

NUTRITIONAL PRINCIPLES OF ADOLESCENT SWIMMERS

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Abstract Adolescence is a period between age 10 and 19. Intensive changes associated with the development of the organism influence the nutritional needs during this period. Young swimmers' training is characterized by large volume, so their diet can play an important role in their results and future career. The energy intake of a developing athlete should be determined individually based on gender, anthropometric measurement, character, and number of workouts per day. The frequent presence of drowsiness and fatigue during training may indicate insufficient dietary energy supply. Dehydration exceeding 2% of body weight should be prevented. Isotonic drinks should only be consumed during training longer than 75 minutes. Young swimmers should consume adequate amounts of carbohydrates to restore glycogen reserves before another training unit. Carbohydrates with a high glycemic index of 1–1.2 g/kg b.w./h should be delivered during the post-training period. Immediately following training, a meal containing a complete protein should be consumed to accelerate post-exercise recovery. The total protein supply should be at least 1.2 g/kg b.w./h. The minimum intake of fat in the diet of a young swimmer should be 2 g/kg lean b.w. It is recommended to limit products containing large amounts of saturated fatty acids.

Key words adolescent, swimming, nutrition, exercise, sports

Introduction

Adolescence is a period between age 10 and 19. This period is characterized by intense changes, both physiological and psychological. It is also a time of rapid body growth, with up to 45% increase in bone mass (WHO, 2005). Due to the increased intensity of growth processes in the body, nutritional needs are greater than in childhood or infancy (WHO, 2005; Charzewska, Wajszczyk, 2008; Jegier, Nazar, Dziak, 2013). The most intense growth occurs in girls aged 12 and in boys aged 14 (Jegier et al., 2013).

Adolescents with moderate physical activity should consume five meals a day and deliver from 2,100 to 2,500 kilocalories (for girls) or 2,400 to 3,400 kcal (for boys) (Jarosz, 2012). There are no unequivocal recommendations for the energy value of the athlete's diet at adolescence. Because of the metabolic processes and the lack of coordination of exercise, this group of the population spends more energy during physical activity

compared to adults (Jegier et al., 2013; Zając et al., 2014; Bean, 2014). Intensification of growth processes makes it difficult to clearly identify the needs of the young organism (Charzewska et al., 2008; Bean, 2014).

While creating a diet plan for young athletes, the need for energy and nutritional components directly related to sports discipline needs to be taken into account (Zając et al., 2014).

Swimming is a discipline practiced from a very young age (Shaw, Boyd, Burke, Koivisto, 2014). Young swimmers preparing to take part in competitions perform large and exhaustive workouts. In swimming, we distinguish 4 basic styles (butterfly, backstroke, breaststroke, freestyle) and medley (combining butterfly style, backstroke style, breaststroke style and crawl). Athletes competing at various distances from 25 m to 1,500 m (male style) or 800 m (any female style). Short distance competitions (25 m, 50 m, 100 m) are considered as speed-strength. In turn, long distance competitions (800 m, 1,500 m) are recognized as endurance (Shaw et al., 2014).

Swimming workout is aimed at physically preparing the athlete to achieve better results in sports competitions (Vanheest, Rodgers, Mahoney, De Souza, 2014). Proper nutrition plays a key role in improving athletic performance, the course of the training process and can be crucial for the future career of young athletes (Hassapidou, Valasiadou, Tzioumakis, Vrantza, 2002; Bean, 2014).

Dominguez et al. (2017) published a review in which they set the nutritional recommendations for adult swimmers. For young athletes, the recommendations may be different due to physical and mental processes of growth and development

The purpose of this review is to create nutritional recommendations for adolescent swimmers to increase performance and improve athletic performance.

Material and Methods

Articles were found with search in databases PubMed and ScienceDirect. The search terms included: adolescent, swimming, nutrition, hydration, carbohydrate, glycogen, fat, protein.

Inclusion criteria were the following: clinical trial, population were swimmers between 10–19 years old.

