

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Abstract
The goal of this pilot study is to pinpoint that a three-day herbal diet before competition improves endurance performances of athletes. Of that purpose an experiment with 10 participants (6 males and 4 females) had been organized. Six males of body heights within a range 185±6.31 cm, body mass of 81.17±6.66 kg, body mass indices within range of 23.62±0.74 kg/m^2 and aged 20.2±0.42, four females of body height within range of 171±3 cm, body mass within range of 71.21±5.64 kg, body mass indices within range of 24.52±4.79 kg/m^2 and aged 20.1±0.42. Endurance performances which had been checked are Cooper's running test 12-minute (K), with maximal and relative consumption of oxygen (VO_2max, VO_2rel), quantity of oxygen consumed over the 12-minute running ($\sum VO_2$), kilocalories consumed over the 12-minute running ($\sum$kcal), critical speed (vVO_2) and genetic capacities of oxygen consumption and critical speed (VO_2max(GK)). Respondents had undergone through two testings. All data from experiments had been processed by using descriptive and comparative statistical procedures. The first testing (test1) had been done when students were at usual mixed meat reach diet. Three weeks later the second testing (test2) had been exposed to herbal diet. At the second testing (test2) all respondents had been reached statistically significant better result (Sig.>.001). Cooper's 12-minute running test (K2) 192 m or 7.41% with average critical speed that were 0.27 m/s^{-1}or 7% greater. Maximal oxygen consumption (VO_2max2) was by them by average greater 0.33 liters/min (L. min^{-1}) *or 9%. Relative oxygen consumption (VO_2rel2) was by average greater 4.16 milliliters by them per kilogram of body mass per minute* (ml. kg^{-1}. min^{-1}) *or 9%. They had burned for 12-minute running period 21.206 kcalalories more. They had started with 69% of their genetic capacity regarding maximal and relative oxygen consumptions (VO_2max (GK), VO_2rel (GK)) and 74.8% of critical speed (vVO_2max (GK)) to reach up to 75% of maximal and relative oxygen consumption and 80.9% of critical speed. These results suggest that herbal diet improves endurance and opens space for additional researches.*

Key words: *diet, endurance, Cooper's test, maximal and relative oxygen consumptions, critical speed.*

Introduction

For every human activity the energy is must (Perić, 2003; Milošević, Milošević, 2013). The energy has been delivering to human body by nutritive materials such as carboxides, fats and proteins. Energy within form of food, muscles (chemical energy) cannot be used directly for action, so it has to go through the transformation under the impact of muscular regulators and activators to be biologically usable. Transformation of chemical energy into mechanical form of energy (muscular contraction) and thermical energy, to be performed without presence of oxygen (anaerobical alcatnic and lacatnic) and also with presence of oxygen (aerobic) aided by many types of enzymes. So there are three metabolic paths for creating an energy: phosphagenic, glicogaenic, and oxidative. All three are acting simultaneously and dominance of any individual way depends of intensity of an organism's action. Beside the energy directly used for muscles' work within a body, energetic reserves have been creating. Energetic reserves are chemical materials which are part of process of food digestion and have been fitting within muscles and other parts of the body. Phosphate reserves (adenozin-3-phosphate and creatine-phosphate) and carboxide reserves (glycogen) and fat reserves. Within liver and other parts of the body carboxide and fats are deposed (Milošević, Milošević, 2013; 2014). It's important that certain nutritions can diminish or increase energetic reserves within human body, and thus increase or decrease performances of endurance.

Research has shown that athletes who consume herbal food do show much higher endurance performance (Chittenden, 1904; Astrand, 1964; Bergström, Hermansen, Hultman and Saltin, 1967; Wharton, 1981:69). One of the most renowned researches with that topic had been performed by Scandinavian researcher dr Pier-Olaf Astrand (Astrand, 1964:27). He had been researching of ten well trained athletes and had been changing their nutrition every three days. At the end of every single period each single athlete had been driving bicycle ergonometer with high speed up to exhaustion. The results had shown that with nutrition reach with meat athletes had been becoming exhausted already after one hour (57 min). When were at mixed nutrition with less meat, fat and proteins and more herbal food they could drive bike by higher speed almost twice longer (1h 54min).

