Croat. J. Food Sci. Technol. (2013) 5 (1) 18-28

Analysis of diet optimization models for enabling conditions for hypertrophic muscle enlargement in athletes

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original scientific paper

Summary

In this study mathematical models were created and used in diet optimization for an athlete – recreational bodybuilder for pretournament period. The main aim was to determine weekly menus that can enable conditions for the hypertrophic muscle enlargement and to reduce the fat mass in a body. Each daily offer was planned to contain six to seven meals but with respect to several user's personal demands. Optimal carbohydrates, fat and protein ratio in diet for enabling hypertrophy, recommended in literature, was found to be 43:30:27 and was chosen as the target in this research. Variables included in models were presented dishes and constraints, observed values of the offers; price, mass of consumed food, energy, water and content of different nutrients. The general idea was to create the models and to compare different programs in solving a problem. LINDO and MS Excel were recognized as widely spread and were chosen for model testing and examination. Both programs were suggested weekly menus that were acceptable to the user and were met all recommendations and demands. Weekly menus were analysed and compared. Sensitivity tests from both programs were used to detect possible critical points in the menu. Used programs produced slightly different results but still with very high correlation between proposed weekly intakes (R^2=0.99856, p<0.05) so both can be successfully used in the pretournament period of bodybuilding and recommended for this complex task.

Keywords: model, hypertrophy, athletes, diet, optimization

Introduction

The outstanding physical ability of top athletes strongly depends on diet as an important part of success. Diet is especially important when athletes have reached the limits in training volume and intensity and in close to competition period. Before tournament, they want to enable the hypertrophic muscle enlargement and to reduce the fat mass in a body so diet has to be optimized for that purpose. Selection of the right food at the right moment to eat will certainly help top athletes to realise their full potential. In order to ensure the balance between digestibility of food, feeling of fullness and satisfaction after taking meals human nutrition should be in accordance with dietary needs (IM, 2005). Food choice decisions that people encounter have been described by Sobal and Bisogni (2009) as frequent, situational, dynamic, multifaceted and complex. The outcome of such diversity of choice can be problematic leading to (i) eating in abundance or (ii) restriction in the dietary intake.
The complexity of the overview that the dietician has to follow in the menu planning of the athletes is given by Pettersson and co-workers (2009) and divided in three segments: between competitions, close to competition weigh-in and post competition weigh-in. Some general recommendations can be adjusted by sports nutrition experts to accommodate the unique concerns of individual athletes regarding sports, body mass and composition goals, health, nutrient needs and food preferences (ADA, 2009). Those key points summarize the current energy, nutrient, and fluid recommendations for active adults and competitive athletes.
In this paper, menu planning was done for bodybuilders. This specific group of athletes is concentrated on the muscle growth in order to create optimal conditions for hypertrophy. The optimal carbohydrates, fat and protein ratio for hypertrophy recommended in literature was found to be 43:30:27 (Brink, 2006). The basic demands that should be considered in the menu planning for these athletes are: (i) nutritive and energy contents of the meals should be in accordance with recommendations (IM, 2005*; Mahan and Escott-Stump, 2007#; Perkov, 2001), (ii) meals could be consumed respecting the daily schedule and routine of the athlete and (iii) his preferences. Due to the complexity of meal planning, computer programs that use linear

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programming (LP) method can help in finding desired menu(s) fast and simple. From authors' experience was noticed that menus obtained in different programs were not always exactly the same. So additional task in this study was to analyze and compare menus determined by different optimization tools. The final offer can be different when different foods have similar content and price. Personal preferences of an athlete are the main criteria for decision in such situations.

Models containing target function and sets of admissible constrains are known as linear models (Brown, 1966; Eckstein, 1967; Martić, 1996; Bhatti, 2000; Deb, 2001, Darmon et al, 2002) and often is in use for menu planning (IM, 1998; IM, 2003, Gajdoš et al., 2004; Koroušić Seljak, 2009). Linear optimization templates were applied in this paper as proven method for searching of economically acceptable daily offers. Those offers were subjected to a number of demanded constraints about energy and nutritional shares (Đunđek et al., 2001; Matijević, 2011).

