

The physical work capacity of female athletes and its determining factors

by Larisa Sharhlina, Doctor of Medicine and a Professor at the Ukrainian State University of Physical Education and Sport, Kiev

ABSTRACT

As a result of a complex examination of talented female athletes specialising in modern pentathlon, athletics and both competitive and synchronised swimming, it has been discovered that, during the menstrual cycle, changes of hormonal status and the complex reorganisation of neuro-hormonal regulation are accompanied by changes in respiration, circulation, blood respiratory function, and oxygen utilisation.

These body oxygen regimes thus determine the specific features of female athletes' work capacity.

Specialists in the theory and methodology of athletics training from different countries around the world have come to the conclusion that, from the end of the 60s until the beginning of the 80s, the volume of training work for female athletes has almost doubled.

The possibility of further increases in training volumes remains but, in practice, it is accepted that high physical and mental loads will result in a greater prevalence of cases of overstraining the body's functional systems. An exhaustion of the body's adaptation abilities will reduce the duration of elite athletes' performances at the highest level. Many athletes and teams, having excessively increased the volume of training loads, fail to achieve the results expected of them (4, 6, 10, 11, 12). This is first of all indicative of the necessity to improve all aspects of athletic preparation and the system of athletic training.

In elite sport today, the opinion of many specialists is that a lot of the most talented people to be discovered by talent identification require an individual approach to their long-term athletic preparation. This allows for a maintenance of the functional reserves of an athlete's body, while providing conditions for the enhancement of the individual's skills, and also their longevity (1, 4, 5, 6, 7, 12, 18). The female is a classic example of the necessity of an individual approach in all aspects of life.

The Atlanta Games confirmed the constant growth and development of female sport and the mass scale character of the Olympic movement for females. For instance, the first Olympic Games (Athens, 1896) were held with the participation of male athletes only and the second Olympic Games (Paris, 1900) were marked by the participation of 11 female athletes, whereas the Atlanta Games (1996) witnessed the participation of 3626 female athletes (V. N. Platonov, 1997). New sports specific disciplines appear every year and women now participate in many sports events previously considered as being purely for men.

Unfortunately until now the training process for male and female athletes has invariably been organised in the same manner. The peculiarities of the female body and, in particular, the biological characteristics of the menstrual cycle, have not been accounted for. This is one of the reasons for health impairment (reproductive function, in particular), a reduction in sporting performance and premature drop-out from sport (1, 2, 4, 5, 6, 12, 15, 16).

It is well known that there are fundamental biological differences between males and females, which are genetically predetermined. Morphological and functional peculiarities of sex dimorphism manifestation are observed from the intrauterine period onwards and they last throughout human life (9, 17). Sex dimorphism has a significant neurohormonal impact on the functions and interrelationship of all body systems. Therefore, the responses of males and females to the same irritants of the internal and external environment may be quite different. According to V. G. Kovichnikov and B.A. Nikityuk (1992), among numerous

differences the greatest degree of sex dimorphism is evident in the indices for body length, strength levels, fat levels, and oxygen consumption. The degree of sexual differences is less marked for the body mass overall than for its individual constituents- the mass of fat component is greater in females, whereas muscle mass is greater in males (2). Thus, the various morphological features are closely connected with the functional manifestations of sex dimorphism, and in turn the body adaptation processes are specific to external influences, and, in particular, to physical loads.

The peculiarities of functional state work capacity and the responses of the female body to various irritants may depend on changes in hormonal condition during the menstrual cycle. During the last three decades, increasing attention has been given in many countries to the study and observation of the rhythmical organisation of the body processes (12). An interest in biorhythms is quite natural as they have a dominant role in nature and cover all manifestations of all living beings -from the activity of sub cellular structures and individual cells to complex forms of body behaviour. According to V. M. Dilman (7), the problems of adaptation, standards and homeostasis should also be considered in the context of the cyclical nature of the vital activity processes. From the standpoint of biorhythmology, it is more correct to say that dynamic homeostasis creates stability in the body rather than homeostatic constancy.

The beginning of sexual maturity of girls at the age of 12-15 is marked by the first menstruation-menarche. The biologically significant and regularly occurring changes in the bodies of young females during the period of sexual maturity are encompassed within the menstrual cycle. It lasts from the first day of previous menstruation to the first day of subsequent menstruation. According to M.S. Malinovsky, the most common is the 28 day cycle (60%), less common is the 21 day cycle (26%), whereas a 30-35 day cycle is observed least frequently (1-12%). The standard duration of menstruation is 3-7 days and the duration of menstruation of a moderate level is 3-5 days as a rule. Regular menstrual cycles are usually established for the majority of girls (87%) during the first year. The character of menstrual function in girls depends on their health and general physical development.

