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MENSTRUAL CYCLE AS AN OBSTACLE TO ACHIEVING MAXIMAL SPORT RESULT

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Abstract

Each woman has different characteristics of menstrual cycle. The main problem is the determination of period in which the measuring would be carried out, so that the results could be directly linked to a certain hormone or phase of the menstrual cycle. Generally it could be said that menstrual cycle does not influence muscle contractility and maximum oxygen consumption, lactate level, heart rate, breathing volume, hemoglobin levels. Therefore, women who compete in anaerobic and aerobic sports do not have to adjust competition schedules to their menstrual cycle. On the other hand the increase of body temperature in the luteal phase of the menstrual cycle, possible cardiovascular strain in this phase, influence of progesterone on the respiratory center, the rise of breathing frequency and volume can have negative influence on long-term intensive sport activities. For this sort of activity female athletes are recommended to adjust their competition schedule to menstrual cycle.
Keywords: menstrual cycle, hormone, exercise, sport, result

Methodological problems in analyzing menstrual cycle

Four important periods can be identified within menstrual cycle. Their alternation is conditioned by the changes in level of four hormones and they are followed by certain, more or less marked, physiological changes in a woman's organism.

In a simpler way the whole cycle can be divided in two parts:

1. Follicle stage (from the first day of menstrual bleeding to ovulation- 14. day of cycle). Its name comes from processes in ovary, where in this period follicular with egg is being produced.

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2. Luteal phase (from ovulation to the first day of menstrual bleeding of next cycle; in cycle lasting for 28 days this phase covers long period of 14 days). The name also comes from processes in ovary, where after ovulation, that is, after dropping the egg from follicular, a yellow body is created- corpus luteum. Because of the processes in uterus this stage is sometimes called secretory phase; in that case, what is called follicular phase can be divided in menstruation-first 4 or 5 days of the cycle and proliferative stage. So, there are four important periods in menstrual cycle: menstrual bleeding, follicular phase, ovulation and luteal phase.

For the need of analyzing menstrual cycle, sometimes it is necessary to divide each of two main stages into three parts: early, middle and late.

Cyclic alternation of these phases is under the control of two hormones of pituitary: Follicular stimulating hormone - FSH and luteinizing hormone - LH, which reacts directly but also through the control of releasing the other two hormones. Those are: Estrogen, which reaches the maximum of secretion at the moment of ovulation, along with the maximum secretion of FSH and LH, and the other peak, which is of less intensity, is reached in the middle of luteal phase. Progesterone, whose maximum secretion is also expected by the middle of the luteal phase of menstrual cycle.

The most obvious physiological change within menstrual cycle is increase in body temperature in luteal phase. Cyclic alternation of phases of menstrual cycle can also be followed by other physiological changes such as heart rate, change of the cognitive function, breathing frequencies, tolerance and subjective perception of effort, muscle contractility… However, apart from the change in body temperature, which is easy to register and prove, finished analysis of the other physical changes did not give consistent results, in the first place because of methodological problems of menstrual cycle analysis. How to recognize days of menstrual cycle in which the "measurements" will be carried out so that results could be undoubtedly linked to a certain phase or a certain hormone?

Earlier analysis of menstrual cycle were based on counting days of the cycle, starting from the first day of menstrual bleeding, considering only women with regular menstrual cycle and relying only on the fact that ovulation comes at the end of follicular phase, that is in the middle of cycle or approximately on 14th day. Main disadvantage of this method is found in big variations in duration of folicular phase even with the women with regular cycle. Contrary to lutheal phase which is a lot more even in the duration (Cole, Ladner & Bryn, 2008; Harlow & Ephross, 1995). Therefore, ovulation can be detected more precisely by counting beck words, starting from the first day of the next cycle. A solution for creating an experiment would be measuring on days determined by counting forward from the first day of menstruation (e.g. from 11. to 14. days when the peak of estrogen is expected and between 19. and 22. days when the peak of progesterone is expected). The control for each measuring would be counting beck words from the first day of the next cycle. So, in the case of major mismatching the found result wouldn't be used in final analyses. There is another setback in this method. Even among the woman with regular menstrual cycle there is a great percentage of them with so colled anovulatory cycle (cycle in which ther is no ovulation) or LPD – luteal phase deficient cycles; both are characterized by low level of progesterone in the second part of the menstrual cycle. It is a mistake to deal with the assumption that testing was performed in the middle of the luteal phase, in the period of maximal concentration of progesterone and connect the received results with progesterone effects, while there was anovulatory or LPD cycle. If we speak about analyzing menstrual cycle in sports women, it should be stated that there are lot of LPD cycles (42%) and anovulatory cycles (12%) in woman who practice recreational running (De Souza, et al., 1998).