The aim in this menu optimization was also to propose the appropriate intake of proteins because they are the basic building blocks of muscle. Only water is more represented in the body than proteins (Perkov, 2001; Sandoval et al., 1989; IM, 2005). In fact, about 17 % of body mass and healthy man goes to protein. Athletes need about 1.5 to 2 g protein/kg of body mass daily (Mahan and Escott-Stump, 2007) while RDA for bodybuilders are often even higher as shown in Table 1 (IM, 2005*; Mahan and Escott-Stump, 2007#; Perkov, 2001).

Aberdeene (2012) emphasis that bodybuilders neglect recommended daily amount of proteins but must be cautious if consuming high levels. Excessive amounts of protein can be excreted from body, but according to Zeratsky (2012), the long-term effects of high-protein diet can potentially result in kidney damage if consumed for extended periods. The same author states that increase of risk of heart disease, constipation or diverticulitis is possible. Ballew and Kilingsworth (2002) described anorexia nervosa, bulimia nervosa, binge eating disorder, muscle dysmorphia and anorexia athletica as eating disorders in athletes. In the second edition of this book Nanna and co-workers (2010) claim that "knowing when an athlete eats in relationship to exercise training may be as important as knowing what he or she eats". Therefore the modern elite athlete needs to be nutrition-conscious (Maughan, 2000). In order to maintain a stable level of blood sugar (glucose) and to a constant and uniform supply the body with nutrients (Brink, 2006) the daily food intake needs to be divided into 6 to 7 servings. That was one of the tasks in this paper.

Additional task was to reach the Pareto optimum where all set goals are reached (Garey and Johnson, 1979; Gajdoš et al., 2004). Two different programs (I) LINDO and (II) optimisation tool built in Microsoft Excel 2010 were used for the computer based menu planning and reaching demanded goals. Both programs for optimization use LP method based on Simplex algorithm.

Materials and Methods

The idea of this research was to examine one mathematical model in two computer programs and determined daily energy and nutritive balanced offer with minimal cost. Final price for daily menu was placed in the goal function of the linear model. This function was subjected to linear constrains that included the information of energy, water and 22 observed nutrient amount. The set of observed constrains was large and included the price, mass of consumed food, energy, water, content of proteins, fats, MUFA, PUFA, SFA, cholesterol, carbohydrates, dietary fibres, minerals: sodium, potassium, calcium, magnesium, iron, phosphorus, and vitamins soluble in water: B_1, B_2, niacin, B_6, vitamin C, as well as fat-soluble vitamins A and E.

The weekly menu in this research is designed for 20-25 years old male student, recreational bodybuilder who wants to advance in strength and muscle mass with decreasing of fat mass. Following features were used to define the necessary daily content of energy and nutrients: body height (180-185 cm), mass (90 kg), percentage of fat mass (16 %), physical activity (5 times per week), 6-7 meals per day, 2.6 g of proteins per kilogram of body mass every day and less than 350 EUR per month for diet (Matijević, 2011). Optimal carbohydrates, fat and protein ratio for hypertrophy, recommended in literature for male athletes, was found to be 43:30:27 and was selected as target in this research. Recommended daily allowances (RDA) of energy, macro and micronutrients for athletes are given in Table 1.

Table 1. RDA values for athletes (IM, 2005*; Mahan and Escott-Stump, 2007#; Perkov, 2001)

Observed parameters	Recommendations
Energy (E_d, kJ)*	13800 - 15900
Proteins (g/day)	220 - 240
Fats (max % from E_d) #	≤ 30
Carbohydrates (g/day) #	345 - 420
Vitamin A (μg)	2600 - 3000
Vitamin E (mg)	100 - 200
Vitamin B_1 (mg)	3 - 4
Vitamin B_2 (mg)	3 - 6
Niacin (mg)	30 - 50
Vitamin B_6 (mg)	5 - 10
Vitamin C (mg)	< 3000
Sodium (mg)	round 3000
Potassium (mg)	4500 - 5500
Calcium (mg)	1200 - 2700
Magnesium (mg)	600 - 1350
Iron (mg)	30 - 50
Phosphor (mg)	1500 - 4000

The national Food Composition database was not used in this research because of reduced number of offered foods (n=582), personal preferences of client for some food and demanded supplements that were not included in the national database. The USDA Digital Food Composition database of foods and meals, rel. 22 (USDA, 2009) was used to calculate the offers that could be used for the weekly menu with the average daily energy offers ranged from 13800 – 15900 kJ. To ensure the accuracy of the results the USDA Table of Nutrient Retention Factors were used (USDA, 2007). Menu offer for each day was constituted of a breakfast (B), snack (S), lunch (L), meal before the training (BT) meal after the training (AT), dinner (D) and meal before bedtime (Bt).

