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Nutrition and physical development assessment of pre-school and primary school children practising artistic gymnastics

S.T. KOLIMECHKOV, L.A. PETROV, A.V. ALEXANDROVA AND P. ATANASOV

Department of Physiology and Biochemistry, National Sports Academy "Vassil Levski" – Sofia, Studentski grad, 1700 Sofia, Bulgaria.
E-mail: dr.lubomir.petov@gmail.com

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Abstract

Overweight among children is becoming more and more serious problem worldwide. The maintenance of a normal weight depends on diet and physical activity. One of the few sports which children from pre-school and primary school can practise is artistic gymnastics. The aim of this study was to assess the diet along with the physical development of pre-school and young school children practising artistic gymnastics. In the study took part 38 young gymnasts aged between 4 and 12 years. Anthropometric parameters were measured and the physical development was estimated by specialised software of the World Health Organisation. The Z-score and percentile score for each variable were calculated. The daily intake of protein, carbohydrates and fat, and the total energy intake were calculated based on a nutrition questionnaire adapted especially for children. The results showed that the protein intake was higher and the carbohydrates and fat were lower in comparison with the national population survey data for the same age group. According to BMI 72% of the young gymnasts were with normal weight and 19% were overweight. However the body mass index did not provide adequate weight assessment for young gymnasts, who had greater muscle mass. In conclusion, for better evaluation of overweight and obesity in young athletes the use of additional indicators such body circumferences, % body fat and dynamometry is recommended. In overweight children the aerobic exercises during the warm-up should increase. The nutrition questionnaire used provides a good estimation of the average level of nutrients and energy intake.

Keywords: Anthropometry, athletes, BMI, diet, energy.

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Introduction

Obesity and overweight amongst children are becoming a serious problem around the world. In 2013 overweight children under the age of five were forty-two million which represents more than one quarter of worldwide children (WHO, 2015). Overweight and obesity among schoolchildren is a significant problem in Bulgaria, too. Comparative analysis shows an increase in obesity in

pupils of both sex (Rangelova, Petrova, Konstantinova, Duleva & Dimitrov, 2014).

It is well known that the reasons for increase in weight are a low level of physical activity and unhealthy nutritional habits. Many authors highlight the fact that this weight gain is mainly due to low physical activity, rather than increased energy intake (Booth, Denney-Wilson, Okely & Hardy, 2005; Goran, Carpenter, McGloin, Johnson & Weinsier, 1995). It is recommended that youngsters spend at least one hour per day engaged in light to moderate physical activity, such as jogging, jumping, dancing and different kinds of sport (Elliot, Erwin, Hall & Heidorn, 2013).

Artistic gymnastics is one of the few sports which children from pre-school and primary school can practise. It develops those main qualities that define physical fitness: strength, speed, endurance and flexibility. The floor exercises and the apparatuses provide a huge variety of movements which lead to positive outcomes for the pupil's physical development (Pajek, Cuk, Kovac & Jakse, 2010). Gymnastics offers a great range of movements and body control which are crucial for children's growth. Moreover, it requires transitions from dynamic to static elements and vice versa, frequent changes of the body position in space (Alpkaya, 2013).

The repeated physical activities require a proper nutritional regimen, providing the right amount of proteins, fats and carbohydrates, maintaining energy intake and optimal amounts of vitamins and minerals. Nutrient needs are higher during adolescence than at any other time in the life cycle. Among young athletes, particularly in sports that focus on body composition and appearance like gymnastics, many are deficient in some of the key nutrients. It is critical that all athletes make nutrition a top priority if they want to win at sports and to have a good health (Nisevich, 2008).

There are a number of studies concerning the optimal value of the nutrient intake in children. In Regulation №23 for the physiological nutritional norms of the population in Bulgaria, it is recommended for children aged 7-10 years to consume: 0.95 g/kg/day complete protein (from animal sources - eggs, meat, chicken, fish, milk); fat - 61 g/day for boys and 54 g/day for girls, which gives 25-30% of the total energy; and carbohydrates - 300 g/day for boys and 266 g/day for girls, which provides 55-65% of the total energy (Regulation N23, 2005).