However, when at herbal nutrition they could drive three times longer before getting exhausted (2h 47min). Bergstrom and associates (Bergström et al., 1967) are doing research of containment of glycogen within muscle quadriceps femoris at 9 healthy respondents with techniques of biopsy done by needle. It has been established that glycogen presence after diet of fat-protein (P) and diet rich of carboxides (C) varies maximal within range of 0.6 g/100 g of muscles up to 4.7g. To all respondents share of glycogene after diet (C) was higher than normal range of muscular glycogen determined after mixed (M) diet.

After each single cycle of diet, respondents had been working out at bicycle ergonometer with working load which is equivalent of 75% of their maximal oxygen intake (VO_2max) until complete exhaustion. Average working time was 59, 126 and 189 minutes after diets of P,M and C and good correlation between working time and beginning contain of glycogen within muscle were fair. It's shown that the content of glycogen and long term working capability can differ significantly by implementation of different diets after glycogen exhaustion. Similar researches dr Russel Chittenden had performed (Chittenden, 1904) from the University of Yale which he wished to determine if the food based on high quantity of animal proteins bolsters the strength gain and the energy gained together with improvement of mental and physical capabilities of human. The foundation of his research was studying of well-trained athletes. At the beginning of this research, all athletes were at typical diet rich with meat. Than they had been moved to the herb-rich diet within 5 - month period. At the end of research, when level of their physical capabilities had been analyzed, the athletes had been improved it by 35%.

Up to date researches have been shown that endurance performance during running can improve exclusively by moving to herbal-diet (Wharton, 1981:69; Nikolić, 2013). Undoubtedly is that this phenomena has been drawing attention of scientific audience as well as trainers and athletes. Thus the goal of this pilot study was to assess impact of various regimes of nutrition indirect at results of endurance performance of students of the Criminalist-police University from Belgrade.

Methods

Sample

The sample of respondents had been made of 10 students of the Criminalist-police University from Belgrade, 6 males (body height 185±6.31 cm, body mass 81.17±6.66 kg and body mass index of 23.62±0.74 kg/m²) and 4 females (body height 171±3 cm, body mass 71.21±5.64 kg and body mass index of 24.52±4.79 kg/m²) aged 20.2±0.42. All respondents were active athletes (4 students were karate and judo masters, 3 students were lower rank, 1 student was MMA fighter, and 2 students were football players).

All respondents were well informed about the nature of the experiments as well as what the study had required from them. Respondents before enrollment to the Criminalist-police University had undergone through medical examination and psychological testing which both confirmed their complete physical and mental health. All respondents were also clinically healthy before examination without visible body shortcomings and morphological aberrations.

Procedure

Endurance performance estimation:For endurance performance estimation age and measured body height, body weight and Cooper's 12-minute running test (Cooper, 1968; Amanović, Milošević, Mudrić, 2004; Milošević, 2014). From those data other performances to be calculate (Milosevic & Milosevic, 2010, 2014; Milosevic, Nemec, Nemec, Milosevic, 2017; Milosevic, Nemec, Nemec, Milosevic, 2018):

- Maximal relative oxygen consumption to be calculated according to the formula:

$$VO_2rel = 3.134304 \cdot 10^{-7} \cdot K^2 + 0.02077344 \cdot K - 9.03125$$

where VO_2rel – maximal relative oxygen consumption which is express in milimeters per kilogram of body mass over one minute period (ml. kg^{-1}. min^{-1}) and K-value of Cooper's test within 12-minute period expressed in meters (m).

- Maximal oxygen consumption to be calculated according to the formula:

$$VO_2max = [(3.134304 \cdot 10^{-7} \cdot K^2 + 0.02077344 \cdot K - 9.03125) \cdot BW] \cdot 1000^{-1}$$

where VO_2max – maximal oxygen consumption expressed in liters per minute (L. min^{-1}), K-value of Cooper's 12-minute running test in meters, and BW – body weight expressed in kilograms (kg).

- Running speed at maximal oxygen consumption to be calculated according to the formula:

$$vVO_2max = 0.0014 \cdot K + 0.1786$$

where -vVO_2max – the speed of running at VO_2max expressed in meters per second (ms^{-1}), K – value of Cooper's 12-minute running test expressed in meters (m).