Basic structure of the linear model is consisted of goal function (Eq. 1) and minimal (Eq. 2) and maximal restriction (Eq. 3) of a nutrient intake were the last inequality represents the consumers' preference (Eq. 4 and 5).

$$\min F = \sum_{j=1}^{N_d} P_{d,j} \cdot d_j \qquad (1)$$

where $P_{d,j}$ denotes the price of a dish (d), d_j the dish of the item j that presents: breakfast, snack, lunch, meal before the training, meal after the training, dinner and meal before bedtime.

Constrains that are subjected to the goal function present the restriction of energy and nutrient content of the daily offer:

$$\sum \alpha_{ij} \cdot d_j \geq \beta_i, \min \qquad (2)$$

$$\sum \alpha_{ij} \cdot d_j \leq \beta_i, \max \qquad (3)$$

where: $\alpha_{i,j}$ denotes the observed information (i) of the dish about the dishes (j) and β_i denotes the range of the tolerable amounts of observed information's (energy, water and observed 22 nutrients), (mass of consumed food, content of proteins, fats, MUFA, PUFA, SFA, cholesterol, carbohydrates, dietary fibres, Na, K, Ca, Mg, Fe, P; vitamins: B_1, B_2, niacin, B_6, C, A and E).

$$\sum \omega_{ij} \cdot d_j \geq \varepsilon, \min \qquad (4)$$

$$\sum \omega_{ij} \cdot d_j \leq \varepsilon, \max \qquad (5)$$

where: $\omega_{i,j}$ denotes the preference note of each dish (j) and ε denotes the minimal or maximal acceptable sum of range of the tolerable amounts of observed information's.

Input matrix consisted of 49 different dishes (7 breakfasts; 7 snacks; 7 lunches; 7 meals before the training; 7 meals after the training; 7 dinners and 7 meals before bedtime) where each dish was defined by its amount of energy and observed nutrients. The fifth group of dishes (meals after the training) were optional and could be included depending to the consumers´ daily schedule.

The additional aim in this research was also to examine the usefulness of optimisation tools that were used. In order to identify the critical variables (individual meals) or constrains (nutrient requirements), the sensitivity test was used.

Presentation of the final results was done by Analysis of variance (ANOVA) from computer program *Statistica ver 8.0.*

Results and Discussion

A large number of athletes use glucose and supplementation of vitamins, especially vitamin C (Maughan, 2000). In this study raisins were used as the source of glucose, orange juice as a very qualitative source of vitamin C and nuts as good source of vitamin E (Frketić, 2012).

The breakfasts and the meals before bedtime were usually combined with milk and dairy products. The meals before and after training were combined with protein and glucose sources and water. The composition of the first snack was usually dictated by the consumers' daily schedule. It was provided a convenient snack and for this purpose was usually served a salami or ham sandwich with low-fat (1 %) or cottage cheese combined with fruits. Each dinner was began with soup and was contained the dessert in the shape of a fruit. Training was held in the gym in the afternoon and so before and after training two specific meals were served, composed mandating literature (Brink, 2006). The LINDO program was skipped the meal after training offering more proteins and desert in the dinner. Dinner was always consisted of curd cheese because it is a source of slow-digesting protein (Maughan, 2000) and thus was served as the constant and optimal supply of body protein during the night (Brink, 2006).

Vegetable oils, especially olive oil, nuts, green vegetable and citruses were included in the recipes in order to avoid the multivitamin supplementation in tablet with special emphasis on vitamin C and E as powerful antioxidants (Maughan, 2000; Sobal and Bisogni, 2009), and omega-3 fatty acids.

With both programs optimal weekly offers were determined and were in accordance with consumers' preferences and financial capabilities as well as with his daily schedule and obligations.

The data basis of meals was built up of 49 dishes and in the ideal case available set of daily offers would consist of 823543 possible offers. The optimisation tools were clarified well balanced combinations (daily offers) concerning the required energy and nutrient content of the athletes. Energy intake of the daily offers determined by using different optimisation tools is presented with Fig. 1.