Excessive motor activity in girls (heavy physical and emotional training loads) delays sexual maturity. On the contrary, an increase of motor activity for boys (to a certain extent) contributes greater development of muscle and enhances the rate of growth and sexual maturation. However, an insufficient locomotor development and decrease of motor activity are followed by a delayed sexual maturation of both boys and girls (1, 2, 3, 4, 5, 6). During the first half of the menstrual cycle an ovule in the ovarian follicles matures and the concentration of oestrogen hormones in the body increases. In the middle of the cycle the follicle ruptures and the ovum leaves it, marking an ovulation process. The ovum life span is about 24 hours and, if it is not fertilised, it dies. In place of the ruptured follicle a new gland-yellow body, or corpus luteum formed which produces progesterone.

The hormonal reorganisation due to the destruction of the ovum results in an impairment of the integrity of vessels in the uterus mucosa, bleeding, and the tearing away of the myometrium mucosa. This is the most apparent external manifestation of the cyclical process, so it is therefore convenient to start counting the cycle from the first day of the last menstruation (8).

Thus, due to maturation and the ovulation of an ovum in the body of the female, changes occur in the concentration of sex hormones. The hormonal regulation of all the functional systems of the body should be individually reflected in the functional capacities and work capacity of each female.

Regularly occurring physiological changes take place in the process of the menstrual cycle: a) in the hypothalamic-pituitary system, which regulates sexual functions; b) in the ovaries (ovary cycle); c) in the uterus (uterine cycle); and d) in the body of the female.

Changes in sex hormone concentration allow for the conventional division of the menstrual cycle (MC) into phases having distinct individual borders and physiological features. During the 28-day cycle we can distinguish 5 phases:

Phase 1 menstrual (1 - 6 days of cycle)

Phase 2 postmenstrual (7 - 12 days of cycle)

Phase 3 ovulation (13 - 15 days of cycle)

Phase 4 postovulatory (16 - 25 days of cycle)

Phase 5 premenstrual (26 - 28 days of cycle)

According to current beliefs the ovaries perform a generative function, this being the site of ovum and sex hormone formation. Oestrogens, progesterone, relaxin and androgens all possess a wide spectrum of biological action.

The cyclical character of the female reproductive processes is the most distinctive feature. The changes in level of the sex hormones in the blood influence all the body systems, which determine biological peculiarity, i.e. the cyclical character of all body system functions.

In their role as an important chain in the adaptation and trophic responses of the body, the female sex hormones provide the possibility for an adequate adjustment of the female body to the environment (13, 24, 25), including training and competitive loads. The elite sport of today is characterised by high physical and mental loads and hypoxic states brought about by either the demands of the load imposed or the nature of the training response. Our studies are based upon a concept of the functional system of respiration (FSR) according to A. Z.. Kolchinskaya (6, 7, 8, 9, 14). It is the FSR that provides for the meeting of tissue oxygen demands due to pulmonary ventilation and gas exchange in the lungs and the circulation and respiratory function of blood. Oxygen transport to tissues by means of tissue mechanisms, which determine oxygen utilisation and the whole process of oxidative phosphorylation, results in the formation of the major source of biological energy - ATP (18, 19).

What is of great interest are the insufficiently studied FSR responses to the changes in the body's hormonal state. One of the natural models for studying the above responses is the cyclical changes of blood hormone content in the female body during the menstrual cycle (MC). Studies of the FSR state that changes during the MC are of both theoretical and practical significance, as they determine to a great extent the work capacity of the female.

We have assumed that the state of the FSR and bioenergetics should change under the influence of changes in blood hormone concentration at different stages of the MC, and that the changes in the FSR state should determine the possibility of the manifestation of physical capacities, coordination of movements, and the mental and physical work capacity of female athletes during the MC.

Therefore, the aim of our studies was to discover the dependence of the FSR state and the work capacity of female athletes on changes to their body hormonal state during the MC under normal and hypoxic conditions.

Methods of studies

52 female athletes with a normal menstrual function served as subjects. The MC phases were defined according to indices of daily basal temperature, data of "fern" phenomenon, and the analysis of a special questionnaire (Table 1). The studies were carried out at each phase of the MC during 23 menses. The FSR response to inhaling a hypoxic mixture containing 11% of oxygen (HM-11) was determined at each phase of the MC in 10 modern pentathletes.