Quality of young swimmers' diet

Analysis of the results of the study led by M.N. Hassapidou et al. (2002) showed that the diets of young swimmers were not sufficient to maximize athletic performance. Adolescent swimmers' diet provided the right amount of calories, however, the insufficient supply of vitamins B1, B2, calcium, iron and zinc was revealed (Hassapidou et al., 2002). A.C. Collins et al. (2012) found that young swimmers consumed too little fruit, vegetables, cereal and dairy products. In another study the diet of most swimmers was characterized by an insufficient supply of energy and carbohydrates in relation to the body needs (da Costa, Schtscherbyna, Soares, Ribeiro, 2013).

A.V. de Mello et al. (2015) stated in his study that the BMI score cannot be used as the sole parameter for assessing body composition of adolescent swimmers. Among the measured participants, the BMI index indicated the risk of being overweight, but the percentage of body fat was normal. There was an insufficient supply of vitamin B9, iodine and dietary calcium (de Mello et al., 2015). Table 1 provides a summary of the study data in which swimmers diets were assessed.

Analysis of the results of the study by J.L. Vanheest et al. (2014) showed that an optimal hormonal and metabolic environment should be maintained to maximize athletic performance, which can be ensured through appropriate dietary energy intake. There was a statistically significant decrease in the average swimming speed

by 9.8% in the swimmers' group with reduced serum level of sex hormones (estradiol and progesterone). In the group of athletes, where sex hormones level was adequate, a statistically significant increase in average swimming speed was observed by 8.2%. The study involved swimmers aged 15–17 years. Female swimmers characterized by decreased secretion of sex hormones provided statistically significantly less energy by their diet compared to those with proper sex hormone secretion. All participants of the study trained every day for about 2 hours. Energy expenditure associated with the training was 900–1,225 kcal per day during the twelve-week training period.

Table 1. Trainings, energy intake and percentage of macronutrient in the diet of young swimmers

Study	Number of participants	Average age of study participants	Energy supply	Carbohydrates supply*	Protein supply*	Fat supply*	Training
Kabasakalis et al.	F 16 M 16	10–11 years	n.d.	<50%	>15%	25–30%	3 times per week; 75–90 minutes; 2,687 m/training
J.L. Vanheest et al.	F 10 M 0	15–17 years	2,481–2,530 kcal	57–59%	15.0%	26–28%	Trainings in pool – 13.5 h/wk; Endurance training on land – 1.6 h/wk
H.L. Petersen et al.	F 24 M 0	18–21 years	2,405 kcal	62%	13.0%	24.0%	Training on land: 1.5 h (3 times per week); Training in pool 6 d/wk (9 two-hour trainings, 6,400–10,000 m/training)
D.D. Ramos et al.	F 0 M 6	12–18 years	3,335 kcal	59%	14.6%	26.4%	n.d.
A.V. Mello et al.	F 7 M 8	16–18 years	50.1 kcal/kg b.w. 54.2 kcal/kg b.w.	49%	27%	24%	Training in pool: 5 h; 6 d/wk
T.A. Trappe et al.	F 5 M 0	19.7 years	5,497 kcal	68.5%	11.5%	20.3%	16.8–18.2 km/d
M.N. Hassapidou et al.	F 15 M 20	15–18 years	2,318 kcal 2,720 kcal	47% 44%	1.1–1.5 g/kg b.w. 0.8–2.5 g/kg b.w.	40.6% 42.5%	Total training: 2.5 h/d
A.C. Collins et al.	F 61 M 30	13.7 years	44 kcal/kg b.w. 50 kcal/kg b.w.	52.0%	14.0%	36.0%	Training in pool: 8.6 h/wk
N.F. da Costa et al.	F 77 M 0	11–19 years	52–62.1 kcal/kg b.w.	4.5–6.5 g/kg b.w.	1.7–2.0 g/kg b.w.	26.9–30.6 g/kg b.w.	n.d.
J.R. Berning et al.	F 21 M 22	14–18 years	3,572.6 kcal 5,221.6 kcal	7.35 g/kg b.w. 7.71 g/kg b.w.	1.84 g/kg b.w. 2.14 g/kg b.w.	41.4% 42.8%	n.d.
A.E. Soares et al.	F 30 M 37	15–26 years	56 kcal/kg b.w.** 67 kcal/kg b.w.**	46% 48.6%	2.5 g/kg b.w.** 2.6 g/kg b.w.**	35% 34.5%	10 intense workouts a week for 3–4 h each

n.d. – no data; F – female; M – male.