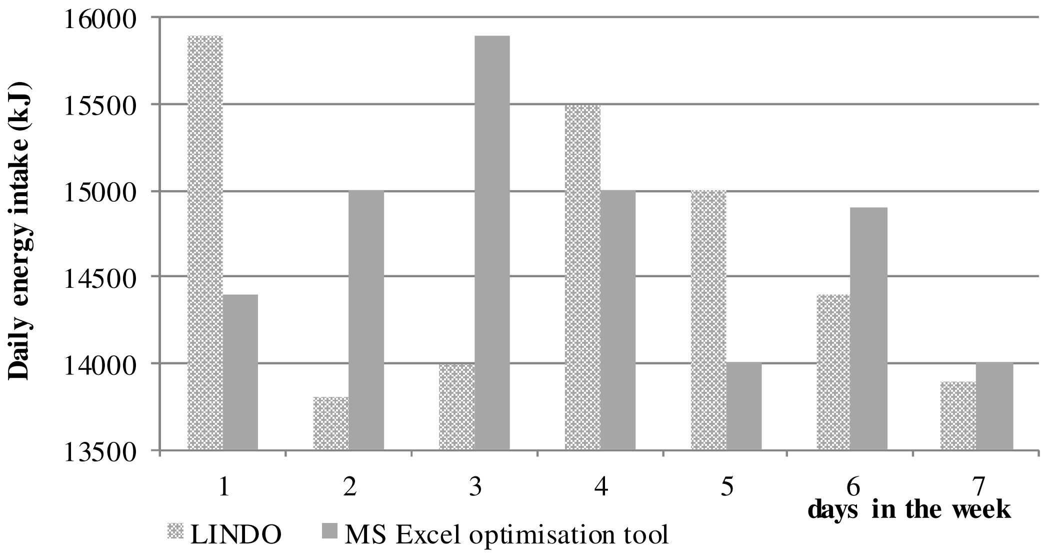

Fig. 1. Daily energy intakes in the weekly menu offer for athletes

Looking the daily offers separately, the energy contents varied during the week as well as regarding the computer program that was used (Table 2a and 2b). Furthermore, the daily offers in the weekly menu can be redistributed during the week for smoothing differences in content and food mass between two neighbour days.

Table 2a. First optimal daily menu determined by LINDO program

Breakfast	Snack	Lunch
Oatmeal (80 g) with milk (300 ml) and honey (5 g), banana 120 g Corn bread, (30 g) with cream cheese and ham (25 g) Orange juice 200 ml Water, 100 ml	Water, 300 ml Ham, 100 g Crunchy wheat bread, 30 g Cheese, 20 g Strawberries, 100 g	Vegetable soup, 250 ml Grilled Veal, 150 g with Rice, 60 g, Red chicory, 40 g Crunchy wheat bread, 30 g Orange juice 200 ml Water, 500 ml

Meal before training	Dinner	Meal before bedtime
Water, 500 ml Protein bar, 20 g Raisins, 50 g	Beef with pasta, 280 g Lettuce, 50 g Raisins, 50 g Almonds, 40 g Water, 500 ml	Fresh cottage cheese, 150 g Crunchy wheat bread, 30 g Water, 100 ml

Table 2b. First optimal daily menu determined by optimisation tool of MS Excel

Breakfast	Snack	Lunch
Milk permanent 0.9 %, 400 ml Corn flakes, 150 g Fresh cottage cheese, 150g Water, 100 ml	Water, 300 ml Salami, 100 g Crunchy wheat bread, 30 g Cheese, 20 g Tomatoes, 85 g Apples, 200 g	Chicken soup, 250 ml Grilled Chicken, 170 g with Spinach, 60 g, Potatoes, 80 g and Cabbage, 40 g Crunchy wheat bread, 30 g Apples, 150 g Water, 500 ml

Meal before training	Meal after training	Dinner	Meal before bedtime
Water, 500 ml Protein bar, 20 g Raisins, 50 g	Water, 500 ml Protein bar, 20 g Raisins, 50 g Orange juice, 200 ml	Risotto with tuna, 260 g Green salad, 40 g Nuts, 35 g Water, 500 ml	Fresh cottage cheese, 150 g Water, 100 ml

The costs for all meals were calculated based on the ingredients and the preparations costs.