We utilised a systemic approach to the estimation of training processes with a combination of modern physiological, biochemical and pedagogical methods, as well as mathematical models of the system of the body oxygen regime regulation (BOR) and the functional system of respiration (FSR) according to A. Z.. Kolchinskaya (8). Determining the functional indices was achieved under conditions of relative rest at each phase of the cycle in normoxia as well as during the inhaling of air containing 11% oxygen and air containing standard oxygen content while performing ergonometry tests of different intensities (including maximum intensity).

The pulmonary minute volume (PMV), respiratory volume (RV) and respiratory rate (RR) was determined by means of the "Volumeter" (Germany). "Spirolyt-2" (Germany) and "Beckmann-MMC" (USA) gas analysers were used to analyse the gas content of inhaled air. Blood haemoglobin was measured by means of a photocolormeter MKMF-1 and blood

oxygen saturation (SaO₂) was estimated by the "Oxyshuttic" (USA), a piece of apparatus which was also used to register heart rate (HR). Stroke volume (SV) was estimated by means of a PA-5 device as well as according to the formula of N. S. Pugina (1966).

The response of the body to hypoxia was determined by means of testing a hypoxic gas mixture containing 11% oxygen (HM-11). The mixture of constant content was supplied by the a "Hypoxicator" device from the Hypoxia Medical Company. The results obtained were statistically processed by the utilisation of criteria formulated by students.

Information concerning the effect of competitive sport on the menstrual function has been obtained by responses to 974 special questionnaires analysed by the methods proposed by N.V.Svechnikova with a slight modification (Table 1).

Table 1

ANONYMOUS AND CONFIDENTIAL QUESTIONNAIRE

Country _____ Height _____ Weight _____

1. Age _____ 2. Title, class (qualification) _____

3. Age when participation in sport began _____
 a) General sports involvement _____
 b) Specialisation in a sport _____

4. Age of menarche _____

5. Nature of menstrual cycle
 a) Regular - after 21, 24, 30, 40, 60 days (underline)
 b) Irregular (indicate duration of intervals) _____

6. Indicate the character of the menstruation phase before involvement in sport (regular, irregular, heavy, scanty, painless, painful) _____

7. Character of menstrual cycle after involvement in sport: regularity, after how many days do the menses occur?—21, 24, 30, etc. (underline)
 a) Scanty, heavy (underline)
 b) Duration of menses (1,2,3,4,5,6 days) (underline) _____
 c) Do you have bleeding? yes/no - if yes, how often _____

8. Feelings before the menses:
 a) Do you have headaches? _____
 b) Do you experience increased fatigue? _____
 c) Do you experience increased irritability? _____

9. Feelings during the menses:
 a) Do you experience increased fatigue? _____
 b) Do you experience increased irritability? _____

10. Do you participate in training sessions during the menses?: yes/no

11. Do you participate in training sessions during the whole of the menses?: yes, no, yes but with some restriction, without restriction (underline)

12. Are the training sessions efficient during the menses? yes, no

13. Do you participate in competitions during the menses?: yes, no

14. What performance level do you achieve as a rule during the menses?: high, moderate, low

15. What means do you use to shift the terms of menses?
 _____ Are they effective?: yes/no

16. The last menses: Date and Month
 _____ (first day)
 _____ (last day)

Results and discussion

The special questionnaire, which covered 974 respondents representing 16 sports, demonstrated that the majority of elite female athletes (98.9%) trained during menstruation and that one in every three athletes experienced menstrual function disorders such as delayed sexual development (late menarche), an impaired cyclical character of the MC, or a reduction or prolongation of menstruation. Each of the above factors indicates that the limits of physiological adaptation are being exceeded with an effect on this function.

The highest percentage of disorders is observed amongst gymnasts, ski racers and acrobats.

An analysis of the results of instrumental examinations has shown that changes of hormonal status during the MC significantly influence the functional state of athletes. According to our observations, body mass increases from the end of the postovulatory phase. It reaches maximum value during the premenstrual phase, slightly decreases during the phase of menstruation and reaches initial values at postmenstrual phase (Table 2). The results presented reflect the dynamics of body mass changes. Such changes may be explained by the impact of oestrogens on fluid and electrolyte balance; by means of aldosterone reabsorption of an increase in sodium which, in turn, enhances the reabsorption of water (4, 11). A change in the hormonal balance of oestrogens and progesterone may lead to a significant increase in body mass including premenstrual oedemas (8, 19, 29).