- Value of genetic capacity of relative oxygen consumption calculated according to the formula:

$$VO_2rel_{(GK)} = VO_2rel_{(I)} + 105 \cdot e[(^{-.02803419 - .00040123 \cdot AGE) \cdot VO2rel\ (I) + 0.0000003134304 \cdot AGE^2}]$$

where VO_2rel ($_{GK}$) – genetic value of maximal relative oxygen consumption expressed in mililiters per kilogram within one minute period (ml. kg^{-1}. min^{-1}), VO_2rel ($_I$) – the initial value of maximal relative oxygen consumption expressed in mililiters per kilogram of body mass within one minute period (ml. kg^{-1}. min^{-1}), AGE.

- Value of genetic capacity of maximal oxygen consumption to be calculated according to the formula:

$$VO_2max_{(GK)} = \{VO_2rel_{(I)} + 105 \cdot e[(^{-.02803419 - .00040123 \cdot AGE) \cdot VO2rel(I)} + 0.0000003134304 \cdot AGE^{2}] \cdot BW\} \cdot 1000^{-1}$$

where $VO_2max_{(GK)}$ – maximal oxygen consumption expressed in liters per minute (L. min^{-1}), $VO2rel_{(I)}$ –initial value of maximal relative oxygen consumption expressed in mililiters per kilogram of body mass within one minute period (ml. kg^{-1}. min^{-1}), AGE – age, and BW – body weight expressed in kilograms (kg).

Endurance performances had been measured twice. The first time (test1) mesurement was realized at the exam of the Special physical education (SPE) and the second time three weeks later after prescribed 3-day "diet" before performing Cooper's 12-minute running test (test2).

The Nutrition Status: at the first measurement (test1) respondents were at usual mixed diet meat-rich regime (student canteen nutrition and fast food). Three weeks later the another testing had been performed (test2) prior to which students had been at three-day herb diet. Balance diet had been prescribed to students so the intake of necessary macro-nutrients to be insured in % of energy (carbohydrates 70%, proteins 10%, fats 20%). Regime of nutrition presumed switching to 100% unprocessed food – diverse fresh fruits, vegetables, grains and nuts (Nikolić, 2013: modified). The respondents had had three main meals. Daily caloric needs calculation were individual taking into account differences between between males and females.

Methods of statistical data processing

All data obtained over the two measurement (test1 and test2) had been processed using descriptive and comparative statistical procedures. Their mathematical processing had been realized by using the Microsoft Excel and the SPSS17,0 within the Windows 7.0 operative system. By applying the method of primary data processing necessary information about the variable distribution within the space examined had been obtained. For testing the differences between average values of variables the Student t-test of coupled samples had been used(Paired Samples Test), determining the p-value and the level of significance ($p<0.01$).Due to determination of the size of impact (Effect size) the eta-squared treatment had been done.

Results

Values obtained in all types of analysis (Table 1) point to great reliability of research results obtained. Descriptive analysis had shown that values of standard deviations are small to all followed variables, in fact 15% less than average values, then estimation error of average value within population is vary low and 5% less than average value of the sample, as well as coefficient of variation which is relatively low. At the graph (Graph 1) the difference is shown, in fact better results obtained at the second mearuement (test2) related to the first measurement (test1) to respondents of both sexes which by average was 192 m (within range of 470 m to 70m) or 7.41% (within range of 2.84% to 17.6%).

In Tabele 2 results of significance of differences of monitored variables had been presented related to the first measurement, emerged under the impact of herbal diet regime, whereby the Student's t-test of coupled samples had been used. Based of the Student's t-test results of coupled samples statistically significant impact of herbal-diet regime had been determined at endurance performances' improvement of students of both sexes (Table 2). Statistically significant improvements of the Cooper's 12-minute test had been determined at the second measurement – K2 (M=2695.00, SD=374.767) related to the first measurement –K1 (M=2503.00, SD=277.611), t=-4.679, $p<0.001$. The average raise was 192m, while the 99% confidence interval extends from 325.362 to 58.638.

The eta-squared value (0.71) shows that the impact of the herbal-diet at the result of repeated test (K2) is high. It's determined that statistically significant improvement of maximal oxygen consumption (VO_2max2) reached at the second measurement (M=3.810, SD=0.857) related to the first measurement (M=3.482, SD=0.669), t=-4.407, $p<0.002$. The average raise was 0.328 liters/minute (L. min^{-1}), while the 99% confidence interval extends from 0.570 to 0.086. The value of the eta-squared (0.68) shows that the impact of herbal-diet at the result of repeated test is huge. It's determined that statistically significant improvement of maximal relative oxygen consumption (VO_2rel2) is reached at the second measurement (M=49.285, SD=8.135) related to the first measurement (M=45.118, SD=6.026), t=-4.672, $p<0.001$.