According the constructed data basis of meals for athletes, the average values (and prices) are given in Table 3. Calculated values allow the analysis of the menu offers for the athletes. Those values are a sum of the nutrient amounts from different foods that are components of a dish and the impact of the food preparation is taken in calculation according to the tables of retention factors (USDA, 2007).

Table 3. Calculated average intake and differences in the daily offer of the athlete

Observed parameters	Average values		
	LINDO optimisation	MS Excel optimisation	Differences MS Excel vs. LINDO
Proteins (g)	234	245	4.5 %
Fats (g)	105	111	5.4 %
Carbohydrates (g)	383	364	-2.5 %
Vitamin A (µg)	2550	2566	0.6 %
Vitamin E (mg)	110	123	10.6 %
Vitamin B_1 (mg)	2.5	2.4	4.0 %
Vitamin B_2 (mg)	3.3	3.5	5.7 %
Niacin (mg)	56	57.2	2.1 %
Vitamin B_6 (mg)	3.9	4.1	4.9 %
Vitamin C (mg)	950	1717	44.7 %
Sodium (mg)	3200	3776	15.2 %
Potassium (mg)	3312	3880	14.6 %
Calcium (mg)	2806	3008	6.7 %
Magnesium (mg)	1498	1501	0.2 %
Iron (mg)	25	22	-12.0 %
Phosphor (mg)	1581	1573	-0.5 %
Price (EUR/day)	10.89	11.11	1.9 %

Average values obtained using LINDO and MS Excel optimisation tools seem to differ slightly from the recommended values (Table 1). The reason is the range of the nutrient tolerable amount (Eq. 2 and 3) that is allowed to be ± 15 % of the recommended intake, as the minimal and maximal amounts of the observed nutrient Đunđek et al., 2011; Darmon et al., 2002). But for some nutrients are expected great benefits consuming them (as vitamin C), then is the equation defined just with the lowest amount of the nutrient that is expected in the optimal offer. This is the reason why has the content of vitamin C exceeded the recommended values for almost 45 %. In case of potential damages per athletes health caused by overdoses the maximal intake also can be defined in the constrain set in the model. Correlation coefficient between results from two programs was calculated in *Statistica ver. 8.0.* For nutrient amounts recalculated in the same mass unit (gram) was found to be 0.99928 (R^2=0.99856, p<0.05).

Analysis of variance presented in Table 4 demonstrates differences between sum, average values and variances calculated for results obtained by two used programs (presented in the Table 3).

Table 4. ANOVA results from Statistica ver. 8.0

	N	Mean	Median	Sum	Variance	Std. Dev.	Coef. Var.	Standard Error
LINDO	21	41,04	1,581	861,88	9088,9	95,336	232,29	20,804
MS Excel	21	42,09	1,717	884,02	9030,2	95,027	225,74	20,737

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	11,66938	1	11,66938	0,001288	0,971549	4,084746
Within Groups	362382	40	9059,551			
Total	362393,7	41				

Scatterplot of calculated average intake values is presented in Fig. 2.

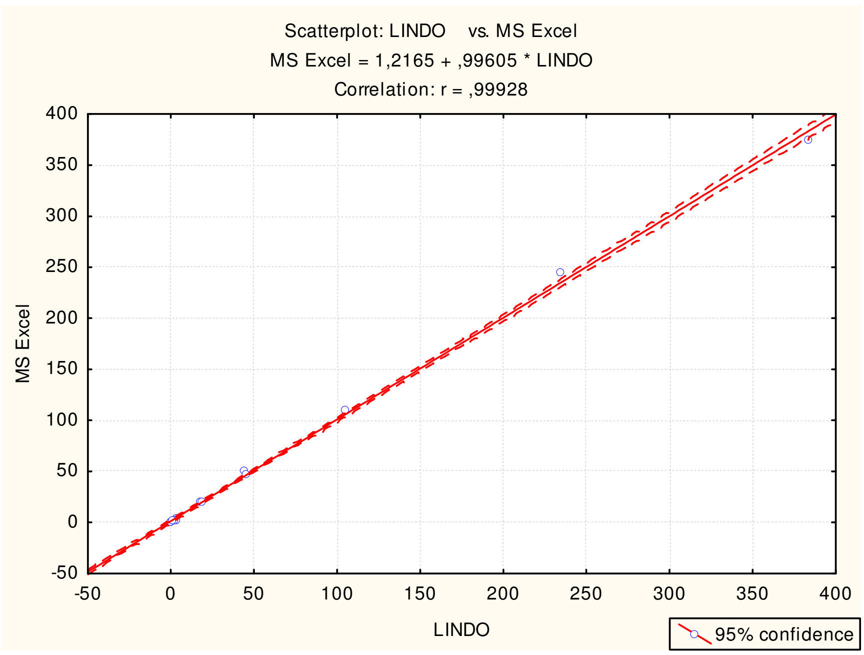

Fig. 2. Scatterplot of average intake values calculated for models in MS Excel and LINDO