Table 2: Changes in the body mass of female athletes from different sports at various stages in the MC (kg) (M ± m)

| MC phases Sports event | I | II | III | IV | V |
|---|-----------|-----------|-----------|-----------|-----------|
| Basketball (junior nation, team of Ukr.SSR) n - 22 | 64,5±0,9 | 63,0±0,85 | 63,8±1,2 | 65,25±1,0 | 67,0±1,2 |
| Competitive swimming n - 15 | 64,2±0,92 | 63,4±0,71 | 63,6±0,93 | 64,4±1,1 | 65,76±1,3 |
| Kayaking n - 19 | 62,5±0,76 | 62,3±0,7 | 62,0±0,8 | 62,8±0,3 | 63,9±0,7 |

The body oxygen regimes (BOR) of athletes change during the MC as well. The indices of respiration reflect changes at rest (sitting position) (Table 3). The highest indices of pulmonary minute volume (PMV) are noted during the ovulation phase (phase 3). It should be stated that during this phase the highest pulmonary ventilation is achieved as a result of high respiration volume (RV), but a relatively low respiration rate (RR) in comparison to other phases of the cycle. However, during the ovulation phase breathing is less economic. The premenstrual phase is characterised by the fastest respiratory rate and the lowest respiration volume: O_2 is utilised by the body from 35.2% - 39.31% of the air entering the lungs (ventilatory equivalent) whereas during the postmenstrual and postovulatory phases O_2 is utilised from 32.71% and 32.91% respectively.

Table 3: Indices of respiration in female athletes whilst inhaling air with 20.9% oxygen and a hypoxic mixture (HM-11) at different phases of the ovulatory menstrual cycle (OMC) (M ± m)

| OMC phase | Oxygen content in inhaled air % | PMV, ml/min | RR in 1 min | RV, ml | O_2 intake, ml/min | VE,l | Sa O_2 , % |
|-----------|---------------------------------|-------------|-------------|----------|----------------------|-----------|--------------|
| I | 20,9 | 6525±204 | 16,8±0,6 | 388,4±21 | 195,6±14 | 33,4±0,6 | 97,2±0,9 |
| | 11,0 | 7825±301* | 17,6±0,4 | 444,6±28 | 225,4±8 | 34,7±0,9 | 81,0±1,0 |
| II | 20,9 | 5713±92** | 16,2±0,7 | 352,6±25 | 174,8±16 | 32,7±0,8 | 97,2±0,4 |
| | 11,0 | 73,25±274* | 15,6±0,4 | 469,6±37 | 254,4±13 | 28,8±0,5 | 82,8±1,2 |
| III | 20,9 | 7050±360** | 17,6±0,7 | 400,6±39 | 200,5±18 | 35,2±0,9 | 97,8±0,4 |
| | 11,0 | 8360±370* | 17,2±0,9 | 486,0±29 | 248,3±19 | 33,7±0,8 | 85,0±0,8 |
| IV | 20,9 | 5800±201** | 16,8±0,8 | 345,3±28 | 175,9±11,0 | 32,9±10,4 | 97,2±1,0 |
| | 11,0 | 7555±362* | 17,2±0,8 | 439,0±39 | 244,6121,2 | 30,0±10,6 | 82,0±0,6 |
| V | 20,9 | 6325±208** | 20,4±1,23 | 10,0±34 | 165,0±15,2 | 38,3±1,2 | 97,2±0,7 |
| | 11,0 | 7100±295* | 16,8±1,0 | 422,6±26 | 207,7±11,8 | 34,2±10,9 | 80,6±0,4 |

NOTE. VE = ventilatory equivalent. Sa O_2 = oxygen saturation of arterial blood.

* reliable differences between normo-, and hypoxic values (p 0.01).

** reliable differences between normo-, and hypoxic values (p 0.01).

The highest values of oxygen uptake during the ovulation phase were due to the stimulating effect of cellular respiration by oestrogens, the concentration of which during

this phase is the highest. An increase in the sensitivity threshold of the respiratory centre to CO_2 during the premenstrual and menstrual phases of the cycle (17, 18, 19, 20). together with a reduction of bronchial permeability and ventilatory capacity of the airways as a result of secretory changes under the impact of sex hormones (4, 10, 11, 17, 18, 19, 20), may be the cause of a compensatory increase in respiration rate and pulmonary ventilation, along with a decreased respiratory volume during these phases (especially the premenstrual phase).