* Values expressed in% of energy supplied with the diet or per kg b.w.

** In the group of participants aged 15–17.

Energy requirements for young swimmers

The Sports Dietitians Australia (SDA) (Desbrow et al., 2014) states that there is no equation with which it would be possible to properly determine the energy needs of adolescent athletes. The energy spent by the body

of an adolescent athlete on growth and physical development means the difference between energy intake and energy spent with sports activity. Growth and development indicators should be regularly reviewed to determine if the athlete's energy intake is adequate (Desbrow et al., 2014).

Children compared to adults spend more energy during the same exercise due to lack of coordination between agonistic and antagonistic muscles. Improving in a given exercise reduces the energy cost. Among those who exercise irregularly daily energy requirements for boys between 11 and 18 years of age are between 2,250 and 2,755 kcal per day, and for girls from the same age group from 1,845 to 2,110 kcal. For a young athlete who trains daily, it can be assumed that the physical activity level (PAL) indicator is equal to 1.6 for moderate training, 1.8 for moderate and intense training, and 2.0 for intensive training sessions every day. As a result of insufficient energy supply, young athletes may experience a frequent feeling of drowsiness and weakness during training. Among children, oxygenic metabolism prevails, and the main source of energy used during activity is fat. Energy costs of swimming can range from 4.3 MET (Metabolic Equivalent) to 13.6 MET while swimming at an average speed of 2-4 km/h respectively (Barbosa et al., 2006). A young athlete can burn up to 700 kcal/h of swimming (Bean, 2014).

One study found that daily energy need of adolescents girls swimming on average 4.3 km per day was 2,300 kcal. For heavier workouts, it can be up to 3,000 kcal per day (Ousley-Pahnke, Black, Gretebeck, 2001). In a study conducted by T.A. Trappe, A. Gastaldelli, A.C. Jozsi, R.R. Wolfe (1996), it was observed that on training days the total metabolism of female swimmers aged 19.7 was approximately 5497 kcal. Athletes swam every day on average 18.2 km of freestyle or 16.8 km of medley style (Trappe et al., 1996). Other data (Berning, Troup, VanHandel, Daniels, Daniels, 1991) indicate that in the group of swimmers aged 14–18, during the 10,000 m distance boys burned 2,166.7 kcal and girls 1,825.4 kcal on average. In addition, female swimmers were characterized with statistically significantly higher body use of oxygen while swimming compared to the male group. (Berning et al., 1991). In the study led by D.L. Costill et al. (1988) participants swimming 8,970 m a day needed 4,667 kcal to cover the total daily energy demand.

There is not enough information from studies to clearly describe nutrition needs of young swimmers. Growth and development indicators should be regularly controlled not to allow insufficient energy delivery.

Hydration status

Proper hydration is essential to achieve peak performance and to prevent overheating of the organism (Higham, Naughton, Burt, Shi, 2009). Adequate fluid supply during physical activity may facilitate exercise and delay the onset of fatigue. The volume of lost fluid depends on the type, intensity, duration of exercise, temperature, humidity, sex, body surface and individual characteristics of human metabolism (Bean, 2014). Within one hour of exercising, adults may lose 2–4 l of fluid (Bean, 2014, Górski, 2008) and adolescents 350–700 ml (Bean, 2014). In the group of swimmers aged 16–18 years average amount of 2.3 l water of fluid loss per day was observed (de Mello et al., 2015).