The results obtained in this paper (partially presented in the Table 4) show that the average daily energy intake is about 200 calories less than the recommended 3500 kcal/day (14651 kJ/day) and it was due to personal preferences of the consumer. At higher energy intake in diet for bodybuilders, increased mass of adipose tissue or total body mass can be observed (Dente, 2004; Driskell and Wolinsky, 2008; Driskell, 2007). Because of that fact and the aim of fat mass reduction the energy offer was slightly decreased in the daily intake.

Slight difference was detected in the protein intake determined by two programs (Fig. 3). It was just an effect of combining dishes in a daily offer. In both weekly menus the amount of proteins had value in recommended range and could enable muscle growth. The average protein intake in one week was calculated to be 239 g/day. That is approximately 2.6 g/kg of the athletes' body mass and is totally equal to targeted value in this study. The recommendation for protein intake of 27 %of daily energy intake and 2.6 g/kg BM seems to be high but is in accordance with the acceptable macronutrient distribution range of DRIs (2005) of 10-35 %, and is following the Guidelines for chronic protein intake for athletes (Genton, 2011). High protein diets could be a concern for healthy individuals potentially causing kidneys problems (Lemon, 1997), but it is unclear why a high incidence of kidney problems is not found in the middle aged strength athletes as many of these individuals have consumed these types of diets regularly for years (Genton, 2011). Further, studies on animals with extremely high protein intakes (up to 80 % protein) for more than half their lifespan have not revealed any serious adverse effects (Zaragoza, 1987; Lemon, 1997). Poortman and coworkers (2000) compared the clearance of creatinine, urea and albumin of bodybuilders to that of athletes consuming moderate protein diets and did not find any adverse effects with protein intake up to 2.8 g/kg. Fat intake was 117 g/day and is in accordance with the consumers' preferences – not to fill the organism with too much fat, to avoid the increase of body mass. The average value of carbohydrate intake throughout the week was showed acceptable average deviation of 3.82 %. Such variations in optimization process are ultimate because the optimisation tools look for a result in a range of nutrient intake mostly with ± 5 to 10 % tolerance from the recommended intake of the observed nutrient (Koroušić Seljak, 2009).

The average values of selected micronutrients that have been compared with the RDA values are also presented in Table 3. Average intake of sodium is found to be acceptable and should be observed in accordance with the RDA values regarding the high physical activity that results with mineral loss through sweat (Driskell, 2007; Driskell and Wolinsky, 2008). Calcium and magnesium slightly exceed the recommended values, but they are kept in a 2:1 ratio which is in accordance with reference recommendations (Perkov, 2001). Among other micronutrients a slight surplus should be noted in intake of niacin (just 2.6 mg) because of the fact that too much niacin causes the anti-ergogenic effect i.e. spent of fatty acids would be blocked causing faster depletion of glycogen (Perkov, 2001; Driskell, 2007, Dente, 2004).

