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In shade of Olympic glory: what should we know about female athletes triad? – a review

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Abstract

Introduction and purpose: The numerous advantages of sport are widely known. Millions of children worldwide are encouraged to start training and significant part of them decide to start professional training. However, there are also certain health risk connected with intensive physical activity. One of them is female athletes triad – a syndrome consisting of three components: low energy availability (LEA), dysregulation of menstrual cycle and impaired bone mineral density (BMD).

Description of the state of knowledge: The intensive physical activity, especially in adolescent women may have deleterious influence on their health and, in consequence, on further sports career. Female athletes triad often co-occurs with eating disorders, especially in sports where slim shape is desirable. Inadequate energy availability results in menstrual cycle dysfunction, meanwhile insufficient level of female sex hormones (estrogens) is detrimental for bones health leading to frequent injuries and stress fractures. In result the vicious cycle of female athletes triad is closed and general condition of athlete deteriorates.

Summary: This paper aims to briefly review current state of knowledge on female athletes triad. It is vital to raise awareness of female athlete triad symptoms among medical professionals as well as sportswomen and members of coaching team to facilitate early diagnosis and proper treatment to avoid further complications.

Keywords: Female Athlete Triad Syndrome, Amenorrhea, Osteoporosis, Feeding and Eating Disorders, Athletes

Introduction:

Female athletes triad is a health condition consisting of following constituents: low energy availability (LEA), dysregulation of menstrual cycle and impaired bone mineral density (BMD) affecting significant amount of professional sportswomen [1,2]. Insufficient calories intake may derive from eating disorders, especially in sports where shape and low weight of athlete is required, for example gymnastics, figure skating or dance. The percentage of athletes affected by secondary amenorrhea can be as high as 69%, whereas in broad-range population it is estimated to touch only 2-5% [3]. Hormonal adaptions, such as oligomenorrhea or amenorrhea are consequences of relative energy deficiency simultaneously leading to osteoporosis, creating therefore vicious cycle of female athletes triad [1,2].

Description of the state of knowledge:

Relative energy deficiency in sport

Low energy availability (LEA) is a state described by insufficient energy intake in comparison to energy expenditure. When permanent, it impairs body homeostasis, affecting not only endocrine and reproductive system, but also immune, gastrointestinal or cardiovascular system [4].

This concept, wider than female athletes triad itself, is known as relative energy deficiency in sport (RED-S), was coined by International Olympic Committee (IOC) in 2014. Normally, EA is balanced when it reach 45 kcal/kg FFM/day, for healthy adults [5, 6]. LEA can be recognized when EA is lower than 30 kcal/kg/FFM/day [12]. Under this threshold negative health consequences appear, especially in endurance sports professionals e.g. cycling or running. [12, 13].

$$Energy\ Availability = \frac{energy\ intake[\text{kcal}] \ - \ exercise\ energy\ expenditure\ [\text{kcal}]}{fat - free\ mass[\text{kg}]}$$

Figure 1. *The energy availability equation. Adapted from Grabia, Monika et al. "Female Athlete Triad and Relative Energy Deficiency in Sport (REDs): Nutritional Management." Nutrients vol. 16,3 359. 25 Jan. 2024*

LEA in athletes may derive from numerous reasons – inadequate nutritional knowledge, low appetite but there is also considerable group among professional sportsmen and sportswomen that suffer from eating disorder [3,7]. Among eating disorders anorexia nervosa, bulimia nervosa and eating disorder not otherwise specified can be distinguished. Term anorexia athletica is also used to name condition concerning female athletes dismayed by the idea of gaining kilograms, despite having appropriate or insufficient weight. Thus, they focus on excessive trainings and creating calorie deficit but they do not meet criteria of anorexia nervosa or bulimia nervosa [3]. The correlation between perfectionism and eating disorders is proved, thus elite athletes are especially at risk group of developing eating disorders [22, 23]. A study by Brook et al. showed that 32.4% of elite para athletes had elevated results in Eating Disorder Examination Questionnaire (EDE-Q), meanwhile less than 10% study participants were aware of Triad/RED-S [10]. Whereas Vardardottir et al. reported that 8.4% of Icelandic elite and sub elite athletes had excessive amount of points in EDE-Q and 19.3% had positive results in Exercise Addiction Inventory (EAI) [11].