Sports Dietitians Australia (SDA) (Desbrow et al., 2014) points out that young athletes should strive to maintain a proper level of hydration throughout the day by supplying fluids such as water and milk. Athletes in adolescence should be educated about proper hydration, especially when fluid supply during exercise is limited or where the environment promotes dehydration. Monitoring body mass changes before and after exercise is necessary to determine the degree of dehydration. Dehydration equal to or greater than 2% body weight (b.w.) should be avoided (Desbrow et al., 2014).

Isotonic drinks during training are recommended only if the activity lasts longer than 75 minutes (Desbrow et al., 2014). For a drink to be classified as isotonic it should deliver 80–350 kcal/1,000 ml and sodium 460–1,150 mg/1,000 ml. The osmolality of the isotonic drink ranges from 270 to 330 mOsm/kg (European Commission, 2001).

Dehydration may increase the subjective feeling of exercise intensity and cause the excessive increase in heart rate. Other signs of dehydration in young athletes may occur, such as muscle cramps, headache, nausea, faster fatigue, loss of strength and reduced concentration (Bean, 2014). In the group of students aged 8–17, no statistically significant association of hydration with cognitive functions such as visual attention, visual memory, short-term memory, visuomotor skills was observed (Trinies, Chard, Mateo, Freeman, 2016).

In the study led by V. Trinies et al. (2016), 42% of students aged 8–17 were diagnosed dehydrated in the morning and this state increased during the day. Ensuring unlimited access to drinking water was significantly correlated with decreased dehydration during the day (Trinies et al., 2016). During swimming there occurs an increased heat loss due to continuous contact with water. In the group of swimmers aged 13–18 years, 85% observed dehydration not exceeding 2% b.w. The authors stated that the subjective assessment of dehydration based on the urine color is an inaccurate method, in contrast to the measurement of urinary specific gravity. In the group of male adolescent swimmers, there was a greater loss of fluid along with the sweat, compared to the group of adolescent female swimmers, suggesting that when performing the same training load, the higher the muscle mass is, the more metabolic heat is produced (Higham et al., 2009).

Study results analysis led by J.D. Adams et al. (2016) deliver similar findings. More than 71% of participants of the study began the training unit being insufficiently hydrated. After two hours of training, during which participants were given drinks ad libitum, there were no statistically significant differences in body weight and subjective feeling of thirst. The author suggested that after the swim training, urine markers of dehydration may not reflect the hydration of adolescent athletes (Adams et al., 2016).

G.L. Briars et al. (2017) analyzed the relationship between hydration status during swimming training with improved performance and existing specific differences in response between individual athletes. For 12 weeks, swimmers, performed an additional task 10 × 100 m, after training unit on Friday. During this training, they drank water, sports drink or did not take liquids at all. During exercise, the center velocity was measured between 25 m and 75 m. The results of the data analysis showed that the fluid intake during swimming is not positively correlated with the average speed of swimming. Four of the nineteen participants swam significantly faster during training, when drinking a sports drink. One person swam significantly faster during training as drinking water. During the study, respondents did not exceed more than 2% of body weight dehydration. The authors suggested that there is another factor besides hydration affecting the swimming performance (Briars et al., 2017).

Other data (Arnaoutis et al., 2015) indicated that 89.8% of adolescent athletes representing different disciplines were dehydrated at the beginning of the training. The urinary specific gravity significantly decreased only in the group of adolescent swimmers. The authors suggested that this could have been caused by submergence of the body in the water (Arnaoutis et al., 2015). Adolescent swimmers should drink enough fluids to prevent dehydration of more than 2% of body weight.

Carbohydrates

Carbohydrates and fats are the main energy substrates for cells. The organism is able to store them and use in case of starvation (Górski, 2008). Increased physical effort enlarge utilization of glucose and free fatty acids from the blood in the cells (Zajac et al., 2014; Górski, 2008).

