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Increased adaptability of young judo sportsmen after protein supplementation

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Aim. **The purpose of this study was to examine the effects of protein supplementation on adaptation process in young judoists. The assumption of this study was that young sportsmen would benefit from the protein supplements because of increased demand due to growth and training.**
Methods. **Twelve judoists were divided into two groups. One group received a soy protein supplement 0.5 g/kg body mass/day (P) and the second group (C) did not. Before and after 4 weeks of training the maximum oxygen uptake ($\dot{V}O_{2max}$) was evaluated in both groups. In addition, they performed Wingate test, where the maximal power output and the total work output were measured.**
Results. **The obtained results indicate that after 4 weeks of judo training the $\dot{V}O_{2max}$ increase and Wingate test performance significantly improves. In both cases the increase was much higher in judoists who received the protein supplement, comparing to the control group. When the judoist were trained for another 3 months but without the protein supplementation, we observed disappearance of the differences in $\dot{V}O_{2max}$ between the two studied groups.**
Conclusion. **These data clearly indicate that the supplementation of a normal diet with soy protein (0.5 g per kg of body mass) is beneficial for a judoist. An increase in aerobic and anaerobic performance is higher in the protein supplemented group, despite the fact that the training protocol is the same for all the athletes. We conclude that it is possible to increase the adaptation to judo training by protein supplementation.**

KEY WORDS: Oxygen consumption - Judo training - Wingate test - Proteins - Diet.

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Most nutritional experts recommend a protein intake of 0.8 g/kg of body mass/day. However the recommendation is valid for sedentary people and is probably suboptimal for individuals who are regularly active.[1] An increased demand of an athlete's organism for protein is an outcome of an elevated biosynthesis-processes induced by training. In addition, the amino acids are used as an auxiliary fuel source, especially when the exercise is prolonged, *e.g.* leucine oxidation increases during an exercise proportionally to the intensity of aerobic activity.[2] A systematic increase of urea concentration in plasma and urine was observed during and after submaximal exercise.[3] The amino acids oxidation can be also stimulated by a high protein diet.[4] Adaptation to any kind of training is the effect of induction of a specific protein biosynthesis. Endurance exercises mainly induce the biosynthesis of mitochondrial proteins and myoglobine. On the other hand they diminish the biosynthesis of some other proteins, *e.g.* glycolytic enzymes.[5] On the contrary, strength training induces mainly the biosynthesis of muscle structural proteins which leads to muscle

TABLE I.—*Characteristics of two groups (P, protein and C, control) of subjects participating in the study.*

Variable	Group P (n=6)		Group C (n=6)	
	Test 1	Test 2	Test 1	Test 2
Age (yrs)	16.83±0.4	—	15.66±1.3	—
Height (cm)	175.5±5.0	175.83±5.1	171±7.31	171.3±7.03
Weight (kg)	66.9±5.9	66.58±4.69	62.9±11.33	63.8±10.94
Training (yrs)	5		5	

hypertrophy. Thus, a suboptimal protein intake might either decrease the performance by limiting the availability of a muscle fuel, or abolish the protein biosynthesis induced by training. In such a case, an adaptation to any kind of training should be limited. It has been observed that an increase of dietary protein is beneficial during strength exercise because when combined with resistance training it can provide an enhanced stimulus for muscle development.[6] In addition, in response to a higher protein intake, an increase in body protein synthesis was observed in strength trained athletes.[7] On the other hand, it was reported that athletes who consumed 1 g protein/kg of body mass/day developed a negative nitrogen balance.[8]

Judo training activities involve a repeated, high-intensity, intermittent exercise which requires both aspects of strength and endurance over a period of up to several hours. This study examines the effects of protein supplementation on the adaptation process of young judo athletes during the preparation training season. The results of the study suggest that protein supplementation substantially elevates the adaptability in judo training.

Materials and methods

Twelve young, healthy judo athletes participated in the study. All the participating judoists had won medals in the Polish National Junior and Cadet Championships. The study was performed during the preparation training season. The sportsmen participated in 45 training units for 4 weeks, out of which 18 units constituted special judo training and 27 units the universal training. Typically for the preparation training season, the endurance training was the dominating component - 47%, the speed training made up 35% and the resistance training 18%.