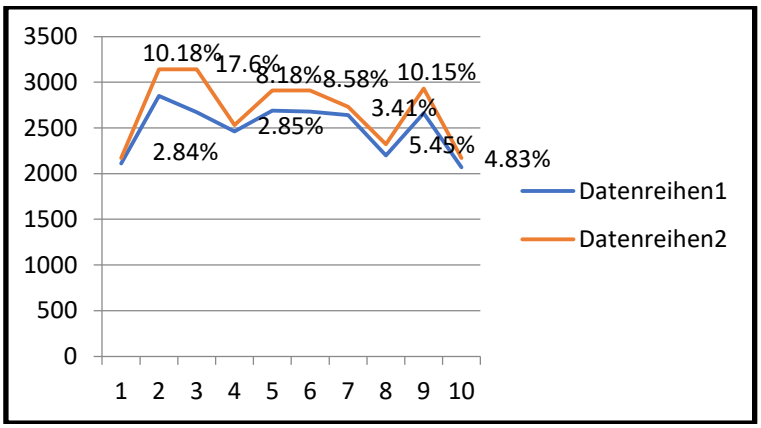
The average increase was 4.167 milimeters per kilogram of weight within a minute (ml. kg^{-1}. min^{-1}), while the 99% confidence interval extends from 7.066 to 1.268. The value of the eta-squared (0.71) shows that the impact of herbal-diet at the result of repeated test is huge. Also it had been determined that statistically significant improvement of the speed of running at maximal oxygen consumption (vVO_2max2) achieved at the second measurement (M=3.951, SD=0.522) related to the first measurement (M=3.682, SD=0.388), t=-4.778, $p<0.001$.

The average increase was 0.269 m/s, while the 99% confidence interval extends from 0.452 to 0.086. Value of the eta-squared (0.72) shows that the impact of herbal-diet at the result of repeated test is huge. Statistically significant increase of calories burn had been determined (∑kcal2) at the second measurement (M=216.671, SD=50.099) related to the first measurement (M=195.465,

SD=38.205), t=-4.853, p<0.001. The average increase was 21.206 kcal, while the 99% confidence interval extends from 35.408 to 7.004. The value of the eta-squared (0.72) shows that the influence of herbal-diet to the repeated test is huge. It had been determined that that statistically significant increase of the quantity of oxygen consumed during the 12-minute period running ($\sum VO_2 2$) at the second measurement (M=43.334, SD=10.019) related to the first measurement (M=39.113, SD=7.655), t=-4.830, p<0.001. The average increase was 4.221 liters, while the 99% confidence interval extends from 7.061 to 1.381. The value of the eta-squared (0.72) shows that the impact of herbal-diet at the result of repeated test is huge.

Table 1. Basic descriptive indicators (test1) and (test2) of both sexes (N=6+4).

Variable	Mean	Std. Error	Std. Deviation	cV%	Minimum	Maximum
Kuper1	2503,000	87,788	277,611	11,091	2070,000	2850,000
Kuper2	2695,000	118,512	374,767	13,906	2170,000	3140,000
VO_2max1	3,482	0,212	0,669	19,222	2,520	4,370
VO_2rel1	45,118	1,906	6,026	13,356	35,720	52,650
VO_2max2	3,810	0,271	0,857	22,505	2,610	4,890
VO_2rel2	49,285	2,573	8,135	16,506	37,890	58,960
vVO_2max1	3,682	0,123	0,388	10,537	3,080	4,170
vVO_2max2	3,951	0,165	0,522	13,204	3,220	4,570
∑kcal1	195,465	12,082	38,205	19,546	141,560	248,380
∑kcal2	216,671	15,843	50,099	23,122	146,570	278,970
vVO_2maxGK	4,955	0,069	0,218	4,401	4,380	5,180
VO_2maxGK	5,076	0,173	0,546	10,759	3,990	6,000
VO_2relGK	65,982	0,413	1,305	1,977	64,110	68,250
∑$VO_2$1	39,113	2,421	7,655	19,572	28,310	49,680
∑$VO_2$2	43,334	3,168	10,019	23,121	29,310	55,790



Graph 1**.** The review of results obtained at the test2 related to the test1 of both sexes respondents and relative difference (K1\K2= %).

