Female athletes and health

Marzena Malara, Grażyna Lutosławska

Department of Biochemistry and Biology, Józef Piłsudski University of Physical Education, Warsaw, Poland

Summary

It is well documented that regular physical activity has a beneficial effect on human health by affecting the metabolic processes that are of fundamental importance in the body’s functions, such as insulin sensitivity and glucose disposal, as well as lipid and lipoprotein turnover. On the other hand, there is a wealth of studies which indicate that strenuous, regular physical activity, such as that performed by high performance athletes, may be detrimental for the athletes’ health especially in women. This review focuses on the factors that contribute to health problems in female athletes, named the female athlete triad, which includes excessive dieting, menstrual dysfunctions (anovulatory menstrual cycles, oligomenorrhea, amenorrhea) and a low bone mineral density (BMD). As a result of these factors, women who participate in sports, especially those focused on leanness, need special attention and education from health professionals, coaches and the athletes themselves to prevent the detrimental effects of an inadequate energy supply against high energy demands.

Key words: Female athlete – Menstrual dysfunction – Energy deficit – Health risk

Introduction

It is well documented that, irrespectively of gender, regular physical activity provides benefits for human health by affecting the metabolic processes that are of fundamental importance in the body’s functions, such as insulin sensitivity and glucose disposal, as well as lipid and lipoprotein turnover [22, 23]. In consequence, the concept of exercise as a “polypill” against several health problems has recently received much attention [16]. On the other hand, there is also data which suggests that regular strenuous physical activity, such as that performed in high performance sport, may be detrimental for the athlete’s health by inducing cardiac remodelling, arterial endofibrosis, impaired vascular compliance, oxidative stress and impaired immune functions [8, 20, 38, 45, 52]. Additionally, there is numerous data that clearly indicates female athletes are at a greater risk of adverse health effects from sport-related physical activity than their male counterparts. It is also well documented that female athletes are at the greatest risk of a poor iron status due to blood loss from menses, but also due to a low density of dietary iron [1, 27].

Health risks in female athletes – the female athlete triad

At present, it is commonly accepted that poor dietary habits in female athletes also bring about other health disturbances, such as anovulatory menstrual cycles, oligomenorrhea, amenorrhea and a decreased bone mineral density (BMD) [5, 58]. According to Klungland-Torstveit et al. [26] three symptoms (disordered eating, amenorrhea and a lowered BMD), named the female athlete triad, can be observed in 4.3% of all female athletes. However, the frequency of eating disorders and menstrual dysfunctions is much higher, and ranges from 5.4 to 26.9%. In addition, triad symptoms were identified in high school athletes aged 13-18 years old, where 5.9% of the participants met two of the triad components and 1.2% experienced all three components of the triad [43]. Moreover, it was noted that in amenorrheic female runners, the plasma total cholesterol and LDL-cholesterol levels were higher than in their regularly menstruating counterparts [17, 25, 28]. Rickelund et al. [50] showed that amenorrhea in female athletes is associated with an unfavourable lipoprotein profile, and an endothelial dysfunction expressed as a decreased flow mediated dilatation (FMD). These findings may be of importance, since Solomon et al. [54] in a cohort study demonstrated that a menstrual cycle irregularity in females aged 20–35 years can increase the future risk of cardiovascular disease.

Moreover, Lloyd et al. [30] revealed that in oligomenorrheic female athletes engaged in track and field, field hockey and basketball, the bone mineral density (BMD) was significantly lower than in eumenorrheic athletes. The association between a disturbed ovarian hormone

Author’s address

Marzena Malara, Department of Biochemistry and Biology, Józef Piłsudski University of Physical Education, Marymoncka 34, 00-968 Warsaw, Poland  marzena.malara@awf.edu.pl
secretion and a decreased BMD was confirmed in female runners, dancers and football players, but also in swimmers and volleyball players [9, 42, 56, 59]. However, it is worth noting that the studies which enabled a diagnosis of the female athlete triad started much earlier, and concerned the disturbances in sex hormone secretions in women who engaged in a strenuous physical activity.