The 12 athletes were divided into 2 groups (Table I): P which received a soy protein supplement of 0.5 g/kg of body mass/day, and group C which received the same amount of liquid (orange juice) without the protein. Sportsmen were informed about the diet protocol. The supplement was given right after the morning training under the control of the staff persons. Except for the presence or absence of the supplement the sportsmen's diet was the same because during the period in study they stayed together in one place. In addition, sportsmen record all food they consumed during the study and the data where used to calculate diet composition. The macronutrient composition of the diet was as follows: protein: 100±27 g/day; fat: 170±33 g/day; carbohydrates: 510±56 g/day. Total calorie intake was around 4000 kcal/day and was not different between the groups. The main source of the protein in the diet was animal protein (72%).

The subjects were submitted to a cycloergometer test. The continuous protocol started at 2 W/body mass for 6 min (v=50 rpm) and increased by 25 W every 1 min until exhaustion.

Gas analyser EOS Sprint (Jaeger) was used in the study. Maximal oxygen uptake ($\dot{V}O_{2max}$) was monitored during the test.

The 30 sec Wingate Anaerobic Test (WAnT) was employed to assess the anaerobic performance capacity.[9]

Statistical analysis

Data was analysed with the general linear model program of the SAS statistical package for personal computers. The obtained data of $\dot{V}O_{2max}$ were analysed using ANOVA with repeated measures, where the time of training was the repeated variable. When a significant main effect was found the Tukey test was used to compare the means. The results of Wingate test were analysed using test for differences in two means. The data are presented as means ± SE. Significance was accepted at $p<0.05$.

Results

Maximum oxygen uptake was measured in both groups of the judoists before the training session (P 1 and C1) and then after 4 weeks of training (P2 and C2). The amount of effective judo training and universal training during this period is given in *Materials and methods*. Groups P and C were exposed to the same training protocol. As indicated in Figure 1 $\dot{V}O_{2max}$ in the both studied groups of athletes increased significantly, however the increase was much higher in group

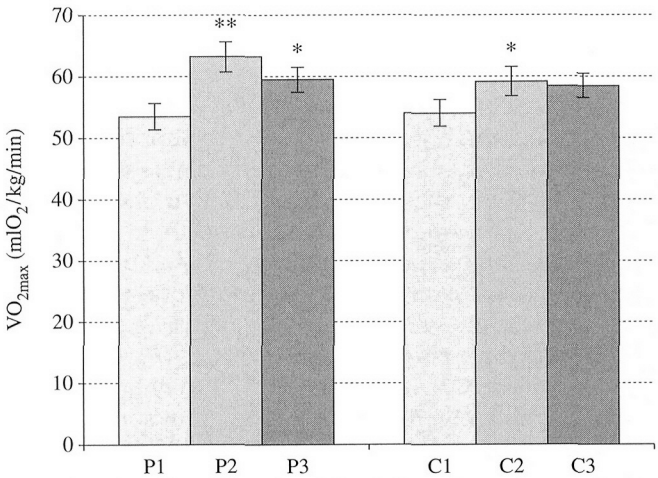

Figure 1.—The effect of 4 week training and protein supplementation on maximum oxygen uptake ($\dot{V}O_{2max}$) of judo athletes. They were divided into two groups: P group, which received a protein supplement of 0.5 g/kg body mass/day, and control group C. P1 and C1 represent the values before and P2 and C2 the values four weeks after the training while group P3 and C3 values three months after the experiment. During this period, they did not receive the protein supplementation and remained on a normal diet. Data presented as the mean ± standard error of the mean. *Significantly different from C1 and P1 group, respectively, at p<0.05. **Significantly different from group P1 at p<0.01.

