NUTRITIONAL RECOMMENDATIONS AND GUIDELINES FOR WOMEN IN GYMNASTICS: CURRENT ASPECTS AND CRITICAL INTERVENTIONS

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Original article

Abstract

Pre-adolescent and adolescent gymnasts, and especially artistics gymnasts (AG) and rhythmic gymnasts (RG), belong to a high risk group for severe deficiency in /lack of basic nutrients, especially calcium, iron, folic acid, vitamin D and zinc. The increased demands of accelerated pubertal development in combination with the need to maintain a reduced body mass and the intense daily training (without energy recovery and adequate rest) expose particularly the younger athletes to growth disorders, long-term nutritional deficiencies, problems of emotional nature (low self-esteem, dissatisfaction with body image, multiple daily weighing, obsessions with body aesthetics and physical appearance), hormonal disorders (amenorrhea), premature fatigue, osteopenia, and a particularly increased risk of injury. The vast majority of athletes feel that they are on a constant (chronic) diet. It is typical for athletes to spend hours of daily training with only water intake and no other snack, and coaches are aware of this. The detection and diagnostic assessment of nutritional deficiencies / shortcomings and future nutrition-dependent disorders during the developmental ages of a gymnast is a field of study for every qualified sport dietician. Keeping this in mind, the purpose of this review is to provide targeted nutritional support directions to elite athletes of AG and RG with priority and emphasis on strengthening the immune system, nutritional strategy for direct energy recovery and the control of timely daily food intake during the annual training season.

Keywords: artistic, rhythmic, gymnastics, malnutrition, guidelines, female athlete triad.

INTRODUCTION

At the highest competitive level of AG and RG, the high volume, intensity, frequency and duration of training (6 days/week, 4-6 hours/day) leads athletes to exhaustion especially in cases of double training sessions with a total length of training approaching or surpassing 30 h/w. The age of first engagement usually lies between 5 to 7 years of age, and by age 10 the training level, volume and duration are intensified (Benardot, 2014; Caine, Russell, & Lim, 2013).

Due to the competitive nature of the sport gymnasts are pre-occupied with their shape, size and/or body weight (which is a competition criterion), while setting high competitive targets often under high pressure for continuous success. According to the literature, the vast majority of athletes of such sports attempt to maintain the "perfect" physical appearance, which is characterized by low total body mass and low fat mass throughout their sporting career (Beals, 2004). Under conditions of continuous self-control, low self-esteem, rigorous self-criticism and perfectionism they feel the need to constantly show the more disciplined side of themselves: their body become their greatest "achievement". Unfortunately, this situation has become part of the "culture" of these sports and has created a "traditional" behaviour that, in our opinion, is not likely to change.

As a result of these underlying attitudes, fears, insecurities and constant psychological stress, which inundate the young athletes, there is an evolving subclinical form of disordered eating behaviour among high performance athletes (Kerr, Berman, & De Souza, 2006). It is estimated that up to 40-45% of elite athletes in "aesthetic" sports, such as artistic and rhythmic gymnastics, show symptoms of eating disorders (Beals, 2004; Bonci et al., 2008; De Bruin-Oudejans, & Bakker, 2007; De Souza et al., 2014; Ferrand, Champely, & Filaire, 2009; Francisco, Alarcao, & Narciso, 2012; Kerr, Berman, & De Souza, 2006; Nordin, Harris, & Cumming, 2003; Sundgot-Borgen & Garthe, 2011; Torstveit, Rosenvinque, & Sundgot-Borgen, 2008; Wilde, 2013). Therefore, gymnastic sports, by "nature" accelerate the development of the disorder with the "demand" for the acquisition and maintenance of the "perfect" body throughout their whole athletic career.

The combination of various demands, such as the increased need for nutrient intake due to the accelerated pubertal development, the need to maintain a low body mass (and indirectly fat mass), the potentially long-term, poor in nutrients and possibly low energy intake (chronic malnutrition), and the intense hours of daily training requirements (without adequate nutritional intake) expose young athletes to growth disorders, long-term nutritional deficiencies, emotional problems, menstrual disorders (amenorrhea), premature fatigue, eating disorders, osteopenia and a particularly high risk of injuries (Caine, Russell, & Lim, 2013; Desbrow et al., 2014; Hoch, Goossen, & Kretschmer, 2008; Meyer & Manore, 2011). All these disorders are central to the pathogenesis of the “female athlete triad”, whose main components are: reduced energy availability (with or without eating disorders), menstrual dysfunction and decreased bone density (osteopenia). These components are interrelated in causality, pathogenesis and effects (Ackerman & Madhusmita, 2011; Bahner, 2009; De Souza et al., 2014; Ducher et al., 2011; Sundgot-Borgen et al., 2013; Wilde, 2013; Zach, 2011).