The other, relatively simple method used for detection of cycles phase, is measuring body temperature, basal body temperature – BBT. Generally from the moment of ovulation BBT increases on the average by 0,3 °C and this slightly increased temperature maintains through whole luteal phase of the cycle. This method has its disadvantages. Firstly, it is confirmed that some women do not have already mentioned increase in BBT after ovulation (Marshall, 1963).

Further more, even thou the increase of BBT in luteal phase is connected to increase of progesterone in that phase, so far analyses haven't determined an important connection between progesterone and increase in BBT (Marshall, 1963; Horvath & Drinkwater, 1982; Bauman, 1981); so results received in this way should not be taken with confident. Detecting LH – luteinizing hormone in urine. When in this way peak of LH is detected, ovulation can be expected in next 14 to 26 hours, with 95% of certainty (Miler & Soules, 1996).

Measuring estrogen and progesterone in saliva or detection of theirs metabolites in urine are reliable, thou a bit les sensitive methods, comparing to contemporary golden standard in determination of menstrual cycles phase – identifying serum concentration of estrogen and progesterone. Determination of both hormone concentration is unique way to confidently determine three important periods in menstrual cycle (according to the level of hormones):

1. Early follicular phase with low levels of both hormones;
2. Late follicular phase, peak of estrogen and low level of progesterone;
3. Middle luteal phase with high concentration of both hormones.

Even if a big "disadvantage" of this method is left out – need for multiple blood taking, another problem arises. Not in the method itself, considering it gives precise hormone values at the moment of blood taking, but in so cold pulsatile secretion of sex hormones. Because of this there are marked variations in their concentration even within several hours (Filcori, Butler, Crowley, 1984). In the first place, during the whole luteal stage concentration of progesterone varies. This is why concentration determined from blood sample dos not have to match the highest daily concentration or the concentration at the moment of experimental work. The problem can be partially solved by taking blood early in the morning when concentration of hormone is the highest (Syroup & Hammond, 1987). Additional problem in analyzing menstrual cycle with sports women is brought by the fact that physical activity increases hormone concentration, so blood taking is recommended in the period of resting (Keiser & Rogol, 1990; Jurkowski, et al., 1978). Results can be influenced by reaction of estrogen and progesterone. Estrogen during menstrual cycle reaches high values twice: once in late proliferative phase with the low level of progesterone, and second time in middle luteal phase with high level of progesterone. That is why two women can have same levels of estrogen but physiological effects are different because of different progesterone level. Therefore some studies suggest that apart from detecting absolute concentration of estrogen and progesterone, their relation should also be determined (Bunt, 1990).

There is another, les mentioned way of determining ovulation. Mini microscope or Maybe Baby. During proliferative phase with increase of estrogen level, concentration of salt in saliva rises. Observed through microscope salt in dried saliva forms different structures in the period of ovulation and immediately before it (peak of estrogen) than in different parts of cycle. Some studies show that sensitivity of this method in detecting "fertile days" – period of ovulation, is over 90% (Galati, 1994). If for some reason (high price, invasiveness, pulsatile secretion of hormones), we wont to avoid detecting serum concentration of estrogen and progesterone or LH level in urine (it is necessary to collect urine for 24h), for the need of menstrual cycle research, phases could be approximately determined by counting days from first day of the cycles. To lower the number of possible mistakes as much as possible, this simple method can be combined with one of more alter non-invasive methods which will serve as control (counting days backwards from the first day of the next cycles, taking body temperature every day and even using mini-microscope).

Time of testing

If question of recognizing cycle phase is solved in satisfactory way, what follows is a choice of periods (days) in menstrual cycle in which experiment research will be carried out. Observing relations between estrogen and progesterone, three phases are determined (table 1):

1. Early follicular phase (from 1. to 6. day) – low level of both hormones;
2. Late follicular (from 9. to 13. day) – high level of estrogen and low level of progesterone;
3. Middle luteal phase (from 18. to 24. day) – when the level of both hormones is high.

It is related to cycle lasting for 28 days.

Menstrual cycle and sports performance

When the method for determining menstrual cycle is chosen and when the periods for experimental research are chosen, an experiment can be created. In this experiment influence of menstrual cycle to numerous physiological parameters is analyzed. It is expected for this parameters to vary in its quality and quantity following increase and decrease in level of female sex hormones. Topic of this article is influence of menstrual cycle to sports performance. Firstly, parameters which can be measured will be reviewed. After that, finished thesis will be approximately divided in, so to say positive ones (those in which the connection between sport performance and certain periods in menstrual cycle is confirmed) and negative ones (those which deny such connection).