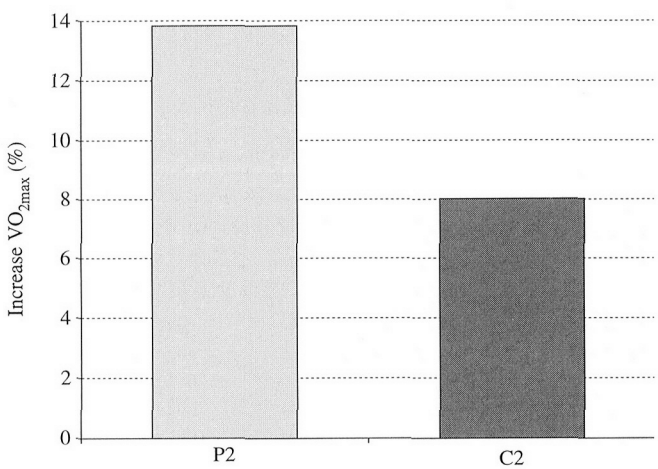

Figure 2.—The increase in $\dot{V}O_{2max}$ (% over control) after 4 weeks of judo training in the control (C2) and protein supplemented (P2) group.

P2 (13.9%) compared to C2 (8%), (Figure 2). Similar results were obtained when Wingate test was performed. For the protein group an increase observed in the maximum power output obtained during the test was higher than in the control group (Figure 3). This value corresponds to the potential of anaerobic metabolism based

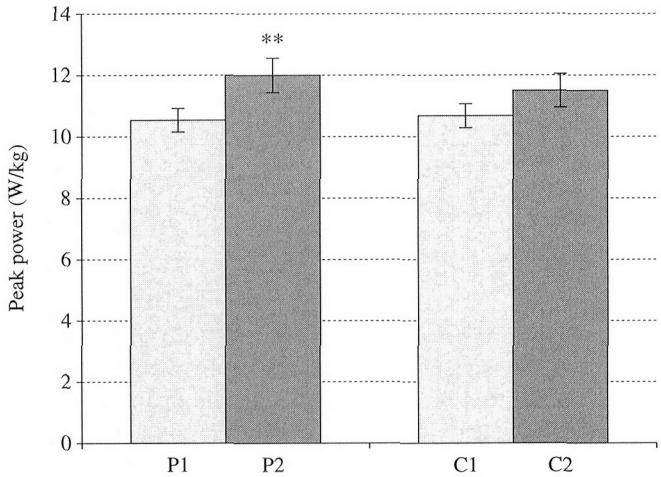

Figure 3.—Effects of a 4 week judo training and protein supplementation on peak power (W/kg) during the Wingate test. Data presented as the mean ± standard error of the mean. **Significantly different from C2 group at p<0.05 and from P1 group at p<0.01.

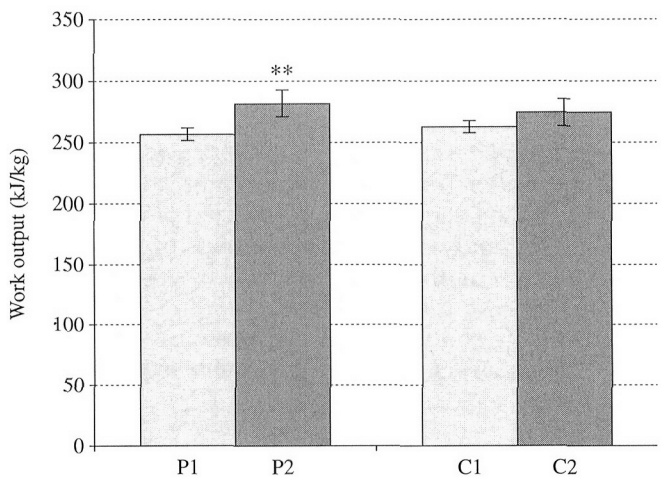

Figure 4.—Effects of a 4 week judo training and protein supplementation on total work output (kJ/kg) during the Wingate test. Data presented as the mean ± standard error of the mean. **Significantly different from group P1 at p<0.01.

on phosphocreatine. The value of the total work output measured during the Wingate test also indicates anaerobic metabolism but in this case the metabolism based on glycolysis. In both cases, the increase was much higher in the judoists who received the protein supplement (Figures 3, 4). On the other hand, after 3 months of regular training without protein supplementation no difference in maximal oxygen uptake was observed between groups P3 and C3 (Figure 1).