Table 2. The t-test sample results – after experimental treatment(both sexes N=6+4).

	Paired Differences					t	df	Sig. (2-tailed)	Eta kvadrat
				99% Confidence Interval of the Difference					
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper				
Kuper1 - Kuper2	-192.000	129.769	41.037	-325.362	-58.638	-4.679	9	0.001	0.71
VO2max1 - VO2max2	-0.328	0.235	0.074	-0.570	-0.086	-4.407	9	0.002	0.68
VO2rel1 - VO2rel2	-4.167	2.820	0.892	-7.066	-1.268	-4.672	9	0.001	0.71
vVO2max1 - vVO2max2	-0.269	0.178	0.056	-0.452	-0.086	-4.778	9	0.001	0.72
∑kcal1 - ∑kcal2	-21.206	13.820	4.370	-35.408	-7.004	-4.853	9	0.001	0.72
∑VO21 - ∑VO22	-4.221	2.763	0.874	-7.061	-1.381	-4.830	9	0.001	0.72

Discussion

Results obtained have shown that respondents at repeated measurement (test2) have shown statistically significant results related to the first measurement (test1). They had been running better at 12-minute Cooper's test (K2) 192 m or 7.41% (t=-4.679; p<0.001) with the average critical speed which is greater for 0.27 ms^{-1}or 7% (t=-4.778; p<0.001). The maximal oxygen consumption (VO_2max2) was by average higher by 0.33 liters/minute (L. min^{-1}) or 9% (t=-4.407; p<0.002). Relative oxygen consumption (VO_2rel2) was by 4.16 milimeters per kilogram of weight per minute (ml. kg^{-1}. min^{-1}) or 9% (t=-4.672; p<0.001) higher. They consumed for 12-minute period running more by 21.10 kcal (t=-4.857; p<0.001). They had started with 69% of their genetic capacity and relative oxygen consumption (VO_2max(GK), VO_2rel (GK)) and 74.8% of critical speed (vVO_2max (GK)) to reach to 75% of maximal and relative oxygen consumption and 80.9% of critical speed.

Results show that switching to a herbal-diet (3 days) has improved the result achieved at the Cooper's 12-minute running test. At the second test (test2) all students have shown better result (t=-4.679; p<0.001) than at the first test (test1). Moreover one student has improved his own result (K2) for 470 m (17.6%), 5 students have improved result (K2) from 220 to 290 m (from 8.18% to 10.18%), while one female student had been run 120 m more, thus had improved result (K2) related to the first (K1) test for 5.45%, 3 female students had improved their result (K2) related to the first (K1) test within the range of 60 to 100 m (from 2.84% to 4.83%). To all respondents the improved result of maximal oxygen consumption (VO_2max) for 9% (from 3.58% to 21.71%) at repeated measurement (test2) related to the first testing. The average running speed of males was 3.74 m/s (test1) and 4.12 m/s (test2) and all participants had achieved better results, of females 3.07 m/s (test1) and 3.19 m/s (test2). Average speed of running of all respondents (3.95 m/s) was at high intensity within aerobic regime (Milošević, 2010).

Which conclusions have impacted this experimental outcome of results achieved from the Cooper's test of students? Cooper's running 12-minute test (Cooper, 1968) to be running at aerobic threshold and all within zone of high intensity – this was a mixt zone which features apparently stable state (aerobic process is at maximal level – oxygen debt creates). Physiological analysis of aerobic metabolic process is giving us directions how to create training programe (Astrand, Rodahl, Dahl,Strømme, 2003; Milošević, Mudrić, Jovanović et al., 2005; Milošević, 2010; Milošević & Milošević, 2013; 2014; Milošević, Nemec, Nemec and Milošević, 2017; 2018) but also how to plan "optimal diet" related to the necessary source of energy (carboxides, fats and proteins) for give physical activity (Sherman, Costill, 1984; Kulier, 2001; Plotnick, Corretti, Vogel et al., 2003; Arciero, Miller and Ward, 2015; Nikolić, 2013; Larson-Meyer, 2018). All respondents which took a part in experiment have received written instructions about balanced "diet" which would assure daily intake of 70% of carboxides (7-8 g/kg of body mass) from overall energy intake. Also a recommendation is given that an intermediate meal (optionally) offering an aditional intake of carboxides. To achieve this improvement of results at the Cooper's test (more meters run, increase intake of VO_2max, increase VO_2rel, improved speed of running) at repeated measurement (test2) many factors are responsible. The respondents had undergone through "diet" by switching to raw herbal food with 70% of caloric intake from carboxides. Filling up of carboxides – "supercompensation" increases deposits of glycogen within muscles and liver which consists of epoch of exhausting training, after which hences 24 – 48 hours of increase intake of carboxices (Sherman, Costill, Fink, Miller, 1981; Costill, Sherman, Fink, Maresh et al., 1981).