Pre-adolescent and adolescent gymnasts aged 9-18 years that are in the high risk group for severe dietary deficiency, i.e., lack of essential nutrients, are characterized by significantly lower amounts than the recommended daily intakes of calcium, iron, vitamin D and zinc (Benardot, 2014; Cupisti, D’Alessandro, Gastrogiovanni, Barale, & Morelli, 2000; D'Alessandro, Morelli, Evangelisti, Galetta, & Franzoni, 2007; Dallas, Simatos, & Dallas, 2016; Jonnalagadda, Benardot, & Dill, 2000; Jonnalagadda, Bernadot, & Nelson, 1998; Lovell, 2008; Michopoulou et al, 2011; Silva & Paiva, 2015; Soric, Misiqoi-Durakovic, & Pedisis, 2008). In Thompson’s (1998) review of five representative surveys of 56 gymnasts, aged 15-18 years, the average daily energy intake was 1789 kcal (or 35,6 kcal/kg). A comprehensive nutritional assessment is the basis for nutritional therapy and for the design of individually set dietary objectives for each athlete. In particular, the nutritional assessment is the first of four stages of the nutritional care process, followed by diagnosis; intervention and dietary control/monitoring (Steinmuller et al, 2014). To this end, a qualified dietitian evaluates the maintenance of the normal development of the body and the good health of the gymnast, identifying predisposing diet-dependent risk factors, detecting malnutrition habits, and timely treating any nutritional deficiencies and/or excess intake (Academy of Nutrition and Dietetics, 2016). In parallel, self-esteem in relation to the gymnasts' perception of body image should be examined, as low self-esteem is associated with an increased risk of eating disorders and negative perception of body image (Duffy, 2008; Kosmidou, 2014).

A new approach to the interpretation of "malnutrition" and under-reporting

In regards to the applied research methodology on the dietary intake of athletes in "aesthetic" sports, there seems to be an overestimation of the projected energy consumption in both the resting metabolic rate calculations and the energy expenditure. A cause for concern is the wide disparity in the actual energy balance, i.e. the real energy needs of the athletes of these sports. In most dietary assessment surveys, these athletes show a negative energy balance (between 250 and 1200 kcal) with a much reduced energy intake Deutz, Benardot, Martin, & Cody, 2000). The majority of such studies conclude that the athletes under-report their energy intake. Large discrepancies between the predicted total daily energy expenditure and the actual energy intake (~ 20-35%) have been observed in published nutritional assessment surveys of athletes. However, a number of studies have questioned the validity and reliability of the calculation equations of both the resting metabolic rate (RMR) and the total daily energy consumption of female athletes (Crenshaw, 2009). Thus, sport specific surveys are needed to calculate more accurately the energy consumption of both AG and RG athletes who endure the long hours of daily training. This is in line with Black (2000; 2001), Goldberg & Black (1998).

During growth, energy availability should be in positive balance, beyond the typical daily energy intake needs and the total energy expenditure (basal metabolism + physical activity) because of the higher requirements of accelerated pubertal development and the needs for support and synthesis of new tissue (Desbrow et al, 2014). However, this surplus of available energy cannot be accurately calculated due to the multivariate pubertal development needs. Crenshaw (2009) found an overestimation of >200 kcal when using equations both for the predictable RMR and the estimated total energy balance. The review of Thompson (1998) also reports a systematic overestimation of the recommended total daily energy intake in adolescents. These differences were mainly attributed to the under-reporting of energy intake by athletes rather than to the indirect calculations for energy expenditure (Crenshaw, 2009). It is reported that especially athletes of "aesthetic" sports, intentionally fail to declare or record lesser amounts of selected intake such as various snacks. Likewise, they may either declare larger quantities of "desirable" food, or temporarily positvely alter their nutritional behaviour. The most common recording errors are observed in athletes who are dissatisfied with their body image. One of the reasons for intentionally under-recording energy intake is the fear of disclosing to the researchers (or coaches) improper dietary practices and the need to positively impress the researchers (Beals, 2004; Black, 2001; De Bruin, Oudejans, & Bakker, 2007; Meyer & Manore, 2011). In survey studies, where the recording of dietary intake (with weighed food) was performed under the constant supervision of a qualified dietitian, the under-reporting was significantly reduced. This was verified with the direct calorimetry method via the double labeled water technique using hydrogen and oxygen isotopes. This technique is used to determine, with high accuracy, the energy expenditure of an individual for periods of 1-2 weeks (Driskell & Wolinsky, 2011; Gibson, 2005; Hill & Davies, 2001).