More change is observed in the indices of circulation (Table 4). The heart rate (HR) increases at the beginning of the ovulation phase, its values maximising during the premenstrual phase. This may be related to the enhanced tone of the sympathetic part of the CNS beginning with the ovulation phase, whereas before ovulation the tone of the parasympathetic part of the CNS is dominant (4). An increased HR results in an augmentation of blood minute volume (BMV) during the postovulatory phase, and especially in the premenstrual phase. According to M. Rotaru this may be considered as a compensatory mechanism related to an increased reverse venous circulation to the right side of the heart and an enhanced blood volume. The lowest cardiac output is observed during the menstruation phase. The changes in stroke volume during the MC were found to be insignificant ($P < 0.05$). The same was true for arterial pressure differences in systolic pressure during different phases of the cycle, constituting a range from 3-5 mm Hg, whereas the differences in diastolic pressure ranged from 4-7 mm Hg. During the first and especially the third phases, the circulation system meets the body oxygen demand most economically- each litre of O_2 during the menstrual and ovulatory phases is supplied from 19-20 litres of circulating blood. During the second half of the cycle. the circulation becomes less economic. The haemodynamic equivalent (HE) increases significantly ($P < 0.05$) whereas the oxygen pulse (O_2CC) diminishes (Table 4).

Table 4: Circulation indices in female athletes whilst inhaling air with 20.9 % oxygen and a hypoxic mixture (HM-II) at different phases of ovulation in the MC.

| OMC Phase | O ₂ content inhaled air,% | BP syst | BP diast | BR in 1 min | SV, ml | BMV, ml/min | HE, l |
|-----------|--------------------------------------|-----------|----------|-------------|----------|-------------|-----------|
| | | mm Hg | | | | | |
| I | 20,9 | 105,0±2 | 65±6 | 65,8±3,4 | 60,2±36 | 3961±1,1 | 20,30±0,6 |
| | 11,0 | 110,0±8 | 68±6 | 88,6±4,2 | 60,4±0,9 | 535±52 | 23,80±0,7 |
| II | 20,9 | 104,6±8,3 | 58±4 | 64,2±2,2 | 63,6±1,1 | 4083±41 | 23,35±0,9 |
| | 11,0 | 102,2±6,1 | 52±4 | 60,2±1,8 | 64,1±1,3 | 5140±38 | 20,20±0,6 |
| III | 20,9 | 107,4±7,2 | 60±5 | 60,0±2,0 | 63,3±0,8 | 4176±44 | 20,83±0,8 |
| | 11,0 | 99,0±4,8 | 60±4 | 85,2±1,2 | 60,2±0,9 | 5129±41 | 20,65±0,9 |
| IV | 20,9 | 109,0±4,3 | 62±3 | 72,0±2,3 | 63,5±0,9 | 4572±42 | 25,90±1,1 |
| | 11,0 | 106,4±8,1 | 54±2 | 85,4±0,9 | 64,2±0,8 | 5482±33 | 28,00±0,8 |
| V | 20,9 | 108,4±6,4 | 64±2 | 73,8±2,3 | 62,6±1,0 | 4620±22 | 28,00±0,9 |
| | 11,0 | 110,0±5,2 | 64±4 | 91,2±1,3 | 63,3±0,8 | 5773±43 | 27,90±0,7 |

Blood haemoglobin content changes are insignificant during different phases of the t MC- from 124.5 +/- 8.0 g/l during the first phase to 126.6 +/- 6.0 g/l during the fifth phase ($P < 0.05$). The saturation of arterial blood with oxygen changes slightly during each phase of the cycle, with the highest values being observed during the ovulation phase (Table 3).

At rest the lowest speed of oxygen delivery to the lungs is observed during the postmenstrual and postovulatory phases, whereas the highest level is observed during the ovulation phase. During this phase the speed of oxygen delivery to the alveoles is significantly higher in comparison to the other phases. An increase in the speed of oxygen transport by arterial blood, which begins in the ovulation phase, becomes most evident during the postovulatory and postmenstrual phases. The level of oxygen uptake is the highest during the ovulation phase despite the greater speed of oxygen transport by arterial blood. The speed of its transport by mixed venous blood during the third phase is statistically low when compared with the values evident in the fourth and fifth phases. The highest values of oxygen intake which are evident in the ovulation and menstruation phases are probably due to the fact that these phases. being the phases of "physiological stress," establish increased energy demands to the body.

Changes in hormonal status and the state of the respiration, circulation and BOR systems influence the manifestation of the physical capacities of female athletes and their work capacity.