Menstrual cycle dysregulation

Menstrual dysregulation is a wide term used to describe irregular or absent menses [3]. It is estimated that about 19% up to 54% of female athletes are affected by various menstrual disorders [7]. The most common menstrual cycle disorder among sportswomen is secondary amenorrhoea, defined as lack of three sequent menstruation bleedings. Primary amenorrhoea is defined as lack of menarche by the age of 15 years. Third among the most common menstrual dysfunction is oligomenorrhoea – condition when period between menstrual cycles is greater than 45 days [5].

According to Gimunová et al. primary amenorrhoea affects up to 53.8% of rhythmic gymnastics athletes, in comparison to less than 1% in general population. The occurrence of primary amenorrhoea is considerable also among football players (20%) and in swimmers (19%) [14]. Secondary amenorrhoea is observed mostly among endurance sports female athletes - as cycling (56%), triathlon (40%) or aesthetic sports athletes – rhythmic gymnastics (31%) [14]. Oligomenorrhoea, triggered mainly by LEA, was noticed amid female boxers (55%), rhythmic gymnasts (44%) and artistic gymnasts (32%) [14].

The main mechanism behind menstruation disturbances in sportswomen is functional hypothalamic amenorrhea (FHA) [15]. FHA is defined as lack of menstruation as a result of suppression in hypothalamic-pituitary-ovarian axis without organic changes in body organs [3,16]. FHA is mostly triggered by intense training, considerable weight-loss or broadly understood stress [16]. At the hormonal level, the mechanism of FHA is based on insufficient secretion of hypothalamic gonadotropin-releasing hormone (GnRH), resulting in lowered levels of pituitary gonadotropins - luteinizing hormone (LH) and follicle-stimulating hormone (FSH) and in consequence lowered estrogen level. It is worth emphasizing that FHA is a diagnosis of exclusion [16, 17].

Another hormonal axis that has influence on menstrual health in female athletes is a hypothalamic–pituitary–adrenal (HPA) axis, which is imbalanced by excessive stress level. Stress causes elevated corticotrophin-releasing hormone (CRH) and cortisol levels which in negative feedback mechanism inhibit GnRH secretion [3, 16].

Impaired BMD:

The maximum level of BMD is reached around the age of 19 in females and 20.5 in males [5, 8]. The bones health is dependent from several factors: BMD, bone remodeling and bone microarchitecture [3]. In general, physical activity, especially strength sports, have beneficial impact on bone health, by the stimulation of bone remodeling [3, 18, 19]. However, non-weight-bearing sports, as for example cycling can be detrimental for BMD. As Martínez-Noguera, Francisco Javier et al. proved, only one season of professional cycling may result in lowered bone health markers and therefore raise the fracture risk [9].

Additionally, one of the most deleterious effects of hypoestrogenism in course of hypogonadotropic hypogonadism is increased fracture risk due to lowered BDM [1]. As mentioned above one of the components of female athletes triad amenorrhoea or oligomenorrhoa that are connected with estrogen deficiency [3].

The International Olympic Committee recommends BMD should be checked by dual-energy X-ray absorptiometry (DXA) that in athletes from osteoporosis and stress fracutures risk groups. Those groups include athletes with LEA, eating disorders or lack of menstruation for over 6 months. The DXA examination should be repeated after 12 months period in adults athletes and 6 months in young adults athletes from risk groups or undergoing osteoporosis treatment [5].

Screening and diagnosing

There are multiple clinical tools that facilitate screening for the components of female athletes triad among athletes.

Among frequently used questionnaires Low Energy Availability in Females Questionnaire (LEAF-Q) may be found. It was proposed by Melin et al. in order to identify female athletes at risk for the triad [20]. The LEAF-Q is proven to be credible questionnaire which sensitivity is 78% and specificity is 90% with regard to asses energy availability, reproductive and bone health [20]. The questions concern three thematic groups: injuries, gastrointestinal symptoms and menstrual function and use of contraceptives. This tool in easy way allows athletes self-reporting of female athletes triad syndrome which enables early diagnosis and intervention [20,21].

Another questionnaire created in order to detect female elite athletes with eating disorders is e Brief Eating Disorder in Athletes Questionnaire (BEDA-Q) proposed by Martinsen et al. in 2014 [22]. This questionnaire, unlike other screening tools for eating disorders, is specifically validated for sportswomen. The BEDA-Q version 2 consists of 9 questions concerning body dissatisfaction, perfectionist traits, dieting and losing weight or episodes of compulsive eating [22].

