



Invited Editorial

Sports and the menstrual cycle



ARTICLE INFO

Keywords

Sports
Physical activity
Menstrual cycle
Amenorrhea

Nowadays, more than ever before, barriers in professional and non-professional sports are being demolished and it is usual for girls and women all over the world to participate in sports. During the Summer Olympics held in Tokyo in 2021, almost 50% of participants athletes were female, compared with only 11% who participated in the Olympic Games in Rome back in 1960 [1]. The general physical benefits of sports for all are well known, but it is important to recognize also the social and psychological benefits for both individuals and groups. Nevertheless, education on long-term health and athletic achievement of female athletes is not equally distributed in different geographical areas. Indeed, besides the multiple beneficial effects of physical activity on health, the possible long-term negative health outcomes of certain types of training need to be carefully described and avoided [2].

Physiologically, the menstrual cycle consists of a series of events aimed to prepare the uterus for potential pregnancy. A regular menstrual cycle is a marker of physical and mental well-being in all women of reproductive age, and when this occurs periodically every 21–35 days, a woman is defined as eumenorrheic. On the other hand, amenorrhea refers to all those situations in which a woman experiences the absence of menstrual periodicity, and this can be due to both physical and psychological stressors [3]. The most well-known health-related threat to female athletes is the loss of the menstrual cycle, which endocrinologists and gynecologists mainly refer to as functional amenorrhea. According to the latest published guidelines on the topic from the Endocrine Society, and co-sponsored by the European Society of Endocrinology [3], the main factors leading to functional amenorrhea are psychological stress, nutritional deprivation, and strenuous exercise training. These can all be present among athletes, regardless of the level of competition. Among female athletes, indeed, gonadal disorders are mostly observed in sports where body weight control is emphasized, such as ballet, gymnastics, and long-distance running [2]. This condition, previously known as the “female athlete's triad”, comprising eating disorders, amenorrhea and osteoporosis, was recently redefined as “relative energy deficiency in sports” (RED-S).

RED-S is characterized by a mismatch between energy intake from

diet and the energy expended in exercise, leaving inadequate energy to support the functions required by the body to maintain optimal health and performance [4]. Neither the duration nor the threshold of energy availability below which menstrual disturbances occurs has yet been identified; however, it is known how adaptive mechanisms highly preserved throughout human evolution are involved in blocking the reproductive system, which begins at the hypothalamus with a reduced GnRH pulsatile function. Independently of the time of onset, RED-S can become a dangerous condition, with multi-systemic severe health consequences involving skeletal health (e.g. stress fractures), cardiovascular and immunological function. Paradoxically, this condition necessarily leads, in the long term, to a worse physical performance due to the increased rate of injuries and illness, and to mood impairment, with the high risk of a rapid fall, in a vicious circle that can ultimately severely impair the overall individual health status of athletes. Therefore, the prevention of RED-S needs special attention from scientific and athletics organizations. Similarly, the development of awareness about this condition among physicians, coaching staff and athletes themselves is crucial to prevent its spread across the whole community [4].

The relationship between physical activity and the menstrual cycle is not one-directional. It is indeed established, also in the general population, how the menstrual cycle and its physical and psychological correlates can negatively impact daily and physical activities [5]. In the sporting setting, similarly, menstrual symptoms (e.g. fatigue, tiredness, abdominal pain) can reduce athletes' ability to train [6]; indeed, up to 50% of elite and non-elite athletes report the perception of a significant performance impairment due to the menstrual cycle [7]. The pathophysiological basis of this perception is not completely known and various mechanisms have been proposed to explain the change in physical performance during the menstrual cycle. In this connection, reproductive hormones surely play a crucial role in such a complex phenomenon. Estrogens and progesterone seem to have opposite effects, mediated by a neuroexcitatory modulation, on force production, resulting in lower strength during the luteal phase, when progesterone is elevated. Moreover, rapid muscle activation also appears to be strongly

<https://doi.org/10.1016/j.crwh.2021.e00367>

Received 25 October 2021; Accepted 1 November 2021

Available online 3 November 2021

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influenced by the menstrual phase, with much lower muscular performance during the early follicular phase [8].

Testosterone, forefather of male androgens, seems to play a role in enhancing physical performance, by changing muscular electrophysiological and contractile properties. However, there is no reliable on the changes in bioavailable testosterone, the most biologically active hormonal fraction, during menstrual cycle phases. Another effect of hormonal changes during the different phases of the menstrual cycle is deemed to be tendon stiffness, since the increased estrogen concentrations appear to reduce collagen density and in turn reduce stiffness of muscles and tendons; however, this observation is still considered controversial [8]. Moreover, changes in metabolism and substrate availability have been proposed among the mechanisms that could impact performance. Indeed, higher estrogen levels could promote lipid oxidation in skeletal muscle and boost the availability of free fatty acids during exercise [9]. Monitoring menstrual phases among professional athletes is becoming increasingly popular, and many elite sport organizations often use smartphone apps to track their athletes' periods, providing the support staff with crucial information to promptly identify disruptions and offer timely nutritional, training-based or medical interventions.

In conclusion, the relationship between the menstrual cycle and sports, in either professional or non-professional settings, depends on the complex interaction of different internal physiological and adaptive mechanisms, as well as a multitude of external stressors, resulting in an intricate riddle, to which our knowledge so far could not find a definitive solution. The understanding of such tangled mechanisms will surely help both athletes and physician to safeguard health and to encourage wholesome physical practice in all sports contexts. However, besides scientific research efforts and progress, it is fundamental for governmental institutions and sports associations - both amateur and elite - to raise awareness of these topics and to promote efficient strategies aimed at offering appropriate knowledge and, when necessary, social support to all individuals at risk.

Contributors

Walter Vena wrote the initial draft.

Stavroula A. Paschou revised the manuscript.

Both authors approved the final version of the manuscript.

Funding

The authors received no funding from an external source for the publication of this editorial.

Provenance and peer review

This editorial was commissioned and not externally peer reviewed.

Conflict of interest statement

The authors declare that they have no conflict of interest regarding the publication of this editorial.

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