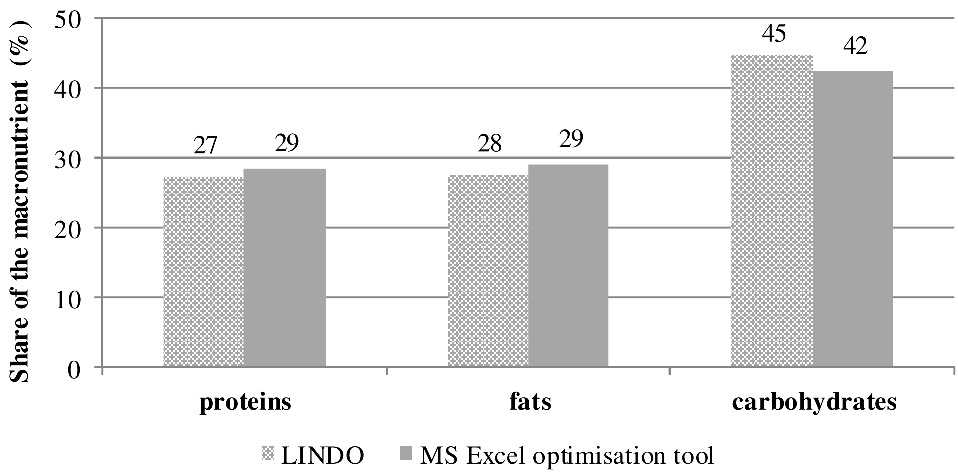

Fig. 3. Average content of macronutrients in the weekly menu offers for athletes, calculated using different optimisation tools

Significant advantage of the used model is certainly the control of the menu costs that ranged from 8.6 to 12.33 EUR per day with the average price of 10.47 EUR per day. Calculated costs are in accordance with the targeted financial capabilities of the athlete.

Booth programs achieved the objectives and showed slight differences. Optimisation with the LINDO and optimisation tool from MS Excel 2010 proved to be a very good and effective due to the possibility of complete control over the data and their relationships in finding the best and most effective solution (Koroušić Seljak, 2009). The programs have understandable and clear structure that provides absolute control over all parameters and constraints. When it comes to the fore the ability of programmers, i.e. menu builder, the consumer has almost complete freedom in creating databases, constraints, and finally in creating of menus. In spite of that simplicity in using, experienced dietician is needed to give the "green light" for the optimised daily and/or weekly offers because some important parameter or constrain could be omitted. That mistake would result with more harm than good for the consumers (Maughan, 2000), especially when the goal is to be in good shape, shape the muscles or prepare athletes for the competition.

To detect critical points regarding observed meals and constrains the sensitivity test in LINDO program was used in order to deduct the critical points (Đunđek et al., 2011). The results of the sensitivity test, conducted on the observed constrains, were showed that minor daily menu offers for the athletes are affected by the increase of protein needs. Furthermore, the weekly menu should contain food that will (a) reach the higher protein needs and at the same time simultaneously not to overload the recommended intake of fats and (b) be rich with vitamin C, glucose and vitamin E to decrease the supplementation with tablets.

The sensitivity test (Jansen et al., 1997) is referred to as sensitivity analysis or post-optimal analysis. This information can be of tremendous importance in practice, where parameter values may be estimate, questions of type "What if..." frequently encountered, and implementation of a specific solution demanded. Sensitivity analysis serves as a tool for obtaining information about the bottlenecks and degrees of freedom in the problem.

All foods are part of a food group considering the food guide pyramid. The conducted analysis showed whether the serving per day should be increased or not regarding the recommended number of servings (Fig. 4a and 4b).