So far, the most often parameters that were measured in researches are: muscle contractility and maximum oxygen consumption VO2 max. Testing muscle contractility includes measuring muscle strength after voluntary contraction or after electro stimulation, monitoring muscle relaxation and muscle fatigability. Maximum oxygen consumption represents ability of organism to transport and use oxygen. It represents physical readiness of a person. It could be measured directly when with gradual increase of effort an ergo-bike or treadmill, ventilation, as well as O_2 and CO_2 in breathed and exhaled air, are measured readiness of a person. It could be measured directly when with gradual increase of effort ergo-bike or treadmill, ventilation, as well as O_2 and CO_2 in breathed and exhaled air, are measured. VO_2 max is reached when oxygen consumption, which increased by increased effort, came to a stabile level. Apart from direct measuring of VO_2 max certain parameters which determinate maximum oxygen consumption, can be monitored. Those are: metabolism and concentration of blood lactate, body weight, plasma volume, hemoglobin concentration, hematocrit, breathing frequency and ventilation, heart rate, body temperature…

Cognitive and motor functions. Although performances of both genders overlap to a large degree, women tend to outperform men in some specific aspects of verbal ability, whereas men achieve higher scores in spatial tasks (Hausmann 2000). Sex hormones are known to influence the organization of the mammalian brain during critical periods of development and can permanently alter an individual's propensity to engage in many sexually dimorphic activity. There is some controversy in the current literature as to the size and extent of sex differences in cognitive abilities. Nevertheless, numerous studies have reported a sex difference in favor of women on tests of verbal fluency, verbal articulation, perceptual speed and accuracy and fine distal motor movements. A reliable sex difference in favor of men has been reported on task involving spatial rotation and manipulation and mathematical reasoning (Kimura and Hampson 1994). Measuring cognitive performance of women during the menstrual cycle, it has been reported that gonadal steroids enhance those skills for which females typically show better results than males (Walpurger 2004). Most of the studies observed improved „female skills" during the

luteal phase, when estrogene and progesterone are high. They found that in the midluteal phase women performed better on tests of manual dextrity, verbal fluency and speeded articulation, known to favor females, but more poorly on perceptual spatial tasks, known to favor males (Kimura and Hampson 1994).

Muscle contractility. Sarwar and associates in 1996 as well as Phillips and associates also in 1996 showed in experimental research on women with normal menstrual cycle that there is stronger muscle contraction in the middle of cycle and in late follicular phase. Significant decrease in muscle strength was detected in period after ovulation (Phillips, et al., 1996; Graves et al., 1999). This points to the possible importance of estrogen to increase in strength of muscle contraction. On the other side, Graves and associates in similar experiment found stronger muscle contraction in the middle of luteal phase, suggesting importance of progesterone in stronger muscle contraction (Graves et al., 1999). Finally, Dibrezzo and associates (1991) as well as Jancee de Jonge and associates (2001) didn't find any connection between phases of menstrual cycle and strength of muscle contraction (DiBrezzo, Fort, Brow, 1991; Jance de Jonge, 2000). Inconsistency of research was suggested in the beginning of this paper. What can be concluded on this level is: in doing sports which mainly require muscle strength, sports women don't have to adjust their trainings and competition calendar to their menstrual cycle.

Blood lactate concentration. Certain works point to the increased concentration of blood lactate in follicular phase. They suggest importance of estrogen in increased oxidation of fatty acid and savings of glycogen (McCracken, M., Anisworth, B., Hackney, A.C.(1994; Jurkowski 1981). In often works, it was suggested that increase in blood lactate concentration is more likely to be connected to a diet and availability of glycogen and fatty acids. Certain studies which predicted strictly controlled diet before the experimental research didn't show connection between menstrual cycle and serum concentration of lactate (Nicklas, B.J., Hackney, A.C., Sharp, 1989; Boenen,1983). It is considered that even thou same combination of nutritional status and menstrual cycle phase could bring to the increase of blood lactate, that wouldn't influence VO_2 max at all.

Body weight. Most of the studies didn't show significant changes in body weight during menstrual cycle (Leburn, et al., 1995; De Sousa, et, al., 1990). Even thou these researches deny supposed hold of liquids in organism in certain stages of cycle, they don't deny influence of estrogen and progesterone to redistribution of liquids.

Redistribution of liquids within an organism would also reflect in change of **plasma volume, hemoglobin concentration and hematocrit**. Unlike some earlier studies with lower number of examinees and without hormonal verification of menstrual cycle phase, which shoved bigger transfer of fluids outside of blood vessels and faster decrease in plasma volume in certain cycle stages, later and more representative studies don't register such changes (McCracken, Anisworth, Hackney, 1994).

