THE EFFECT OF THE MENSTRUAL CYCLE ON EXERCISE PERFORMANCE

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Introduction

Editorial

Imagine the daily life of a professional male athlete – regardless of his discipline – whose diet, training schedule and sleeping patterns are fine-tuned to optimize their performance. To make it even more complicated: how about the female athlete, subject to her menstrual cycle? Unfortunately, evidence on the effect of hormonal levels on exercise performance is very scarce as women are still significantly underrepresented in studies on sport and exercise medicine [1]. Bruinvels et al. recently reported a negative impact of the menstrual cycle on exercise training and performance, as experienced by both elite and non-elite female athletes [2]. Moreover, the need for more research into the hormonal effects on athletic performance to address female physiology and avoid further sex misrepresentation is emphasised [3]. What is the current evidence on the hormonal influences on exercise performance and what are potential obstacles in this research field?

The menstrual cycle

Based on the levels of ovarian hormones – oestrogen and progesterone – the ovulatory menstrual cycle can be divided into three phases. During the early-follicular phase (day 2-7), levels of both hormones are low. During the late-follicular phase, oestrogen levels increase just before ovulation, which is followed by the mid-luteal phase with increasing levels of both hormones. Apart from their reproductive function, oestrogen and progesterone are known to influence other physiological systems, such as the thermoregulatory, respiratory, cardiovascular and metabolic system. Consequently, these hormones influence exercise performance and, moreover, interact with each other, which further complicates the system. It is not surprising that most research on female exercise performance has focused on the early follicular phase, e.g. to minimise the impact of hormone levels on study outcome [4].

Effects on exercise performance

In exercise medicine, different physiological parameters are studied, depending on the discipline of interest. A review by Janse de Jonge looked at the effects of hormone fluctuations on three different exercise-related outcomes: skeletal muscle contractile characteristics, maximal oxygen consumption (VO2max) as indicator of aerobic exercise performance and prolonged exercise performance. Based on the available evidence, the author concluded that muscle contractile characteristics and VO2max are not affected by the menstrual cycle. In maximising prolonged exercise performance on the other hand, female endurance athletes may have to adjust for their menstrual cycle. This is especially true when competition is expected to take place in hot, humid conditions due to increased body temperature and potentially increased cardiovascular strain during the (mid-)luteal phase. Included studies, however, showed conflicting results and several limitations in menstrual cycle research are put forward, as will be discussed later on [5].

Effects on exercise metabolism

Oosthuyse and Bosch acknowledge the inconsistency in studies investigating the effect of the menstrual cycle on exercise performance and reviewed the alterations in metabolism associated with ovarian hormone levels [4]. They suggest that menstrual phase variations in exercise performance could be largely due to changes in exercise metabolism driven by fluctuations in ovarian hormone levels. In endurance performance, for example, oestrogen might promote performance by influencing carbohydrate, fat and protein metabolism, whereas progesterone often acts antagonistically. Consequently, endurance performance might only be higher in the mid-luteal phase compared to the early follicular phase when the E/P (oestrogen-to-progesterone) ratio is high. Metabolic perturbations were often found to be dependent on the extent to which hormone levels increase between the different phases and the E/P ratio, but energy demand and nutritional status could be confounding. The authors state that the effect of hormone levels on exercise metabolism and performance occurs in a highly complex and often tissue-specific manner [4].

Limitations

Several limitations are encountered when studying the menstrual cycle. This is partly due to the biologically complex effects of hormones, as discussed previously. Next to the large variations in hormone levels between different phases, there is a high intra- and inter- individual variability in oestrogen and progesterone levels [6]. Due to the pulsatile secretion of hormones, levels might differ even within a day, for instance with higher progesterone in the morning [7,8]. Additionally, exercise is known to temporarily increase hormone levels, which makes the timing of measurement critical [9, 10]. Furthermore, a majority of the women does not have a natural cycle due to the use of oral contraceptive. Some female athletes, in particular endurance athletes, no longer menstruate due to intensive athleticism [11].

Menstrual phase comparative research also shows limitations with respect to methodology. Difficulties arise when determining the cycle phase of the female subject. Counting the number of days from the onset of menstruation is not sufficient, as there is a high incidence of anovulation and luteal phase deficiency (LPD) in active women with regular bleeding. Both are characterised by low progesterone levels during the second half of the cycle [12]. Basal body temperature or urinary luteinising hormone are two other phase indicators, but the golden standard is the actual measurement of oestrogen and progesterone. This method comprises the only way to identify the three phases. However, the most accurate determination – in serum – is quite invasive. The use of the E/P-ratio, instead of only looking at absolute values, may provide information about opposing effects of oestrogen and progesterone. Next to the complications in determining the actual phase, there has been inconsistency in phase terminology and subsequent protocols used by previous studies, which further impedes comparison of existing evidence [5].

Apart from hormonal influences, exercise performance is already a complex combination of multiple parameters. A remarkable example is the

VO2max, which is determined by hormone-associated variables and additional factors varying per individual [5]. Confounding by these additional factors are hard to exclude in determining the effect of hormonal levels alone.

Furthermore, exercise trials investigating hormonal effects have not always been methodologically representative. For instance, Oosthuyse and Bosch suggested to investigate the effect of oestrogen in ultra-endurance events, considering its (long-term) metabolic influence on fat use and sparing glycogen stores, whereas exercise trials to date were limited to less than 2 hours [4]. In other cases, good methodology is almost impossible: a time-to-exhaustion test at submaximal intensity is not very reproducible, but this is not a hormone-specific issue [5].

Conclusion

Although research on hormonal effects on exercise performance has been scarce and inconsistent, it should be clear that it comprises a highly complex subject that definitely deserves more attention. Apparently, the effect of hormones on exercise performance varies at least per discipline, between women and even within one individual. It is likely that female athletes can optimize exercise performance according to their menstrual cycle. Georgie Bruinvels (see introduction) recently launched a campaign with Libresse (the Red.fit programme [13]), in which advice is given on exercise and nutrition based on the cycle phase. This initiative is a step forward in creating awareness of the hormonal effects on exercise performance. Increasing attention to female physiology as a clearly distinct aspect of exercise medicine can possibly help uncover and overcome potential obstacles currently faced, to further advance this field of research and support female athletes in their exercise goals.

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