Discussion

The determination of an optimal intake of various nutrients for active people is very difficult, as most of the recommendations do not take into consideration the needs of individual sportsmen. Genetic differences and environmental factors play an important role in the individual's need of nutrients. Thus, the recommended protein intake, 0.8 g/kg of body mass/day, should be optimal for most people but certainly not for all. As mentioned before, an intensive sport training substantially elevates the demand for proteins and other nutrients. In most of the studies, two prevailing approaches are followed in order to determine an individual athlete's need for proteins. The first approach is the classical nitrogen balance approach, or tracer technique, which indicates an overall need for proteins. A negative nitrogen balance has been observed in endurance athletes, who consume less than 1.5 g of protein/kg of body mass/day.[8]

In the second approach, the effects of sport training are measured in sportsmen with and without protein supplementation. An increase of body weight after a heavy resistance exercise was much pronounced in the sportsmen, who consumed 2.8 g of protein/kg of body mass/day compared to those who consumed only 1.5 g of protein/kg of body mass/day.[6] However, in another study, despite the increase of protein intake from 1.35 to 2.62 g/kg/day, no enhancement of muscle mass/strength gains was observed during the 1st month of training. In addition, it was demonstrated that 1 week protein supplementation had no effect on the mean power output and fatigue index of sportsmen performing the Wingate test, despite the decrease of a muscle and blood lactic acid concentration after the exercise.[10]

In this study, the effects of protein supplementation on aerobic and anaerobic performance were examined. We observed that the young judo athletes who were on the same diet as their collegues from the control group (C), but who additionally received a protein supplement of 0.5 g/kg/day (group P), showed statistically significantly better results in the Wingate test and a higher increase in the maximal oxygen uptake after 1 month of training. This data clearly indicate that the effectiveness of training could be much higher for those sportsmen whose protein intake is optimal. However, one should remember that a fixed protein supplementation dose not always lead to the same results. As suggested before, the diet of many sportsmen already contains the optimal amount of proteins, therefore it cannot be expected that the supplementation will have any positive effect. An earlier study, conducted on Polish sportsmen whose protein consumption was determined, indicated that for some of the sportsmen the protein intake was smaller than 1 g/kg body mass/day.[11]

Another important factor that may influence the effects of protein supplementation is the time. The proteins in a diet constitute a source of amino acids which are partly used as energy fuel and partly as substrates for protein biosynthesis. As adaptation to any kind of training induces the biosynthesis of specific proteins, a limited protein intake might also inhibit this process. It has been reported that endurance training increases the level of mitochondrial enzymes and oxygen consumption in a muscle.[12-15] In another study it was observed that 28 days of electric stimulation were optimal to induce a citrate synthase activity in the muscle. This and many other studies indicate that a period of 4 or more weeks of training is usually necessary to increase the protein level in a human or animal muscle.[16, 17]

In our study, we observed a higher increase in $\dot{V}O_{2max}$ in the judoists whose diet was supplemented with soy protein. However, it is generally accepted that it is not the muscle mitochondrial activity but the cardiovascular system which by limiting the O_2 supply, limits the $\dot{V}O_{2max}$.[18] $\dot{V}O_{2max}$ can increase from anywhere of 20% to 40% with several weeks of endurance training and this is accompanied by a rise in the maximal cardiac output.[18] This may indicate that the adaptive changes in muscle metabolism and the cardiovascular system are more pronounced when the protein intake is adequate. It cannot be excluded that the protein in a diet might induce some metabolic changes regardless of the training. Recently, it was observed that the soy protein, but not casein improves glucose tolerance and insulin sensitivity in rats. It may suggest that the effect of a particular protein is mediated by nitric oxide formation since the soy protein is a good source of an arginine substrate for NO synthase (7.45 g arginine/100 g of soy protein).[19] Because the NO is a very potent vasodilator, one may expect it to influence $\dot{V}O_{2max}$.[20] Thus, it is believed that the positive effect of protein supplementation reported in this study is a result of the adequate dose and timing of the supplementation.