Sports Dieticians Australia (SDA) (Desbrow et al., 2014) points out that recommendations for the supply of carbohydrates for adult athletes may be suitable for the athletes during the period of adolescence. The carbohydrates intake should depend on the type of discipline, exercise duration, and its intensity. Young athletes within 4 hours after training should provide carbohydrates in the amount of 1–1.2 g/kg b.w./h. The daily intake of carbohydrates with the diet for athletes with low-intensity training sessions should vary between 3–5 g/kg b.w. For those who perform moderate intensity training the amount of 5-7 g/kg b.w. of carbohydrates is recommended. Among young athletes training 4–5 h per day, performing endurance training, the supply of carbohydrates should be at the level of 8–12 g/kg b.w. During exercise that lasts less than 75 minutes it is not recommended to supply carbohydrates, but during a training period between 75 minutes to 2.5 hours, the recommended carbohydrate intake is 30–60 g/h (Desbrow et al., 2014).

D.L. Costill et al. (1988) examined the physiological and psychological changes associated with a sudden increase in exercise volume in a group of swimmers aged on average 19.1 years, training intensively for the 6 months preceding the study. During the training period, which was characterized by increased intensity of the training, the daily energy demand of the studied swimmers was on average 4,667 kcal, the energy needs related to swimming training (on average 8,970 m per day) were 2,293 kcal. Those subjects who were classified as chronically fatigued (not fulfilling the criteria for overtraining status) provided statistically significantly less energy (48.2 vs. 62.8 kcal/kg/d) and carbohydrates (5.3 vs. 8.2 g/kg/d) compared to the other participants of the study. There was a statistically significant decrease in muscle glycogen concentration at day 11 compared to day 0 of the study (110.2 vs 130.5 mmol/kg). Among athletes from the group classified as chronically fatigued, there was a statistically significant decrease in muscle glycogen resources compared to other participants of the study. A 10-day training period with increased training volume did not affect significantly the speed or endurance parameters in the swimmers' group. The authors concluded that lower tolerance of training loads in the group of athletes classified as chronically tired could have been caused by the low muscle glycogen resources status. The authors concluded that the depletion of muscle glycogen resources was due to swimming training and that intensive swimming training was correlated with a decrease in blood lactate concentration. Participants of the study with increased training volume had a problem maintaining proper energy and carbohydrates supply (Costill et al., 1988).

Research conducted by H. Soultanakis, T. Platanou (2008) revealed that during swimming training unit changes in blood glucose concentrations occur. During training with swimmers providing 8 g/kg b.w./d carbohydrates with diet, it was observed that blood glucose level at 60th minute of training was statistically significantly lower compared to pre-workout levels. Among those athletes who delivered 5 g of carbohydrates/kg b.w./d, a comparable decrease in blood glucose was observed 20 minutes after the start of exercise. The value of serum glucose level during training and at the end of it was significantly higher in the group providing 8 g of carbohydrates/kg b.w./d. No case of hypoglycemia occurred among participating athletes during training. The authors concluded that a faster decrease in glucose levels in one group may be caused by a lower glycogen resources in the liver at the beginning of the training. According to the authors, the athletes providing more carbohydrates with the diet could present higher glycogen reserves, which could be responsible for its supercompensation in the liver and muscles.

The authors stated that carbohydrate intake should be determined individually based on intensity and duration of exercise (Soultanakis, Planatou, 2008).

Analysis of results of T. Reilly, V. Woodbridge (1999) showed that changing the amount of carbohydrates in the diet may affect the athletic performance of adolescent swimmers. Increasing energy from carbohydrates was associated with an ergogenic effect on the performance of teenage athletes during swimming training at distances of 100–400 yards at submaximal and maximum speeds. The change in carbohydrate intake was associated with a statistically significant effect on the mean speed when the blood lactate concentration was equal 4 mmol. Among participants of the study who had a reduced carbohydrate supply diet (39.4% vs. 53.6% energy) for 3 days, a statistically significant increase in mean swimming velocity from 0.67 to 0.7 m/s for blood lactate equal 4 mmol concentration was observed. According to the author, the results of the study allow us to question the effectiveness of measuring lactate concentration in blood as a tool for determining the intensity of swimming training for swimmers during adolescence. The study confirmed the ergolytic effect of reduced carbohydrate intake in combination with maintaining a regular workout. Changes in diet carbohydrate supply had a statistically significant effect on the amount of lactate produced while swimming at maximum and submaximal speeds. The author stated that diet and blood lactate concentrations should be continuously monitored (Reilly, Woodbridge, 1999).