The recommended nutrient intake for children and adolescents who are engaged in extra physical activity is different from that in ones who are not involved in sports. It is believed that for high intensity training, about 65-70% of energy should be provided by carbohydrates. It is recommended for gymnasts that they

should increase their energy supplies of carbohydrates at least an hour and a half before the start of training or a competition. Energy reserves should be restored to their formal level within the first two hours after training (British Gymnastics, 2005). Another study relating to children practising sports recommends additional intake of carbohydrates for very light intensity training - 3-5 g/kg body weight, for moderate or heavy training – 5-8 g/kg, for pre-event 'loading' (24-48 hours prior) – 8-9 g/kg, for post-event refuelling (within 2-3 hours) - 1.7 g/kg (Nisevich, 2008). When the glycogen stores are depleted, the body increases the use of proteins for energy (Thompson, 1998).

Child athletes need more protein than the recommended intake for those children who are not involved in physical activity. It is necessary that 15% of total daily calories come from proteins and 25-30% from fats (Johnson, Russ & Goran, 1998). Compared to adult athletes, young athletes use more free fatty acids than carbohydrates as an energy source when performing sports activities. It has been acknowledged that there is a significantly greater increase in the level of free glycerol in the blood during prolonged exercise (30-120 min.) in children as compared to adults (Unnithan & Goulopoulou, 2004).

It is advisable for children involved in gymnastics that they should not accumulate too much body weight. The increased body weight leads to deterioration of the gymnastics technique. Moreover, it increases the risk of injuries due to excessive weight on the structure of the body (British Gymnastics, 2005). Therefore, it is essential to have an adequate estimation of the energy consumption as well as the diet of children practising gymnastics, in order to guide their proper and harmonious physical development and successful participation in sports activities. Thus the aim of this study was to assess the diet of pre-school and young school children practising artistic gymnastics in relation with their physical development, which complements a previous study of our research group (Kolimechkov et al., 2013).

Methodology

Participants

The study involved 38 children (20 boys and 18 girls), between the ages of 4 and 12 years, attending gymnastics classes at the "Sports Centre Levski", city of Sofia (Bulgaria), 2012. They were made up of two groups: pre-school (4-6 years of age) and primary school (7-11 years of age).

The standing height of the children was measured to the nearest 0.1 cm with a stadiometer. Body weight was measured to within an accuracy of 0.05 kg with an electronic scale; the subjects were barefoot and they wore T-shirts and shorts. The body mass index (BMI) was calculated using the standard formula:

BMI (kg/m^2) = Body weight (kg) / Height^2 (m)

A specialised software designed by the World Health Organisation (WHO) – "WHO Anthro" (for children under six years of age) and "WHO Anthro Plus" (for children over six years of age) was used to analyze the physical development of children (WHO, 2007). For each variable we calculated the Z-score and percentile score for the relevant age. To distinguish the BMI scores, we used references provided by the WHO for children from 5 to 19 years of age (overweight > +1 SD, obesity > +2 SD, thinness < -2 SD, severe thinness < -3 SD).

Body composition

To determine body composition and body fat percentage, the skinfold measurement was used. The measurement of skin folds was carried out with a caliper (Lange Skinfold Caliper, Cambridge) to an accuracy of 1 mm. Body fat percentage (% fat) was determined by the sum (Sum) of the two skin folds – triceps and scapula, using the equations of Slaughter (Slaughter et al., 1988), as they are specifically recommended for male and female adolescents because of their accuracy and simplicity (Boye et al., 2002; Laurson, Eisenmann & Welk, 2011).

Boys under 10 years of age: $\%Fat = 1.21 \times Sum - 0.008 \times Sum^2 - 1.7$
Boys between 11 and 13 years of age: $\%Fat = 1.21 \times Sum - 0.008 \times Sum^2 – 3.4$
Girls – all ages: $\%Fat = 1.33 \times Sum - 0.013 \times Sum^2 – 2.5$

Nutrient intake

The food frequency questionnaire which had been used for adult athletes (Zaikova et al., 2012) was adapted for the purposes of this study in order to assess the nutrient intake of the children. The nutritional questionnaire was made up of 24 questions relating to the weekly consumption of basic foodstuffs and questions about the physical activity, height and weight of children. The questionnaires were completed by the children's parents with the participation of a doctor from the research team.

For children over 6 years of age (who go to school by themselves, and thus can buy food on their own, a fact which is not always known to their parents) we added additional questions about the food consumed outside of the home. Based on the results, the daily intake of proteins, carbohydrates and fats, protein/kg body weight, in addition to the total daily energy intake (kcal/24h) was calculated.