Conclusions

In the course of this study it was observed that young judo athletes demonstrate a higher increase in aerobic ($\dot{V}O_{2max}$) and anaerobic performance after the protein supplementation in comparison to their colleagues from the control group. Because the training protocol was the same for both groups of the athletes, it is possible to conclude that a higher protein intake, increased by 0.5 g per kg of body mass, was responsible for this phenomenon. The study was performed on young sportsmen who, on the one hand needed more protein for growth and training, but on the other hand did not have a special protein enriched diet which is often the case for more advanced athletes.

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References

1. Lemon PW, Dolny DG, Yarasheski KE. Moderate physical activity can increase dietary protein needs. Can J Appl Physiol 1997;22:494-503.
2. Rennie MJ, Edwards RH, Krywawych S, Davies CT, Halliday, Waterlow JC *et al.* Effect of exercise on protein turnover in man. Clin Sci 1981;61:627-39.
3. Haralambie G, Berg A. Serum urea and amino nitrogen changes with exercise duration. Eur J App Physiol Occup Physiol 1976;36:39-48.
5. Forslund AH, Hambraeus L, Olsson RM, El-Khoury AE, Yu YM, Young VR. The 24-h whole body leucine and urea kinetics at normal and high protein intakes with exercise in healthy adults. Am J Physiol 1998;5(2 Pt 1):E310-20.
4. Schantz PG. Plasticity of human skeletal muscle with special reference to effects of physical training on enzyme levels of the NADH shuttles and phenotypic expression of slow and fast myofibrillar proteins. Acta Physiol Scand 1986;Suppl 558:1-62.
6. Fern EB, Bielinski RN, Schutz Y. Effects of exaggerated amino acid and protein supply in man. Experientia 1991;47:168-72.
7. Tarnopolsky MA, Atkinson SA, MacDougall JD, Chesley A, Phillips S, Schwarcz HP. Evaluation of protein requirements for trained strength athletes. J App Physiol 1992;73:1986-95.
8. Gontzea I, Sutzescu P, Dumitrache S. The influence of muscular activity on nitrogen balance and on the need of man for proteins. Nutr Rep Int 1974;10:35-43.
9. Dotan R, Bar-Or O. Load optimization for the Wingate Anaerobic Test. Eur J App Physiol Occup Physiol 1983;51:409-17.
10. Vukovich MD, Sharp RL, King DS, Kershishnik K. The effect of protein supplementation on lactate accumulation during submaximal and maximal exercise. Int J Sport Nutr 1992;2:307-16.
11. Matuszkiewicz A. Protein defficiency in Polish sport diet. Pol J Environ Studies 1997;6:67-18.
12. Holloszy JO, Oscai LB, Don IJ, Mole PA. Mitochondrial citric acid cycle and related enzymes: adaptive response to exercise. Biochem Biophys Res Commun 1970;40:1368-73.
13. Holloszy JO. Adaptation of skeletal muscle to endurance exercise. Med Sci Sports 1975;7:155-64.
14. Holloszy JO, Booth FW. Biochemical adaptations to endurance exercise in muscle. Ann Rev Physiol 1976;38:273-91.
15. Holloszy JO, Rennie MJ, Hickson RC, Conlee RK, Hagberg JM. Physiological consequences of the biochemical adaptations to endurance exercise. Ann Acad Sci 1977;301:440-50.
16. Hood DA, Pette D. Chronic long-term electrostimulation creates a unique metabolic enzyme profile in rabbit fast-twitch muscle. FEBS Lett 1989;247:471-4.
17. Hood DA, Zak R, Pette D. Chronic stimulation of rat skeletal muscle induces coordinate increases in mitochondrial and nuclear mRNAs of cytochrome-c-oxidase subunits. Eur J Biochem 1989;179:275-80.
18. Saltin B. Hemodynamic adaptations to exercise. Am J Cardiol 1985;55:42D-7.
19. Forslund AH, Hambraeus L, van Beurden H, Holmback U, El-Khoury AE, Hjorth G *et al.* Inverse relationship between protein intake and plasma free amino acids in healthy men at physical exercise. Am J Physiol Endocrin Metab 2000;278:E857-67.
20. Maxwell AJ, Ho HV, Le CQ, Lin PS, Bernstein D, Cooke JP. L-arginine enhances aerobic exercise capacity in association with augmented nitric oxide production. J Appl Physiol 2001;90:933-8.