However, questionnaires may facilitate screening for female athletes triad, the medical history and physical examination, conducted by sports medicine doctor and followed by laboratory tests, is the basis of diagnosing triad and starting point for treatment. Screening should take place at annual or pre-competition check-ups [3, 24].

The detailed questions about diet and training, body image, history of injuries in the past and reproductive health should me asked. Finding one symptom of the triad, should be alarming, thus other symptoms should be looked for [3, 24].

On physical examination there are signs that suggest female athletes triad. They include low heart rate, orthostatic hypotension or hypothermia, however, those are not specific signs, they should be differentiated with hypothyroidism. Patents suffering from bulimia nervosa often have damaged enamel, enlarged parotids and knuckle scars. Whereas signs of anorexia nervosa include bradycardia, lanugo and dry skin. Obligatory part of psychical examination while screening for female athletes triad is musculoskeletal system examination. Any inadequate or unusual pain should raise alertness of osteoporosis [3,24].

The detailed laboratory test should be carried out. They should include complete blood count, metabolic panel and electrolytes to screen for LEA. While patient presents amenorrhoea or oligomenorrhoea, beta-human chorionic gonadotropin should be at first tested, in order to exclude pregnancy. Further, more detailed bloody test should performed to determine the etiology of menstrual dysfunction. The basic laboratory test include FSH, prolactin, TSH and free thyroxine. If patient presents symptoms of hyperandrogenism, further tests are obligatory – LH (to check ratio of LH/FSH which in characteristically >2:1 in polycystic ovary syndrome), testosterone and sex binging globulin, dehydroepiandrosterone sulfate. The diagnostics can be extended to include blood estrogen and progesterone levels [3, 24, 25].

In the diagnosis of osteoporosis, it is necessary to perform DXA, if any of female athletes triad had appeared in the past (stress fractures, amenorrhea or the patient had a history of eating disorders) [3, 26].

Treatment

The treatment of female athletes triad is challenging, because it requires multidisciplinary. The cooperation between athlete, dietitian, psychologist or psychiatrist, coach, sports medicine doctor and gynecologist or endocrinologist is vital in order to achieve therapeutic success. [2, 3, 27].

The non-pharmacological treatment lays at the basis of female athletes triad treatment. It includes nutritional and psychological treatment. The first step should be increasing energy availability, which in athletes usually should be achieved by increasing energy intake [27]. It is proved that in regaining regular menstrual cycle may appear when energy availability is increased up to 30 kcal/kg FFM per day and when it is greater than 45 kcal/kg FFM per day it has beneficial impact on bone health [27].

The meaningful part of non-pharmacological treatment is psychotherapy, especially in athletes suffering from eating disorders and athletes from 'slim sports' with perfectionist traits [3, 29, 30].

For increasing BMD, calcium and vitamin D supplementation is notable part of treatment. The recommended daily dose of calcium is 1300 mg and 600-1000 IU of vitamin D in minimalizing risk of stress fractures [2, 27, 28]. The use of bisphosphonates is not suggested in young female athletes. There are two reasons of this – first, due to teratogenic effect of bisphosphonates they are generally avoided in young females treatment. Secondly, the mechanism of action of bisphosphonates in focused mostly on decreasing bone reabsorption, while in female athletes triad the osteoporosis is caused by decreased bone formation [27, 28].

The efficacy of combined oral contraception (OC) and hormonal replacement therapy (HRT) in treatment of female athletes triad is ambiguous. Whereas OC may regulate menstrual cycle, it can also mask symptoms of triad and give false sense of health by regular withdrawal bleedings which are not equivalent to period bleedings. The beneficial effect of OC on bones health is debatable – there are not strong evidence of growth of BMD while taking those medications. This phenomenon can be described by " first pass effect" occurring while oral hormones are metabolized in liver, therefore hepatic production of insulin-like growth factor-1 and its' positive impact on BMD is reduced [27, 30]. The more beneficial alternative for oral hormonal treatment is transdermal estradiol therapy. It has beneficial effect on BMD that is not diminished in hepatic "first pass effect". However, it is noteworthy that this form of estrogen therapy does not have contraceptive effect [2, 3, 30].

Conclusions

Female athletes triad is a grave syndrome affecting young sportswomen. The consequences of undiagnosed triad may be harmful for athletes health, have deleterious influence on their results and even it can result in earlier end of their sport carrier. The awareness of female triad syndrome is crucial in early diagnosis and rapid treatment, which will prevent the development of the disease.

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All authors contributed to the article.

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