In another study conducted by L. Afshari, S. Mohammadi, S. Shakerian, R. Amani (2014) it was shown that in the group of swimmers aged 12–17 the consumption of 200 ml 6% sucrose solution 5–15 min before the 200 m sprint significantly increased the time of swimming compared to the 200 ml group drinking 6% glucose solution or placebo drink which contained aspartame. The authors concluded that the availability of glucose in the blood may affect the exercise capacity of swimmers during adolescence (Afshari et al., 2014).

Other data indicate that insufficient carbohydrate intake in the group of adolescent swimmers may contribute to upper respiratory tract symptoms, such as nasal congestion, sneezing, bronchitis, sinusitis, or rhinitis (Ramos, Toriani, Silva, Dalquano, 2010). Adolescent swimmers, who train few times a day should deliver 8–12 g/kg b.w. carbohydrates daily. Carbohydrate-rich products should be eaten between the training sessions to maintain proper glycogen restoration.

Protein

The role of proper protein intake among adolescent swimmers is immense. During performing an exercise 1–5% of energy is derived from proteins, depending on its intensity. During prolonged exercise of moderate intensity, there is a small increase in alanine concentration and a decrease in glutamine and BCAA levels, which is caused by the increased use of alanine in the process of gluconeogenesis and its reduced de novo production in the muscles. During short-term exercise, characterized by submaximal and maximal intensity, the increase of free alanine and glutamine in the muscles and in the blood occurs. Exercise increases the oxidation of leucine and other branched chain amino acids in the body (Górski, 2008).

Sports Dieticians Australia (SDA) (Desbrow et al., 2014) indicates that in order to determine the protein needs of adolescent athletes, recommendations for adults can be used because the research data to determine protein requirements for the adolescent athletes is insufficient. Protein-rich products should be evenly distributed through the day so that protein supply is steady. A meal rich in proteins should be consumed immediately after workout. The daily amount of protein adequate to cover the growth and development needs, and the maintenance of lean body mass for boys aged 12–13 and 14–18 years is 0.94 and 0.99 g/kg b.w., respectively, whereas in girls at

the same age, 0.87 and 0.77 g/kg b.w. These recommendations may also be suitable to physically active teens. However, they will not be adequate for high-performance athletes during adolescence (Desbrow et al., 2014). Other recommendations suggest that young athletes should deliver 1.1–1.2 g protein/kg b.w. with diet. Growing athletes should know their individual protein requirements and be able to deliver the right amount of protein with conventional products (Bean, 2014). The use of supplements is not necessary for adolescent athletes, but they are acceptable in this age group if they are used to improve the comfort of preparing meals and the quality of food eaten (Bean, 2014; Desbrow et al., 2014).

In S. Krause, M. Langrock, M. Weiss (2002), a statistically significant negative correlation between training volume and BCAA plasma concentration was observed. The authors concluded that the race for 100 meters freestyle did not lead to depletion of glycogen stores, so there was no protein utilization. The authors also found that the body has worse adaptation to exercise after a break in training sessions, which may be characterized by higher levels of ammonia in the blood (Krause et al., 2002).

The research needed to create nutritional recommendations for adolescent swimmers protein intake is insufficient. In order to cover protein needs essential for growth and development processes and physical activity, young athletes should supply at least 1.1–1.2 g/kg b.w. protein a day.

Fat

Apart from carbohydrates, the second most important energy substrate used by working muscles are fats, more specifically, free fatty acids, triacylglycerols in the plasma, triacylglycerols found in muscles and ketones (Górski, 2008).