A number of recommendations have resulted despite these issues of validity and reliability. Specifically, Meyer and Manore (2011) suggested energy intake > 45 kcal/kg fat-free mass/day during periods of intense training and pubertal development. Others suggest that the critical threshold for female athletes should be the quotient resulting from the relationship of Energy Intake (EI): RMR > 1.45 and/or > 1.55 (Black, 2000; Goldberg & Black, 1998; Jonnalagadda, Benardot, & Dill, 2000). Furthermore, using the double labeled water technique, Thompson's (1998) recommendation for overall energy consumption in adolescent girls is ~ 40 kcal/kg or 1.75 times x RMR. Recently, Dallas, Simatos, & Dallas, (2016) approached the aforementioned reports in relation to the total daily energy balance, and estimated that according to the projected RMR, the body mass of the Greek female gymnasts previously reported (Pavlou, 1992) remained stable [neutral energy balance, EI (7-day): RMR = ≥ 1,6]. In fact, the planned RMR that Pavlou (1992) proposed coincides with the boundary values proposed by McMurray (2011), i.e. 0.9 kcal/kg/h for females in the general population and 1.15 kcal/kg fat-free mass/h for female athletes. Something similar was concluded in the recent research of Silva & Paiva (2015). It should be noted that corresponding recommendations for male gymnasts have not yet been established.

Predisposing factors of the "Female Athlete Triad" syndrome; A constant threat to the smooth development of an athletic career

It is estimated that one in two young athletes, who engage in sports with emphasis on a thin body, exhibit significantly more food behavioural problems compared to the general population, and to the athletes whose body mass is not a significant performance factor in their sports. In addition, one in five athletes of "aesthetic" sports presents at least two components of the female triad syndrome (reduced energy intake and menstrual dysfunction) and is exposed to an increased risk of injury and other health problems. In a recent survey, Dallas, Simatos & Dallas (2016) reported a large energy deficit in female athletes with their average energy intake not adequately meeting (qualitatively and quantitatively) the nutritional requirements of the corresponding six-hour duration of training. In fact, this applies more to RG. With the longer duration of daily training (~ 8h) rhythmic gymnasts exhibit a permanently negative energy balance, especially following afternoon training. This is also confirmed by the survey of Deutz, Benardot, Martin, & Cody, (2000), where large energy deficits (> 300 kcal/h) were associated with a higher percentage of body fat in elite female athletes particularly in RG (Fig. 1).

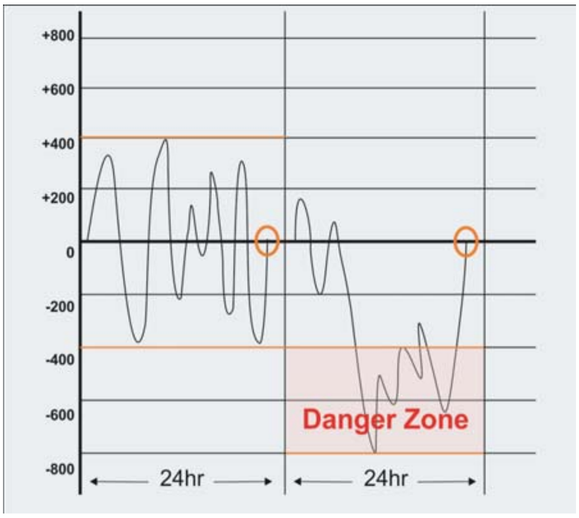

Figure 1. Ideal nutritional standards on left side) and nutritional profile of female gymnasts (on right side); A comparison (Deutz et al, 2000).