The basal metabolic rate (BMR) in kcal/24h was calculated using the formulae of Harris-Benedict (Blinman & Cook, 2011). The estimated daily energy expended (kcal/24h) was derived by employing the BMR coefficient for physical activity (Harris & Benedict, 1919), for which we adopted a value of 1.4 for children practising 3 times per week, and 1.6 for children practising 6 times a week.

Statistics

The statistical processing was conducted with Excel 2007 spreadsheet, using descriptive statistics and Student's t-test. Statistically significant differences between the average values was evaluated at $p<0.05$. All data in the text are presented as average ± SD.

Results

The data in Table 1 show the average anthropometric variables of the males and females who participated in this study, with respect to boys and girls from pre-school (3-6 years of age).

Table 1: Anthropometric data of the studied pre-school children 3-6 years (Average ± SD)

Variables	**Males (n=7)**	**Females (n=5)**
Age (y)	5.00 ± 0.58	5.6 ± 0.89
Sports experience (months)	7.43 ±5.35	24.6 ± 12.28
Height (cm)	112.2 ± 6.25	116.6 ± 5.91
Z-score	-0.28 ± 0.65	0.10 ± 0.87
Percentile score	40.23 ± 22.50	50.40 ± 25.94
Weight (kg)	18.83 ± 2.83	21.6 ± 3.11
Z-score	-0.39 ± 0.77	0.25 ± 0.66
Percentile score	38.57 ± 22.80	58.64 ± 23.17
BMI (kg/m^2)	14.91 ± 1.30	15.79 ± 1.06
Z-score	-0.37 ± 1.03	0.24 ± 0.67
Percentile score	39.46 ± 32.17	59.5 ± 23.92
Percentage body fat (%)	12.07 ± 2.21	14.66 ± 2.74

The data in Table 2 show the average anthropometric variables of the males and females, primary school (7-11 years of age) boys and girls.

For some children, the values for height and weight, indicated by their parents in the questionnaire, differed significantly from those that we measured (data are not shown).

Table 2: Anthropometric data of the studied primary school children 7-11 years (Average ± SD)

Variables	Males (n=13)	Females (n=13)
Age (y)	7.55 ± 0.16	8.7 ± 0.67
Sports experience (months)	26.82 ± 4.61	14.8 ± 4.42
Height (cm)	126.3 ± 1.17	131.8 ± 3.82
Z-score	-0.28 ± 0.19	-0.27 ± 0.35
Percentile score	40.24 ± 6.38	44.6 ± 9.69
Weight (kg)	25.54 ± 0.84	30.87 ± 3.22
Z-score	-0.10 ± 0.24	-0.02 ± 0.41
Percentile score	47.39 ± 8.12	52.5 ± 11.11
BMI (kg/m$^{2)}$	16.01 ± 0.48	17.30 ± 0.89
Z-score	0.04 ± 0.31	0.30 ± 0.27
Percentile score	50.86 ± 10.02	58.46 ± 8.56
Percentage body fat (%)	12.53 ± 0.84	17.36 ± 1.78

The calculated individual Z-scores of the BMI showed that there were no children classified as thin (Z-score < -2) or obese (Z-score > 2). However, seven children were found to be overweight (1 < Z-score < 2) (Figure 1).

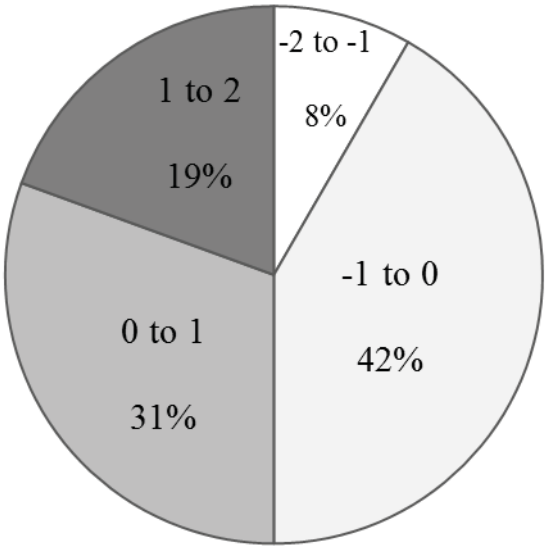

Figure 1: BMI Z-scores and the corresponding percentage of all children who formed the basis of our study falling into each category