History of exercise – the female athlete triad connection

In the early 1980s, it was demonstrated that 16 of the 48 women enrolled in marathon training were characterised by a monophasic body temperature [46]. Additionally, among 32 women with biphasic BBT only 16 had a normal luteal phase length (mean 11.1 ± 1.2 days), while the other 16 women had biphasic cycles that were characterised by a short luteal phase (mean 6.4 ± 1.8 days). Moreover, in the subjects with a monophasic BBT or a short luteal phase, the daily running distance was longer than in the participants with normal menstrual cycles (about 10 vs. 8 miles/day). The above data clearly suggests that regular training adversely affects the ovarian hormone secretions and that this effect is intensified with an increased training load. The detrimental effect of strenuous and regular physical activity on the circulating female sex hormones has been supported by many studies [4, 6, 14]. Moreover, a delayed menarche or even amenorrhea was reported in adolescent ballet dancers [19]. Further studies have also indicated disturbed luteinising hormone (LH) and follicle-stimulated hormone (FSH) secretions in females who are engaged in regular training of a low intensity [3, 12].

At the time of these studies, some authors hypothesised that rigorous exercise should be recognised as a stressor for increasing ACTH and cortisol secretions and the plasma levels, which in turn has a potential to depress the gonadotrophin-releasing hormone (GnRH) pulse generation [32]. However, the hormonal disturbances in female athletes were not limited to sex hormone, adrenal hormone and gonadotrophin secretions. In amenorrheic, the total circulating triiodothyronine (T3) and leptin was depressed, suggesting a hypometabolic state [13]. This assumption has been supported by further studies which indicated that the resting energy expenditure per kilogram of fat free mass in exercising women with anovulatory menstrual cycles was lower than in ovulating women, but in amenorrheic participants it was even lower than in their non-ovulating counterparts [11].

Thus, it seemed that menstrual dysfunctions shifted the female hormonal profile in a direction which promoted energy conservation. Taking into account that, in humans, energy is conserved mostly in the adipose tissue, these findings enabled a return to the old hypothesis concerning fat levels as a determinant of the menarche and normal menstrual cycle [18]. On the other hand, some data suggested that no relationship existed between body fat and reproduction, since no differences in adiposity were noted between eumenorrheic and amenorrheic female runners [32, 51]. However, a close association was shown between a disturbed sex hormonal profile and low energy availability (energy intake reduced by energy expenditure) in women who engaged in strenuous physical activity [31, 34, 63]. Interestingly, deteriorations in the LH and FSH secretions similar to those observed in female athletes were observed in sedentary women with eating disorders, such as bulimia nervosa [29, 49]. Thus, it was postulated that hormonal disturbances in female athletes are the body’s response to an inadequate energy intake vs. a high energy expenditure.

Energy availability in female athletes

Numerous data has demonstrated that the energy intake in active females is inadequate, taking into account their increased energy expenditure. However, this energy inadequacy is most common in sports which are focused on leanness (e.g. gymnastics, distance running and figure skating) but also occurs in other sports such as soccer and surfing [15, 41, 44, 64]. Sudi et al. [55] noted that in some female athletes, anorexia athletica was even observed, with a markedly restricted calorie intake and over-exercising to achieve or maintain a low body and fat mass. According to Manore [37], most female athletes require at least 2300–2500 kcal/day to maintain their body weight. In the case of endurance sports (marathon, triathlon) their daily requirements may be as high as 4000 kcal/day. On the other hand, Loucks et al. [33] proved that an energy availability (defined as the energy intake minus the energy expenditure) of 30 kcal/kg LBM/day is a threshold value below which the reproductive function is depressed due to disturbances in the LH pulsatility and amplitude. Moreover, Williams et al. [62] demonstrated that the frequency of menstrual disturbances is markedly affected by the magnitude of the daily energy deficit, and is significantly greater for a 42% than for an 8% energy deficiency. Since the time of these earlier studies until now, intense research has focused on analysing the dietary habits of female athletes and their energy availability [39, 47, 48, 53, 61].

In consequence, to prevent the adverse effects of energy shortages, De Souza et al. [10] have recommended developing psychometric indices for evaluating the drive for thinness as a proxy indicator of energy deficiency in exercising women, to prevent the development of dietary disorders. Recently, Melin et al. [39] proposed the LEAF Questionnaire (Low Energy Availability in Female Questionnaire), which is composed of questions regarding dietary habits and health problems, including the reproductive functions of female athletes. This procedure seems to be of importance, since it has been found that dietary interventions have the potential to restore menses in female athletes [2, 7, 21, 36].
Furthermore, it is worth noting that despite many years of studies concerning the female athlete triad, and clear procedures to prevent its adverse effects, recent data indicates that a similar phenomenon can be observed in male sportsmen who are engaged in disciplines that emphasise a lean body composition, accompanied by the well-known adverse effects including false dietary habits, hypogonadotropic hypogonadism and a low bone mineral density [24, 57]. Thus, both coaches and sport medicine health professionals need to be especially concerned about the dietary habits of athletes to protect them from adverse health effects and a decrease in their performance.

References


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