The most likely explanation of this phenomenon concerns various homeostatic mechanisms; the reduction in metabolic rate (↓ RMR) and adjustable thermogenesis ("survival" mechanism - energy storage), the increased muscle catabolisms, various metabolic and hormonal changes such as a decrease in estrogen, T3, IGF-1, leptin, and an increase of cortisol and endocrine "resistance", as well as a general disruption of the homeostasis of adipose tissue (Benardot, 2014; De Souza & Williams, 2004; De Souza et al., 2014; Deutz, Benardot, Martin, & Cody, 2000; Filaire, Colombier, Beque, & Lac, 2003; Fuqua & Rogol, 2013; Gibbs et al., 2013; Lebenstedt, Platte, & Pirke, 1999; Malina et al., 2013; Rottstein, 2013; Smith, 2000; Trexler, Smith-Ryan, & Norton, 2014; Weimann, Witzel, Schwiderqall, & Bohles, 2000; Weimann, 2002). This situation seems to confirm the overestimation of the predicted daily energy consumption (and/or expenditure) in the nutritional assessment of gymnasts of AG and even more, of RG. By assessing AG and RG elite athletes, Deutz, Benardot, Martin, & Cody (2000) conclude that within-day energy deficit increased skinfold-derived or DEXA-derived body fat percentage. Their data suggest that despite exercising, the metabolic rate is reduced due to energy deficit. Their findings should discourage athletes from drastically reducing their energy intake and remaining practically without food during their long training sessions, in order to achieve their "ideal" body composition and target body mass.

The reduced daily energy intake (qualitative and quantitative) may cause severe hormonal disorders such as prolactin elevation, which in turn reduces secretion of the hypothalamic gonadotropin-releasing hormone (GnRH) and leads to amenorrhea (Warren & Constantini, 2000). This phenomenon is exacerbated by the demands of an intense physical strain of training (volume, intensity, frequency) done without the required nutritional intake. Therefore, although menstrual disorders have a multifactorial etiology, the main reason is the reduced energy intake (Benson, Engelbert-Fenton, & Eisenman, 1996; Caine, Russell, & Lim, 2013; Dueck, Manore, & Matt, 1996; Gibbs et al., 2013; Malina et al., 2013; Mallinson & de Souza, 2014; Maïmoun et al., 2013; Maïmoun, Georgopoulos, & Sultan, 2014; Roupas & Georgopoulos, 2011; Warren & Perlroth, 2001; Williams, Helmreich, Parfitt, Caston-Balderrama, & Cameron, 2001). At least one in two young athletes engaging in aesthetic sports where particular emphasis is given to the thin body, displays significantly more menstrual cycle disorders (Caine, Russell, & Lim, 2013; Di Cagno et al., 2012; Klentrou & Plyley, 2003; Silva & Paiva, 2015). Indeed, 20-35% of elite gymnasts have primary amenorrhea versus just 1% in the general population (Beals, 2004; Georgopoulos et al., 2002; Maïmoun et al., 2013; Maïmoun, Georgopoulos, & Sultan, 2014; McManus & Armstrong, 2011). Generally, in competitive gymnastics, later onset of menarche i.e. between 14 and 16 years, is the norm. This can then lead to a delay in bone mineral accretion and deter the attenuation of peak bone mass in the adolescent gymnasts. It is possible a female gymnast of an actual age of 15 years to have a skeletal age of ~ 13 to 13.5 years **(**Markou et al., 2004). In addition, menstrual dysfunction in athletes has been clearly associated with reduced bone density (Ackerman & Madhusmita, 2011; Caine, Russell, & Lim, 2013; De Souza et al., 2014; Maïmoun et al., 2013; Maïmoun, Georgopoulos, & Sultan, 2014; Markou et al., 2004; Roupas & Georgopoulos, 2011; Sands, Caine, & Borms, 2003; Tournis et al., 2010; Warren & Perlroth, 2001). The paradox is that AG athletes have been found to have an increased rate of osteogenesis and higher bone mass (especially in the hip and spine) than athletes of other sports and of the same age, probably due to the multiple mechanical stimuli of their training (Burt, Greene, Ducher, & Naughton, 2013; Greene &Naughton, 2006; Vicente-Rodriguez et al., 2007).