The total work capacity determined by means of an ergometry test significantly differs during different phases of the MC (Fig. 3). Both maximum power and maximum volume of performed work show differences too. In modern pentathletes the highest values of the above parameters were noted during the postmenstrual and postovulatory phases, reduction of work capacity has been observed during premenstrual, menstrual whereas a significant reduction of work capacity has been observed during the pre-menstrual, menstrual and ovulatory phases of the cycle.

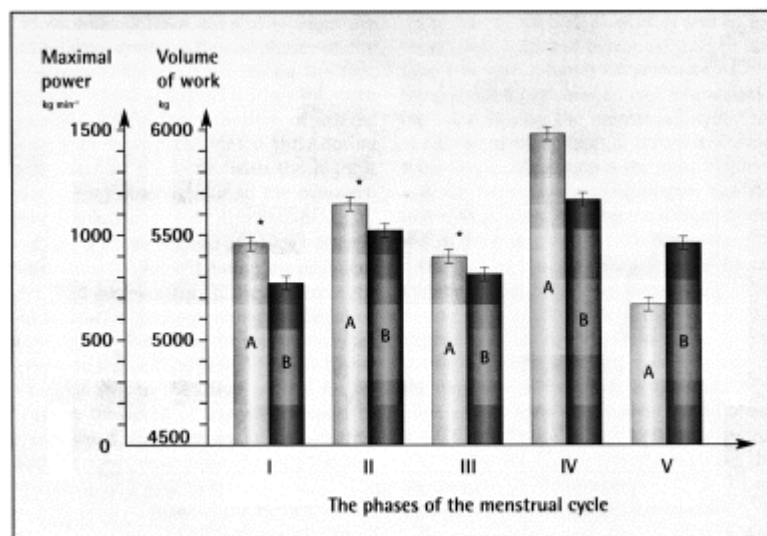


Fig. 3. Maximum power—A and total volume of performed work—B in athletes specialising in modern pentathlon (* $P < 0.05$)

The functional cost of work is also of interest. High values of maximum oxygen up-take and low volumes of performed work bring about a high oxygen cost in undertaking loads during the menstrual, ovulatory and premenstrual phases of the cycle. During these phases respiration is the most frequent and the least economic-ventilatory equivalent is the highest whereas the oxygen effect within the respiration cycle is the lowest.

During maximum intensity, the blood minute volume (BMV) significantly increases during phases 1, 3 and 5 of the cycle at the expense of HR augmentation; the lowest stroke volume is observed during phase 5, the highest during phase 2. There is a high pulse cost of work respectively during phase 3 --0.46 HR/kg min; phase 1--0.44; phase 5 -- 0.41 HR/kg min. During the above phases the low oxygen pulse constituted 18.3 +/- 0.3 ml O₂/HR, 17.0 +/- 0.4; 18.9 +/- 1.0 ml O₂/HR.

Optimum regimes of respiration and circulation functioning have been noted during phases 2 and 4 of the cycle; this is confirmed by much lower values of ventilatory and haemodynamic equivalents along with increased oxygen effects of respiration and cardiac cycles.

The findings show that during the course of the MC, changes of hormonal status (complex reorganisation of neurohormonal regulations) are accompanied by changes in respiration, circulation, respiratory function of the blood and speed of oxygen utilisation in the body of the female. We have revealed a high economy in the functions of the respiratory and circulatory systems, as well as high reserves of respiration during the postmenstrual and postovulatory phases of the cycle. These factors determine the higher work capacity of athletes during these phases as compared to the ovulatory, premenstrual and menstrual phases.

Taking into account the fact that strenuous physical loads are accompanied by hypoxic states, we were interested in the response of the female body to hypoxia during the MC. No data on this subject was found in the literature. There were only some notions about changes in such aspects as respiration, circulation, respiratory function of the blood and the

oxygen regimes of the female body at an altitude of 2000-4000 m, but nothing in relation to the MC.

Our studies have shown that the responses of the female body to HM-11 inhaling for 10 minutes have their own features in each phase (Table 3, 4).

Under hypoxic conditions PMV increases at each phase, being at the highest during the ovulation phase. It's increase during phase 3 is due to an augmentation of respiratory volume (RV) which is indicative of an enhanced efficiency of lung respiration and economy (VE has decreased) (Table 3).

While inhaling HM-11, the highest HR is observed during the premenstrual and menstrual phases. This contributes to the enhancement of BMV. Changes in stroke volume under these conditions have been insignificant (Table 4).