Sports Dieticians Australia (SDA) (Desbrow et al., 2014) indicates that fat intake among adolescent athletes should be consistent with national guidelines (Desbrow et al., 2014). According to the Nutrition Standards for the Polish population, the percent of fat in the diet of people aged 10–18 should be 20 to 35% of total energy intake (Jarosz, 2012). Young people should consume vegetable oils and fish to provide unsaturated fatty acids. People in adolescence should limit their intake of foods rich in saturated fatty acids. It is also important to draw attention to the high energy density of fat, which, when over-consumed, can promote the formation of adipose tissue (Desbrow et al., 2014). Other recommendations (Bean, 2014) suggest that the proportion of fats in a young person's diet should not be greater than 35% (Bean, 2014).

According to recommendations made on the basis of studies involving athletes of strength sports, which include swimming, athletes who train more than 2 hours a day should provide 2 g of fat per kilogram of non-fat mass daily. This amount is essential for the regeneration of muscle triglycerides stores, utilized during exercise. The supply of fat at this level also aims to assimilate fat-soluble vitamins supplied with the diet, to provide substrates for hormone synthesis and to build cell membranes. It is believed that higher fat intake in strength sports athletes could impair muscle glycogen recovery and muscle tissue regeneration. However, there are no recommendations whether the same dietary fat recommendations also apply to young swimmers (Boesch, Décombaz, Slotboom, Kreis, 1999; Décombaz et al., 2000; Decombaz et al., 2001).

A study by P.M. Andrade, B.G. Ribeiro, M.T. Bozza, L.F. Costa Rosa (2007) showed that fish oil supplementation results in an increase in alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA) docosahexaenoic acid (DHA) and a decrease in the concentration of arachidonic acid in the blood. Study participants supplemented 2.5 g of fish oil (including 950 mg EPA and 500 mg DHA) a day for a 6 week period. High availability of n-3 acids in cell membranes

was associated with reduced production of strong lipid mediators of inflammation caused by intensive training. In order to support the immune system during intensive training, a diet rich in n-3 acids is recommended. The study was conducted with swimmers aged 20–35 years old (Andrade et al., 2007).

On the basis of available data, it can be recommended for the young athletes to provide 2 g/kg/l.b.m. of fat with diet daily, in order to keep the proper amount of muscle triglycerides in the body. Further studies on supplementation of fatty acids in the group of high-performance swimmers in adolescence are needed.

Conclusions

In order for a young swimmers to develop properly and improve their athletic performance, they should take care of proper fluids, energy, and macronutrients supply.

Young swimmers should drink fluids regularly during the day, to prevent dehydration of more than 2% b.w., which could impair exercise capacity during training or competitions. An isotonic drink is recommended if the training unit lasts more than 75 minutes.

Determining the energy needs of a growing swimmer should be set individually. Appetite level and anthropometric measurements can be used to determine energetic requirements.

Carbohydrates are the main energy substrate for swimmers during adolescence. The proper supply of this macronutrient will help to keep muscular glycogen stores at a proper level. Swimmers who do more than one workout per day should consume products with a high glycemic index after each training unit, in the amount of 1–1.2 g/kg/b.w./h, which is supposed to accelerate glycogen resynthesis.

Proteins participate in many processes in the body and are essential for the proper development and regeneration of the body's immune system. Young swimmers should consume 1–1.2 g/kg/b.w. of protein daily.

Fat is also an energy substrate that can be used by the body during swimming training. Adolescents should consume at least 2 g/kg/l.b.m. a day. It is important to reduce the intake of products containing a large amount of saturated fatty acids and to provide a proper intake of omega-3 acids with diet.

The demand for young swimmers for micro- and macroelements is higher compared to adult athletes. In conclusion, there is not enough research to unequivocally establish nutritional recommendations for this age group of athletes performing swimming training.

The main test groups for athletes are cyclists and runners. Less research is done including swimmers, especially those during the period of adolescence.

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