Heart rate. Some studies show certain increase in heart rate in middle luteal phase compared to before ovulation cycle period (Bailez, Zacher, Mittelman, 2000). Increase of frequency could be explained by the increase of basal body temperature in luteal phase of cycle, considering that average rate increases 7 to 8 heartbeats for 1°C of body temperature rise. Increase in heart rate that could happen in luteal phase with average increase of body temperature for 0,3°C would be of no importance. That is why it is no surprising that there are much more researches in which there is no connection found between menstrual cycle phase and change in heart rate; it goes for the state of resting and resting after physical activity (Boenen, et al., 1983; Leburn, et al., 1995; De souse, et al., 1990).

Basal body temperature. Basal body temperature won't be discussed in details considering that this fact is known for more than a century. BBT increases for 0,3°C to 0,4°C after ovulation, and stays at that level during whole luteal cycle phase (Marshall, 1963).

Ventilation. In researches conducted on animals it has been shown that progesterone with direct influence on hypothalamus and respiratory centre could bring to the increase of respiratory frequency and ventilation volume. Increase in respiratory frequency and breathing volume could be expected in luteal phase of menstrual cycle. This could be expected when both body temperature and progesterone concentration are increased. Certain studies shoved increased ventilation both in the state of resting and during physical exercises in luteal cycle phase (Schoene, et al., 1981; Dempsey & Johnson, 1991). It is not necessary to mention that in certain researches such change is not registered.

Maximum oxygen consumption. As it can be seen, certain parameters which define and reflect VO_2max, certain determinants of VO_2max, vary during menstrual cycle, or at least that is what some researches suggest. However, these changes seem not to be enough to bring to limitation of VO_2max. Most studies do not found changes in VO_2max during menstrual cycle (De Sousa, 1990; Dombovy , et al., 1987; Beidelman, et al., 1999). Considering that VO_2max is the most important indicator of sport performance in intensive anaerobic/aerobic sports, and since it is not under the influence of menstrual cycle, at this level it can be concluded that sports women who compete in intensive anaerobic/aerobic sports do not have to adjust their trainings and competition to their menstrual cycle.

Conclusion

Since it has been already emphasized that in sports which, in the first place, require muscle strength, as well as wit anaerobic/aerobic sports, maximum sport performance and results will not depend on menstrual cycle phase. In this part instead of conclusion we can show some more results which can be important to same sports women. Prolonged intense physical activity, especially in conditions with high temperature and humidity of surrounding, could be restricted to a certain level in luteal phase of menstrual cycle. Considering previous studies, showing increase in body temperature, heart rate and ventilation in middle luteal phase of cycle (Bailez, et al., 2000; Schoene, et al., 1981 Williams & Krahenbuhl, 1997), which all point to increased cardiovascular and thermoregulatory stress in this phase, during intensive and prolonged physical activity (especially if increased thermal stress, caused by overheating or increased humidity of surrounding is added), in this point we can conclude: If sports women play sports which are related to prolonged and intense physical activity, they should be advised to adjust their competition calendar to their menstrual cycle, since middle luteal phase cud have negative effect. In the same way menstrual cycle can have influence to working efficiency, if women are expected to work for a longer period of time in overheated and humid surrounding.
We should mention one more time research on muscle power and menstrual cycle: the best period for top sport results (considering muscle power) would be follicular phase, as suggested by Sarevan and associates, as well as Phillips and associates (Sarwar, et al., 1996; Philips, et al., 1996)

Therefore, female athletes:

1. If you play sports which in particular requires muscle power, you do not have to adjust calendar of competition and trainings to your menstrual cycle.

2. Furthermore, for sports which require muscle power, in the first place it is good to know that some researches point to a potential positive effect of late follicular phase (from 9. to 14. day).

3. For most aerobic/anaerobic sports, you do not have adjust calendar of competitions and trainings to menstrual cycle.

4. For sports which are related to long physical effort, especially if it will take place in conditions where there is high temperature and humidity, second part of menstrual cycle should be avoided.

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Table 1 *Menstrual cycle phase*

		Days	***Estrogen***	***Progesterone***
Follicular phase	*Early follicular phase*	***1-6***	***low***	***low***
	Middle follicular phase	***6-9***	***increase***	***low***
	Late follicular phase	***9-13***	***high (around ovulation)***	***low***
Ovulation		***14.day***	***low***	***low***
Luteal Phase	*Early luteal phase*	***15-18***	***increase***	***increase***
	Middle luteal phase	***18-24***	***high***	***high***
	Late luteal phase	***24-28***	***decrease***	***decrease***