Our finding suggests that even without "supercompensation" was possible to refill deposits of glycogens (Fogelholm, Tikkanen, Naveri et al., 1991; Bussau, Fairchild, Rao, Steele and Fournier, 2002; Jeukendrup, 2011) only with 3-day diet regime with 70% of caloric intake of carboxides, what was sufficient to improve performance of endurance of Cooper's 12-minute running test of all respondents (average 7.41%).

Results have pointed out that this type of diet has mighty stimulans on increasing of endurance performances and physiologica adaptation (maximal energetic balance of glycogen of muscles and liver, glycose reserves within liver and blood, increasing of levels and efficiency of regulator (minerals and vitamins) and activators (oxydative enzimes) of muscular contractions, increasing speed of decompositions and resynthesis of glycogen within muscles, improvement of regulation of metabolic reactions based on increasing level of glycogen and increase of enzime activity). According to that, that wat you eat before sporting effort could have the impact on performance endurance (Fogelholm et al., 1991; Bussau et al., 2002; Plotnick et al., 2003; Jeukendrup, 2011; Arciero et al., 2015; Sugiyama, Yamaguchi, Hu, Kobayashi, Kobayashi, 2017).

It's important to highlight, that at the second measurement (test2) our respondents were feeling noticeably fresher, they had been done the Cooper's 12-minute running test easier and were in positive mood. Light sickness and pain in upper abdomen after test had been registered to one female student caused by premenstrual syndrome – PMS. Opposite of that, at the first measurement (test1) generally, all members have shown tiredness, were tense and in bad mood and sickness was also registered at three of males.

Those observations would anyway need to be checked with additional examinations.

Conclusion

This pilot study had been conducted to determine the effects of different diet regimes at endurance performances of students athlete at the Criminalist-police University from Belgrade (6 males and 4 females). Results of study suggest that specific diet with increased intake of carboxides (70%) improves endurance performances (the result of the Cooper's 12-minute (K), maximal and relative oxygen consumption (VO_2max, VO_2rel), the amount of oxygen consumed of 12-minute running ($\sum VO_2$),kilocalories consumed during the 12-minute running (∑kcal), the critical speed (vVO_2max) and genetic capacities of the oxygen consumption and the critical speed (VO_2max(GK), VO_2rel (GK) and vVO_2max (GK)). All respondents in experiment after three-day balanced diet regime of 70% of carboxide intake, 10% of protein intake and 20% of fat intake have improved results at the second measurement (test2) related to the first measurement (test1) when they were at mixed meat-reached diet.

By average at the second measurement (test2) they had been run the Cooper's 12-minute (K) for 2695 m which was 192 m more or 7.41% related to the first measurement. The average critical speed (vVO_2max2) is 3.68 m/s what is faster than the first measurement for 0.27 ms^{-1} or 7%. The maximal oxygen consumption (VO_2max2) was by average 3.48 liters in minute (L. min^{-1}) which is 0.33 (L. min^{-1}) higher than at the first measurement or 9% higher. The relative oxygen consumption (VO_2rel2) is 49.18 kg^{-1}. min^{-1} which is 4.16 kg^{-1}. min^{-1} or 9% higher related to the first measurement. Respondents had been by the average consumed for 12-minute running 216.671 kilocalories (kcal) which is more than at the first measurement for 21.10 kilocalories or 10%. By the average with 69% of their genetic capacity in maximal and relative oxygen consumption and 74.8% for critical speed (test1), and after herbal diet they had arrived to 75% of maximal and relative oxygen consumption and 80.9% of the critical speed. Based on results obtained it can conclude that well resolved problem of research and the goal of our study is achieved. Further researches are necessary to identify and confirm all these findings.

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