Table 3 shows data of the dietary intake of children (3-10 years of age) who took part in the study, compared with the data for the same age group from the Nutrition Survey of the Population of Bulgaria, 1997 (Petrova et al., 2003). There was a relatively higher amount of protein intake in children from our group compared to the country-wide survey (60.4 g/24h versus 46.2 g/24h for 3-

6 years of age and 73.9 g/24h versus 55.6 g/24h for 6-10 years of age), while the calculated amount of carbohydrates and fat showed lower values for the children from our study. The energy proportions of essential nutrients - proteins, carbohydrates and fats calculated from the questionnaire completed by the both groups of children we studied, compared to values from the national study, were respectively 16% : 48% : 33% versus 10% : 52% : 37% for 3-6 years of age, and 16% : 47% : 34% versus 10% : 49% : 40% for 6-10 years of age. The energy intake was slightly higher in children from the Bulgarian population study in comparison with those from our studied groups: 1740 kcal/24h compared to 1503 kcal/24h for 3-6 year olds, and 2069 kcal/24h compared to 1831 kcal/24h for 6-10 year olds.

Table 3: Food intake data of the children from our study (aged 3-10 years) and children of the same age group from the Nutritional Survey of the Population of Bulgaria, 1997 (Petrova et al., 2003) (Average ± SD; NA – data not available)

Variables	**3-6 years of age, urban population, Bulgaria 1997**	**3-6 years of age, children under study (n=12)**	**6-10 years of age, urban population, Bulgaria 1997**	**6-10 years of age, children under study (n=26)**
Basal metabolic rate (kcal/24 h)	NA	935 ± 114	NA	1032 ± 73.5
Expected energy expenditure (kcal/24 h)	NA	1423 ± 243	NA	1558 ± 135.9
Energy intake (kcal/24 h)	1740 ± 479	1503 ± 330	2069 ± 518	1831 ± 432.2
Protein (g/day)	46.2 ± 12.3	60.4 ± 14.69	55.6 ± 14.7	73.9 ± 19.1
Protein (E %)	10.5	16.0 ± 1.7	10.7	16.1 ± 2.35
Protein/kg	NA	3.23 ± 0.87	NA	2.94 ± 0.86
Carbohydrates (g)	228 ± 70	182 ± 45.6	254 ± 72	217.1 ± 59.3
Carbohydrates (E %)	52.2	48.4 ± 4.7	49.1	47.3 ± 5.59
Fat (g)	72.6 ± 21.6	55.6 ± 12.9	92.4 ± 29.5	70 ± 18
Fat (E %)	37.3	33.3 ± 3.9	40.2	34.4 ± 4.47

Figure 2 shows the average age, sports experience and energy proportion of proteins, fats and carbohydrates in overweight children and young athletes (with more than 2 years sports experience and participation in national competitions), the mean age of overweight children was higher by 1.5 years. There were an identical energy proportion of the essential nutrients for both categories.

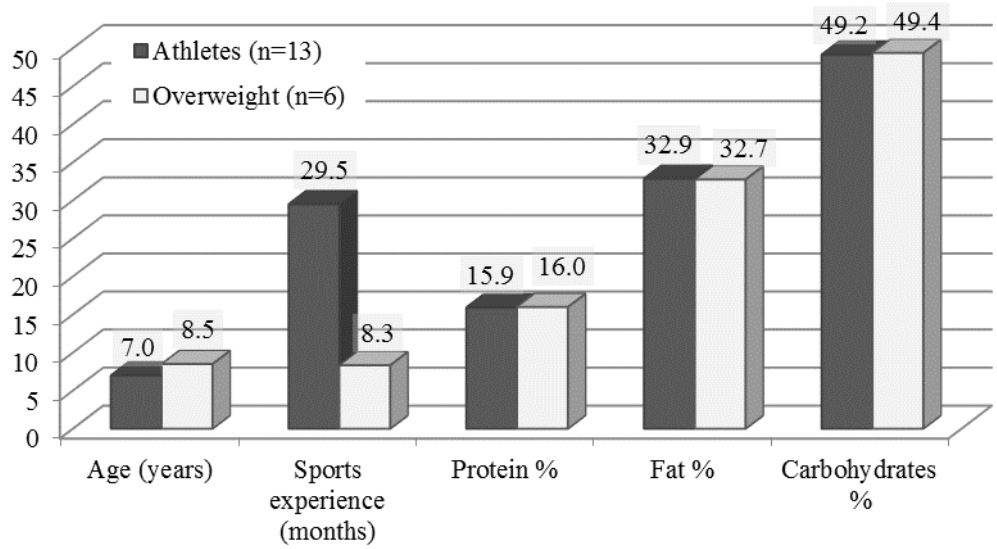

Figure 2: Average age (years), sports experience (months) and energy proportion of the essential nutrients in overweight children (n=6) and young athletes (n=13)