A hypoxic mixture inhaled for 10 minutes has resulted in an insignificant increase of blood haemoglobin content during the ovulatory and premenstrual phases. During HM-11 inhalation, saturation of arterial blood with oxygen (SaO_2) decreases to 82.0 +/- 0.4% during the postovulatory phases, 82.8 +/- 0.3% during the postmenstrual phases, and 85.0 +/- 0.6% during the ovulation phases. In revealing the peculiarities of changes in respiration and circulation, SaO_2 determines the specifics of the body oxygen regimes in hypoxic conditions as well. Significant changes have been noted in both speed of stage-by-stage oxygen transport and cascades of O_2 (Fig. 2.). Under hypoxic conditions the speed of oxygen delivery to the lungs and especially to the alveoles is lower than that of oxygen transport by arterial blood in all phases of the MC except the ovulation phase. During phase 5 the highest speed of oxygen transport by arterial blood is due to the highest values of BMV: PO_2 during HM-11 inhaling decreases to a level lower than critical (Fig.2).

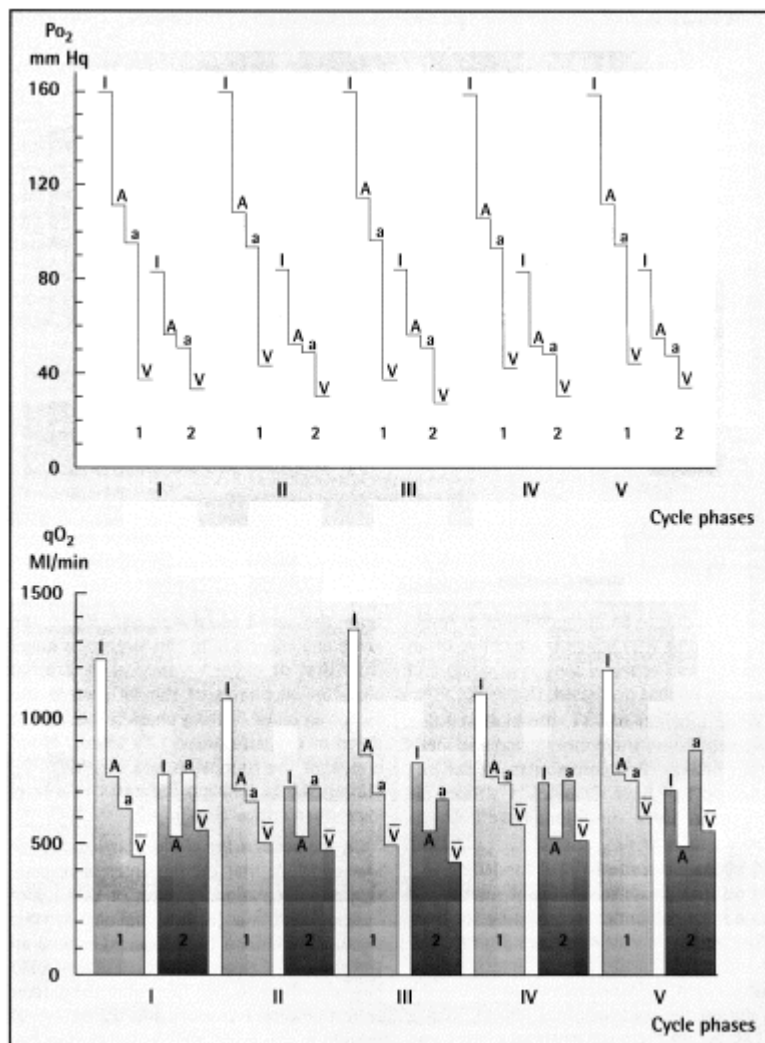


Fig. 2. Cascades of PO_2 and speed stage-by-stage oxygen delivery in modern pentathletes whilst inhaling air containing 20.9 % O_2 (1) and a gas mixture with 11 % O_2 (2) during phases 1 - 5 of the MC.

On the basis of the studies carried out, we may conclude that the responses of respiration and circulation, changes of BOR under hypoxic conditions (whilst inhaling a hypoxic mixture containing 11% oxygen) depend on the phase of the menstrual cycle. One should pay attention to the fact that the better conditions for transport and utilisation of oxygen in the body are created during hypoxia at the expense of greater stimulation of respiration and circulation function during the most crucial phase for the female body which is phase 3 of the menstrual cycle, when the process of ovulation called upon for reproduction, dominates.