The most likely interpretation of the increased bone density seen in gymnasts relates to the extremely high level of relative muscle strength (per kg of body mass) that these athletes develop. On the other hand, the increased lean body mass explains, in part, the increased frequency of bone injury because, despite the increased bone density, their bones are functionally and architecturally immature (i.e., growth plate fusion) in relation to muscle strength. Apparently, the large compressive and impact forces / loads that the athletes experience when exercising, are often up to 10 times their weight (exceeding the limit of mechanical bone strength) and causes local accumulated minor injuries mainly in the epiphyses of immature bones (Maffulli, Longo, Spiezia, & Denaro, 2011; Malina et al., 2013). Following hours of intense and monotonous training and increased strain of the musculoskeletal system, the risk of severe acute trauma, chronic overuse syndromes (wrist, lumbar, ankle, etc.), and stress fractures (Tofler, Stryer, Micheli, & Herman, 1996; Zetaruk, 2000) dramatically increase.

According to research data, a high-level artistic gymnast will miss, due to injuries, up to 21% of the total annual preparation time (frequency > 4 injuries / 1000 h training), i.e. approximately two months. The corresponding frequency of injuries in RG is ≤ 2 injuries / 1000 h training (Kolt & Kirkby, 1999; Caine, Russell, & Lim, 2013). For this reason, although the epidemiological research of the female athlete triad receives strong criticism due to the simultaneous consideration of all 3 parameters of the triad that dramatically reduces the syndrome's occurance (McManus & Armstrong, 2011) the increased incidents of musculoskeletal injuries in female athletes as a result of the female athlete triad, is no longer being questioned (Barrack et al., 2014; Caine, Russell, & Lim, 2013; De Souza et al., 2014; Roupas & Georgopoulos, 2011; Sundgot-Borgen et al., 2013; Wilde, 2013).

Critical risk factors / special rercommendations

1. When assessing nutrition, it is preferable that sport nutritionists use combined techniques for the estimation of the total energy intake and expenditure of the athletes (individually), instead of being based only on indirect calculations and predictions (Burke, 2015; Heaney, O'Connor, Gifford, & Naughton, 2010). In any case, dietary recommendations should consider all parameters: age, sex, type of sport, phases of annual competitive preparation, duration and weekly frequency of training, environmental conditions, nutritional assessment, medical history etc.

2. The daily carbohydrate intake should be increased to ≥ 6 gr/kg in order to ensure optimal glycogen stores, and next day's training should take place within safe energy limits. Female gymnasts have a permanent "deficit" of glycogen due to the long daily and weekly duration of their trainings (Deutz, Benardot, Martin, & Cody, 2000). In our view, it is possible to gradually and individually raise it up to 20-30% their energy intake (more snacks). It is preferable that a gymnast regularly, timely and in sufficient quantity increases the energy intake rather than her being permanently in energy deficit during the entire day or, even worse, trying to cover the deficit retrospectively.

3. It is proposed that the athlete exhibiting symptoms of the female athlete triad, be considered "injured", with direct intervention (combination of curative measures) and a clear restriction/ban from training and competitions (Sundgot-Borgen et al., 2013; Wilde, 2013).

4. The perceived "pressure" from the coaches, the obsession for a thin body and the constant criticism of the body mass of the athlete cause a "silent", chronic trauma of the inner emotional world of the gymnast with enormous psychological costs (the feeling of fear and unbearable psychological pressure reaching the limits of coersion). The coach - athlete relationship should be governed by trust and positive motivation. Under the present conditions, it is estimated that only through the guidance of a responsible coach can the number of athletes who are in danger of developing eating disorders be drastically reduced. For the early identification of predisposing risk factors of the female athlete triad, a procedure is necessary to inform and educate coaches, parents and athletes. The procedure should include intervention programs and aim at improving the dietary attitudes, early identifying predisposing risk factors of the female athlete triad, and enhancing physical self-perception and self-image of the athletes. Furthermore, it would be particularly useful to educate athletes in methods of concentration, in managing pre-competition stress and in effectively controlling anxiety (Byrne & Mclean, 2002; Duffy, 2008; Kosmidou, 2014).