Table 4 shows the calculated energy intake in relation to the expected energy expenditure, as well as the consumed intake from food in terms of protein, fat and carbohydrates per kg body weight in the group of overweight children and in the group of children athletes who have participated in competitions. The only statistically significant difference was established in the energy expenditure per kg body weight, which in the overweight group was considerably less than the energy intake.

Table 4: Energy expenditure and energy intake; protein, fat and carbohydrate / kg body weight (Average ± SD) in the overweight children (n=6) and children athletes who participated in competitions (n=13)

Variables	Competitors (n=13)	Overweight children (n=6)	t-test
Energy expenditure (kcal/kg/24h)	70.16 ± 8.82	48.73 ± 8.98	p<0.001*
Energy intake (kcal/kg/24h)	72.32 ± 21.19	63.65 ± 15.28	p>0.05
Protein (g/kg)	2.87 ± 0.86	2.57 ± 0.80	p>0.05
Fat (g/kg)	2.65 ± 0.88	2.30 ± 0.50	p>0.05
Carbohydrates (g/kg)	8.86 ± 2.62	7.86 ± 2.02	p>0.05

The relationship between positive energy balance and obesity is illustrated in Figure 3. The ratio (energy intake / energy expenditure) in the overweight children was 1.27, which meant that the energy intake exceeded the energy expenditure by approximately one third. The average ratio in the children athletes who have participated in gymnastics competitions was 1.03, which

indicated a neutral energy balance (the taken calories were equal to the expended calories) hence weight was maintained at normal levels.

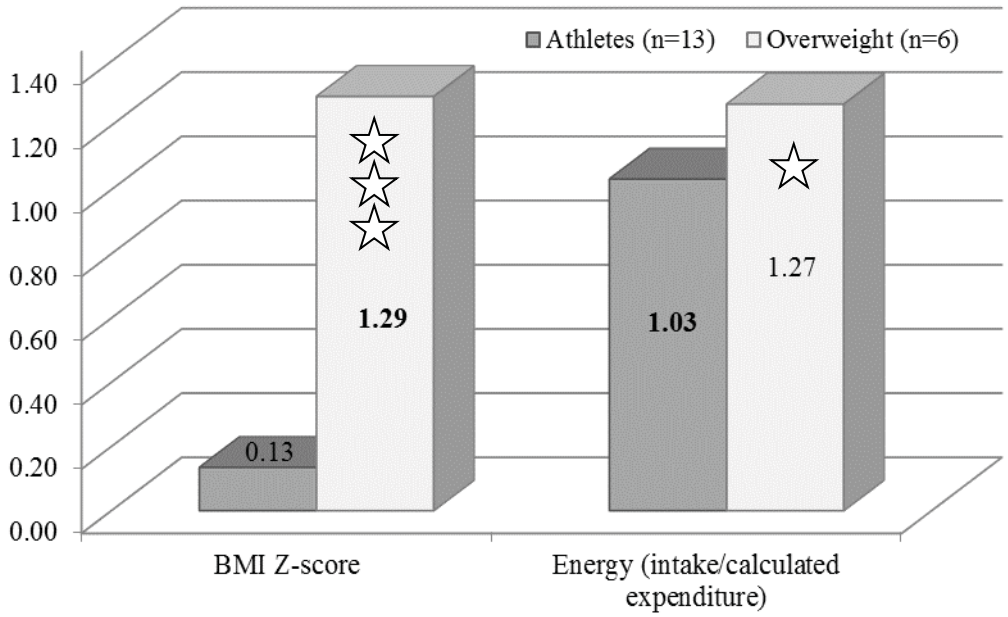

Figure 3: BMI Z-score and ratio (energy intake)/(energy expenditure) in the overweight children (n=6) and the children athletes who participated in competitions (n=13) (* $p < 0.05$; *** $p < 0.001$).