The above results demonstrate that hormonal changes (complex neurohormonal reorganisation of regulatory mechanisms during the MC) determine the biological cyclical character of all the body system functions. A high economy in the functions of respiration, circulation, BOR and high respiration reserve during the postmenstrual and postovulatory phases of the cycle provides for the greater work capacity of female athletes during these phases as compared to the ovulatory, premenstrual and menstrual phases.

We have also discovered that the female body's response to hypoxia is different in various phases of the MC. The most economic adaptation to hypoxia is observed during the postmenstrual and postovulatory phases.

On the basis of what is outlined above, we may conclude that there is a need for a reorganisation in the training of the female body during the different phases of the menstrual cycle. By redistributing the training load planned according to volume, intensity and direction in each phase of the cycle, the coach is able to maintain the health of the athlete and future mother, provide an enhancement of her performance and an increase in the length of her career in sport.

References

1. GILYAZOVA V.B.
Directions on how to improve the training methods for female athletes in endurance events. 60 years of All-Russian SRIPhC. Coi.sc.works. M., 1993, 217-221.
2. DEMIDOV V.N., MALEVICH Y.K., SMKYAN 5.5.
External breathing, gas and energy exchange in pregnancy. -Minsk: Science and Technics, 1986.- 117 p.
3. DILMAN V.M.
Problems of medical biorhythmology. -M.: Medicine, 1985.-207 p.
4. (E.VIKHIYAEVA, ed.).-M.
Guidance in endocrine gynaecology : Medicine, 1997.-p.5-195.
5. KOVESHNIKOV V.G., NIKITUK B A.
Medical anthropology. -Kiev, "Zdorov'ya", 1992.-192 p.
6. KOLCHINSKAYA A.Z.
Oxygen regimes of the body of children and adolescents. -Kiev: Naukova Dumka, 1973.- 320p.
7. KOLCHINSKAYA A.Z.
Secondary tissue hypoxia. Kiev: Naukova Qumka, 1983.-254 p.
8. KOLCHINSKAYA A.Z.
Mechanisms of interval hypoxic training action.- Kiev, 1992, KSIPh.C, Moscow "Elta plus", p.107-114.
9. KOLCHINSKAYA A.Z.
Interval hypoxic training in combination with traditional athletic training-an efficient method of athletes' preparation. Kiev, Science In the Olympic Sports, 1995, N .1 (2). p.44-55.
10. KOMAROV F.I.
Chronobiology and chronomedicine. Guidance. - M.,Medicine, 1989.-399 p.
11. KRUPKO-BoLSHOVA Y.A.
The Pathology of sex development in girls.-Kiev: "Zdorov'ya", 1990.-229 P.
12. PLATONOV V.N.
Adaptation in sports. -Kiev: "Zdorov'ya", 1988.- 199 p.
13. PLATONOV V.N.
The XXVI Atlanta Olympics: outcomes, lessons, problems. -"Science in the Olympic Sports". K., 1997, N 1.-P.11-28.

14. IAUER N.V., Kolchinskaya A.Z.
Body oxygen regime II Body oxygen utilisation and its regulation.-Kiev: Naukova Dumka, 1966.-P.3/15.
15. RADZIYEVSKY P.A.
Peculiarities of load hypoxia in females and teenagers. In: Secondary tissue hypoxia (A. KOLCHINSKAYA, ed.).-Kiev: Naukova Dumka, 1983,-P.216-229.
16. SOHA T.
The problem of dimorphism in modern sport J' Science in Olympic sport.-Kiev: Olympic literature, 1995, N 2(3), P. 24-30.
17. SHAKHLINA LG.
The response of the female athlete's body to de- creased oxygen content in inhaled air, its dependence on the phases of the menstrual cycle (Hypoxia Medical Ltd.) 1993, N 4.-P. 15-18.
18. SHAKHLINA LG.
Medico-biological bases for managing the process of sports training of females.-Doctorate Dissertation, Kiev., 1995.-3, p.
19. SHAKHLINA LG.
The functional state and physical work capacity of talented female athletes with reference to the biological cyclical character of the female body.-Science in the Olympic Sports, K., 1997, N 1.-P.84-91.
20. SHAKHLINA LG.
The individual approach to improvements in the sports training systems for female athletes.-Prob- lemy Dymorfizmu Ptciowego w Sporcie (cz. 4). Materiały Po-konferency jne IV Miedzynarodowej Konferencji Naukowej. Katowice, 1997, p. 506-515.

[return to "DRILLS" main page](#)