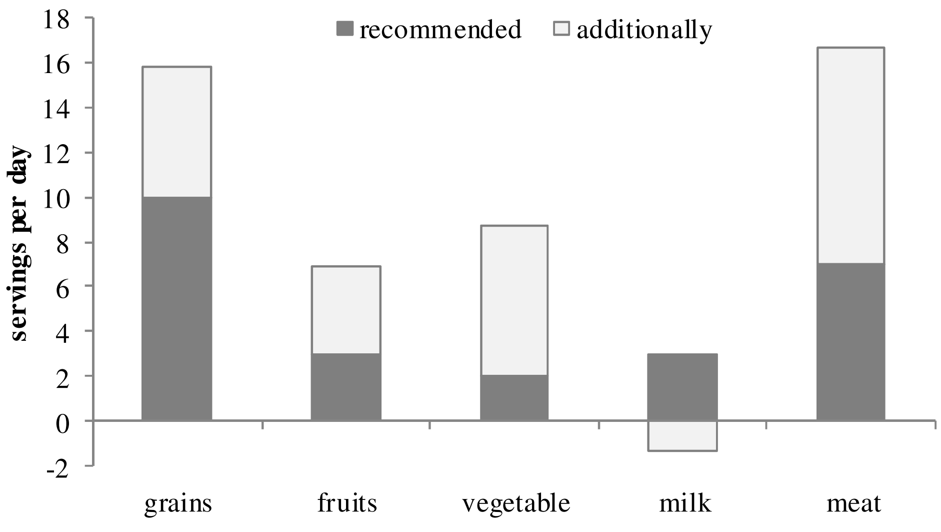

Fig. 4a. One part of sensitivity analysis done in LINDO program

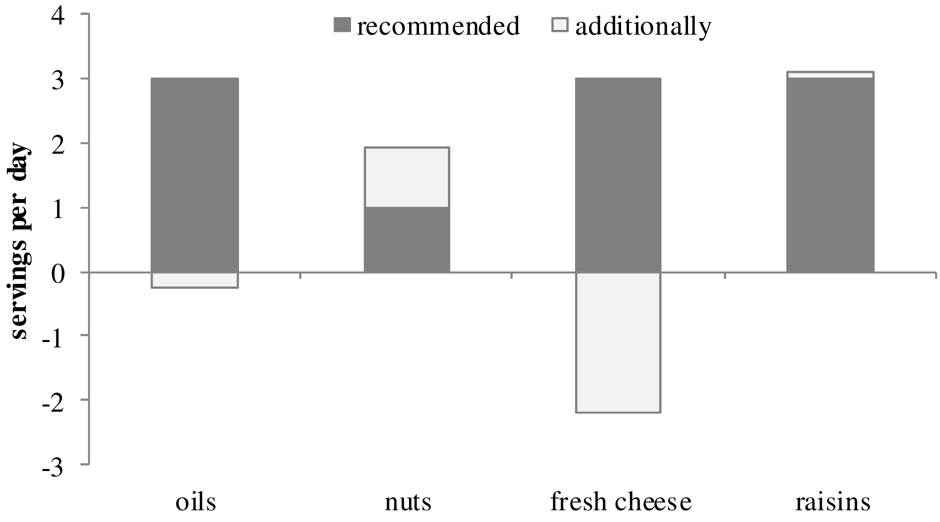

Fig. 4b. Other part of sensitivity analysis done in LINDO program

It is obvious that an increase of servings is allowed in the 4 of 5 food groups except milk that should be decreased from average 3 servings (1.2 serving/day less).

The intake of additional oils, nuts, fresh chees and raisins that are food with qualitative composition was also tested. Analyzed foods were included in the sensitivity test because of their high fat content, richness in dietary fiber, vitamin E or calcium. The calculated calcium intake could be a burden for the kidneys in combination with high proportion of vitamin C. The sensitivity test showed the need of decreased intake of oils (in this category was added butter) and fresh chees (Fig. 4b). Decreasing of the fresh cheese in daily offers could be solved if the determined cheese intake would be spread through a week.

The study of Genton (2011) has shown that in the middle aged strength athletes were not found any consequences of high protein intakes although they have consumed these types of diets regularly for years, our plan for the next study is to follow the athletes diet, performance and their biomarkers in two phases; before and after the period of the diet rich in proteins to see the possible correlations between the observed parameters.

Conclusions

Mathematical models for diet optimization were created and used in this study. Optimization for an athlete was done by using two computer optimization tools according to RDA values for bodybuilders. Model testing and examination showed that determined weekly menus can successfully enable conditions for the hypertrophic muscle enlargement and stay in planned budget.

The weekly menu consisted of daily offers that were distributed in 6 to 7 meals (dishes) as breakfast, snack, and lunch, meal before the training, meal after the training, dinner and meal before bedtime. All daily offers met RDA values and satisfied user's personal demands. Both menus were in accordance with the financial capabilities as well as with daily schedule and obligations.

Determined weekly menus were analysed and compared. Ratio of carbohydrates, fats and proteins in weekly menu of 43:30:27 was chosen as the target. In the menu determined using LINDO program this ratio was found to be 45:28:27 while in MS Excel it was 42:29:29. Calculated ratios are in the region of tolerance for both used programs and can be accepted.

Sensitivity tests from both programs clearly showed that special attention should be paid on food with reduced content of fat and rich on proteins, glucose, vitamin C and E. In determined menus amount of grains, fruits, vegetable, meat, nuts and raisins can be increased while amount of milk, oils and fresh cheese can be decreased. User should be cautious in menu changing according to sensitivity test because costs and total price of weekly menu consequently could be much higher. Both programs successfully solved the problem and determined weekly menus were very similar. Statistical analysis showed between them the very high correlation coefficient of 0.99928 (R^2=0.99856, $p<0.05$) in the total contribution in diet.

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Received: November 19, 2012
Accepted: May 13, 2013