Discussion

The proper development of adolescents requires adequate diet and appropriate physical activity. Nowadays many children suffer from overweight and obesity and the main reason is not as the abundant eating as the lack of sufficient movement. Many parents enrol their children to practice some kind of sport. Gymnastics is considered as a sport which contributes most to basic physical fitness, as well as symmetry and harmony of the body. Children, who practise gymnastics (especially girls), have a lower percentage of fat and BMI in comparison to those who are not engaged in sports (Jemni, 2011). It has been shown that the range of BMI is between 12.9 and 20.8 kg/m^2 for elite gymnasts aged 7-10 and from 14.6 to 20 kg/m^2 for those between the ages of 11 and 14. Respectively the percentage of fat for these two categories is 5.1% - 16.7% and 6% - 15.1% (Benardot & Czerwinski, 1991). In our study, the BMI values did not differ from the above mentioned research, but we reported a higher body fat percentage for the group of girls aged 7-11 (Table 2).

In our study, according to the BMI Z-scores, only seven children were overweight (Z-score of BMI > 1) amongst the 38 children. These differences

derived from the greater muscle mass of the sportsman with larger practice. BMI is not an appropriate indicator for assessing weight in athletes with great sports experience in different sports (Lutoslawska et al., 2014). Therefore because muscles weigh much more than fat, many adolescent athletes are incorrectly classified as obese based on BMI. It is very likely that in child athletes with greater muscle mass, BMI is not an adequate indicator too. It should be emphasized that the BMI is a measure of the relative body weight and not of the body composition (Etchison et al., 2011). In these cases, additional anthropometric data as % fat, skin folds, as well as strength indicators (data for muscle hypertrophy and dynamometers) should be taken in consideration. There are available methods for assessing the % fat based on only two skin folds (triceps and scapula), which are designed specifically for children and adolescents, and are commonly used in Europe and the USA (Boye et al., 2002). The BMI can be used as an indication of the appropriate weight of children with little or no sports experience, who do not have muscle hypertrophy. Therefore, in regard to young athletes not only conventional weight norms should be used, but also standards developed for particular sports.

The harmonious development of children requires an individual approach to the training process. It includes not only tracking the physical development, but also the nutritional diet (Makaveev & Nikolay, 2012; Makaveev & Nikolov, 2013). A nutritional study, directed at gymnasts aged 7-10, indicated the following average daily values of nutrients: 219g carbohydrates, 68 g protein and 60 g fat, and the estimated energy expenditure was 1651 kcal; and those for gymnasts aged 11-14 years: 227g carbohydrates, 67g protein and 62g fat, energy expenditure was calculated to 1706 kcal (Benardot, Schwarz & Heller, 1989). Our experimental results were similar to these data (Table 3). However we found an increased protein intake in comparison with the results from the survey concerning the Nutrition of the Bulgarian population, 1997(Petrova et al., 2003). Adequate protein intake is crucial for children, especially athletes practicing sports which require physical strength. It has been suggested young female gymnasts to consume protein between 1.45 - 1.76 g/kg (Joubert, 2005), and even between 2-3 g/kg (Benardot, Schwarz & Heller, 1989). In our study we established much higher values: 3.23 ± 0.87 for preschool and 2.94 ± 0.86 for primary school children. These figures were similar to those published by Fulgoni (2.4 ± 1.1 for 4-8 year olds) and those published by Alexy (2.0 ± 0.3 for prepubescent children) (Alexy, Remer, Manz, Neu & Schoenau, 2005; Fulgoni, 2008).

The intake of essential nutrients and gained energy in our study were approximately equal comparing the overweight children and the children-athletes, who participate in competitions. However the energy expenditure was much smaller (Figures 2 and 3) in overweight children. In order to correct the weight of these children coaches should work in two directions. Firstly, the

volume of aerobic exercise in the preparatory part of the gymnastics session must increase, in addition various games and different athletic exercises also may be included. Secondly, foods with high energy content (bakery products, chocolate, candy, etc.) must minimize, and those of fruits and vegetables maximise. The nutritional diet and physical activity of those children should be carefully analysed and discussed between coaches, parents and children. Children need to understand the importance of healthy eating and to accept it as a conscious care for their proper development and physical condition.

In conclusion, the use of nutrition questionnaires is an appropriate method to assess the nutrient intake of children. The nutrition questionnaire used in this study gives a good indication of the average intake of the main food groups, nutrients and energy, which is confirmed by the close accordance between the obtained data and data from other studies.

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