5. For injury prevention, the authors suggest reducing the frequency and duration of the many hours of training of elite athletes, which are often twice a day, morning and afternoon. Such a proposition will surely provoke fruitful discussions/debates in modern coaching. To avoid injuries and monotony, a larger variety of apparatus training could be adopted during each session. Undoubtedly, the strict coaching structures that characterise AG and RG with early specialisation, long hours of daily training and few official competitions, need redesigning.

6. In order for female athletes to continue their athletic career in safety, it is an absolute priority (Bratland-Sanda & Sundgot-Borgen, 2013; De Souza et al., 2014; Sundgot-Borgen et al., 2013; Wilde, 2013):

- to regulate their menstrual cycle
- to ensure the qualitative and quantitative adequacy of their diet
- to "reconcile" themselves with their body and to indirectly enhance their self-esteem
- to set an "acceptable" body mass limit for each gymnast, that is based on all relevant scientific criteria.

Targeted directions for nutritional support of elite athletes of AG and RG

1. Nutritional assessment by a qualified sports dietitian throughout the yearly competitive season with frequent detailed re-examination (as appropriate for each gymnast) is necessary.

2. Particular emphasis should be given to the gymnast's adequate daily nutritional balance (qualitative and quantitative) and nutritional sufficiency, in the following order (Academy of Nutrition and Dietetics, 2016; Desbrow et al., 2014; Meyer & Manore, 2011; Driskell & Wolinsky, 2011; Sundgot-Borgen & Garthe, 2011)**:**

- Energy (not < 1800 kcal/day and ≥ 40 kcal/kg BW or > 45 kcal/kg lean mass) with emphasis on carbohydrates (≥ 5 gr/kg BW/day: dry and/or cooked; simple sugars complex carbohydrates) and on the time of the energy intake to ensure glycogen reserves
- Fat (not < 30% of total energy intake): Hormonal function, fat-soluble vitamins (A, D, E)
- Calcium (not < 1300 mg/day): Increased need of calcium due to the accele-rated pubertal development, especially in female athletes with menstrual dysfunction
- Vitamin D (not < 15 mg/day): Skeletal health, anti-inflammatory effect, calcium absorption
- Iron (20 mg/day): Haemoglobin synthesis, oxygen transfer system, increased developmental needs, developing muscular system - protein synthesis, preventing iron deficiency
- Zinc (10 mg/day): Strengthening the immune system and supporting adoles-cent development.

We believed that, especially during the critical developmental ages, adding 2-3 inter-mediate meals (snacks) is critical. Furthermore, reduced daily calcium intake is considered an important predisposing factor to low bone accretion, which in turn is associated with an increased likelihood of stress fractures.

3. Adequate hydration, frequent consumption of fluids and electrolytes is required. Due to greater body surface area (per kg of body mass), children are more prone to exercise-induced heat strain and thermal disturbances (faster heat absorption, lower sweating rate) (Desbrow et al., 2014; Meyer, Volterman, Timmons, & Wilk, 2012). In any case, losses ≥ 2% of body mass should be avoided during training or competitions.

4. A strategy of favourable energy support and fluid replacement, during and after training, through specially designed snacks with high glycaemic index is advisable. With customary training sessions being > 3 h, energy coverage/support with carbohydrates and electrolytes at the right time and in sufficient quantities is required during the long hours of training. The basic rule is ≥ 30 gr of carbohydrates per hour (or 0.5 gr carbohydrate + 0.2 gr of protein /kg BM /h). This guideline:

- is the most critical parameter for the promotion and acceleration of the recovery process [faster healing of

minor injuries, rehabilitation of injured cells/tissues, protection of the immune system] from muscle strain/fatigue from training (Academy of Nutrition and Dietetics, 2016; Desbrow et al., 2014; Meyer & Manore, 2011),
- Is individualised as appropriate in accordance with the specific needs, objectives, coaching priorities and level of the athlete (Academy of Nutrition and Dietetics, 2016; Desbrow et al., 2014; Meyer & Manore, 2011).

For the same reason, and in order for the daily rate of protein synthesis to be maintained at a satisfactory level and for aminoacids to be sufficiently available, the correct distribution of the daily protein meal (e.g. 4 x 20 gr) is necessary to cover the required daily amount (≥ 1,5 gr of protein/kg). The "key" is the planning of portions at specific times, in order to achieve optimal protein availability and better use by the body.

5. Administering creatine is a matter open to discussion in the scientific community. Creatine has a significant contribution to the anaerobic muscle metabolism and it is used as an ergogenic aid mainly in anaerobic high intensity sports. The administration of creatine appears to limit the exercise-induced muscle damage both through the reduction of delayed muscle pain and fatigue, and by reducing the levels of creatine kinase and lactate dehydrogenase in the plasma (Bassit et al., 2010). For endurance sports, there is disagreement on its effect (increasing body mass) and especially for ages up to 18 years. In general, though, for ages <18 years, creatine supplementation safety has not been established (Cooper et al., 2012). To date there are no recorded systematic creatine supplementation data in competitive gymnastics probably because in sports such as AG and RG where numerous rest periods are observed (non-practicing periods) and actual practice time per session does not exceed 60-80 minutes and is not considered high volume, the amount of creatine needed by the body is obtained through the gymnast's daily diet (fish-meat).

6. A general evaluation of the health risks, particularly where early warning signs are available (first detection level) including:
- Loss of large amounts of blood (heavy bleeding) during menstruation
- Longer/sparse menstrual cycles (oligomenorrhea) or fluctuations in the frequency of menses (in particular the absence of 3 consecutive cycles)
  - Primary or secondary amenorrhea
  - Restricted eating behaviours
  - Frequent daily weighing
  - Early, unexplained fatigue
  - Systematic and persistent refusal of food and liquid intake

Each coach should also be able to promptly recognise these predisposing risk factors.

7. A monthly assessment of body fat and a weekly assessment of body mass is recommended; various field methods have been proposed such as anthropometry (skinfolds), anthropometry (skinfolds equations) (Ackland et al., 2012). Furthermore, given the different pace of biological maturation and physical development of each gymnast, the assessment of body fat and body mass should be individualized. There is no default value but an approximate optimum value, where the personal history coincides and is co-evaluated with the athletic performance and the promotion / maintenance of health. In any case, our goal is a fixed body mass between - 1 < BM <+ 1 kg (range up to ± 2%) during the annual competitive season, since the daily weighing usually fluctuates ± 1 kg (Sundgot-Borgen & Garthe, 2011).

8. It is sad, but typical of the attitudes and intentions of the coaches, that individual weighing of athletes has been established as part of the daily training. We recommend that coaches reconsider and avoid this practice. Coaches should be aware that the scale is a "tough opponent" in the management of specific cases of athletes who are prone to developing eating disorders and that body composition is not always the ultimate competitive advantage since**:** a) athletic performance is shaped by a set of different parameters, b) there is great variation in body fat percentages between successful high-level athletes (Turocy et al., 2011). Therefore, any misconception and futile expectation of the "ideal" body mass (or ideal body fat), should be discouraged (or even eliminated) as they are not viable scientific terms.

9. In "aesthetic" sports, the role of the coach is decisive during these sensitive developmental ages, in terms of informing athletes of the immediate and long-term negative consequences: a) of reduced energy intake (malnutrition), b) of menstrual disorders and c) of the loss of valuable bone mass. Undoubtedly, total cooperation between coaches and parents (information, supervision, monitoring, guidance, compliance) is required (Holli & Beto, 2014).

CONCLUSIONS

Pre-adolescent and adolescent gymnasts, and especially artistics gymnasts (AG) and rhythmic gymnasts (RG), belong to a high risk group for severe deficiency in /lack of basic nutrients, especially calcium, iron, folic acid, vitamin D and zinc. Basic purpose of this study is to provide targeted nutritional support directions to elite athletes of AG and RG with priority and emphasis on strengthening the immune system, nutritional strategy for direct energy recovery and the synchronization of the time-divided daily nutritional intake throughout the year's training season. For chronic forms of reduced energy intake it should be emphasized that it is detrimental to athletic performance and is considered a forerunner of negative development with serious future health consequences**:** weaker immune system, critical nutrient deficiencies, dehydration, chronic fatigue, menstrual and hormonal disorders, decreased bone density, increased injury susceptibility and increased risk of developing permanent eating disorders.

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