Original Article

Assessment of Lung functions during different Menstrual phases in female athletes

Salwa Mostafa Al-Badry[1], Abeer Mohamed Eldeeb[1], Amr Helmy Yehia[2], Mariam Hossam El Ebrashy[3]*

[1]Department of Physical Therapy for Woman's Health, Faculty of Physical Therapy, Cairo University, Giza, Egypt. [2]Department of Obstetrics and Gynecology, Faculty of Medicine, AinShams University, AinShams, Egypt. [3]Department of Physical Therapy for Gynecology and Obstetrics, Badr University in Cairo BUC, Egypt.

Correspondence: Mariam Hossam El Ebrashy, Department of Physical Therapy for Gynecology and Obstetrics, Badr University in Cairo BUC, Egypt.
Email: dr_mariam_elebrashy @ yahoo.com.

ABSTRACT

Objectives: This study was conducted to study the effect of different phases of the menstrual cycle on lung functions in female athletes. Patients and methods: Forty-six swimmers aged 15 to 20 years old and body mass index of >19.9 kg/m^2 were selected. Zan spirometer was used to assess lung functions including forced vital capacity (FVC), forced expiratory volume (FEV), Tiffeneau index, and peak expiratory flow (PEF) of each swimmer in different menstrual phases. Results: In the swimmers, the mean values of FVC, FEV, Tiffeneau index, and PEF were significantly higher (p=0.001) in the luteal phase when compared to the menstrual phase. In addition, the mean values of FVC, FEV, Tiffeneau index, and PEF were significantly higher in the ovulatory phase compared to the menstrual phase (p=0.001, 0.005, 0.001, and 0.001 respectively). Conclusion: Phases of the menstrual cycle should be taken into consideration to design the best program for the swimmers.

Keywords: pulmonary function, menstrual cycle, swimmers

Introduction

The menstrual cycle occurs in the reproductive system of females as a regular natural change. It is the cyclical shedding of the uterine lining in response to interactions of hormones with a 28-day average duration. The menstrual cycle has three phases, including the menstrual, ovulatory, and luteal phases.[1]

The fluctuation of hormones in the menstrual cycle influences many physiological systems; their action during exercise may have consequences for exercise performance. The hormones released by the ovary affect physiological changes in the brain, the musculoskeletal system, and the cardiovascular and lung functions.[2]

Access this article online	
Website: www.japer.in	**E-ISSN:** 2249-3379

How to cite this article: Salwa Mostafa Al-Badry, Abeer Mohamed Eldeeb, Amr Helmy Yehia, Mariam Hossam El Ebrashy. Assessment of Lung functions during different Menstrual phases in female athletes. J Adv Pharm Edu Res 2020;10(3):77-81.
Source of Support: Nil, Conflict of Interest: Declared.

Variations in the lung functions at different phases of the menstrual cycle follow a cyclic pattern that may be due to the function of different hormones. Progesterone and estrogen levels enhance the bronchial smooth muscles relaxation and strengthen the respiratory musculature.[3]

In the luteal phase, progesterone reduces alveolar and arterial PCO_2 and increases the ventilatory response of the respiratory center to CO_2. It also relaxes the smooth muscles. In premenstrual days, the fall in progesterone plasma levels may lead to bronchoconstriction due to the withdrawal of this relaxant effect on bronchial smooth muscle.[4]

Factors that affect lung functions include the lungs' elastic recoil, airway resistance, compliance of the thoracic cavity, and respiratory muscle strength. Also, the function of lung varies according to physical characteristics such as body weight, height, and age.[5]

Recent studies showed that athletes have a great respiratory system capacity in comparison to their age-matched sedentary lifestyle. Some particular sports disciplines showed more improvement in the lung functions than others; these ports include swimming, rowing, water polo, and basketball.[6]

Regular exercise done by the athletes improves functions of the respiratory muscle strength, thoracic mobility, and the balance between the lung and chest elasticity. It also positively affects the lung by increasing the lung capacities and volumes.[7]

The lung function changes occur due to fluctuations of hormones during different phases of the menstrual cycle. High progesterone levels may lead to an increase in ventilation during the luteal phase. It has a role in the relaxation of the bronchial smooth muscle, which diminishes the contractile response of these muscles. Also, there is an increase in the expiratory resistance in the follicular phase.[8]

Many studies have investigated the effect of different menstrual phases on the lung function in sedentary females. Goyal et al. [9] found that pulmonary functions were significantly improved in the luteal phase compared to the menstrual phase. Moreover, Arora et al. [10] and Kaur et al. [11] showed that the lung function was significantly higher in the secretory phase than the follicular phase. To the authors' knowledge, there is no study yet to show the effect of the menstrual cycle on lung function in healthy female athletes.

This investigation was aimed to provide evidence about changes in lung function among different menstrual cycles in swimmers and to decide on which phase of the menstrual cycles the swimmers could have optimal lung function performance. The hypothesis of this investigation was that there would be changes in lung function among different menstrual cycles.

Materials and Methods:

This study was cross-sectional and included a total of 46 swimmers. A physician referred them from Sports Medicine Specialized Center. Their ages ranged from 15 to 20 years and body mass index was >19.9 kg/m^2. All participants experienced at least 5 years of participating in swimming training. They were free from any medical disorders and had a regular menstrual cycle. Each participant and the parents of participants under 18 years signed an informed consent form. The Ethical Committee of the Institution approved the study protocol of this study.

The physician excluded the swimmers if they had a history of the irregular menstrual cycle, anemia, nausea, vomiting, acute illness, recent viral infection, undiagnosed hypertension, psychiatric illness, or smoking.

The menstrual status was evaluated through a self-administered questionnaire at the starting of this study.

The questionnaire included questions about the age of the first menstrual cycle, duration of bleeding, the 1st day of the last menstrual period, the number of periods in the last twelve months,

Questions about having any menstrual irregularities, or using any steroids.

The daily basal oral temperature was used to determine the phases of the menstrual cycle. It is one of the simplest and least invasive methods to detect ovulation. In normally ovulating females, the body temperature increases by 0.5-1 °F for 2 weeks after ovulation. The rise of basal body temperature results from the thermogenic effect of progesterone. During the follicular phase of the menstrual cycle it keeps in the lower range (97.0 - 98.0°F) until approximately one day before ovulation. When it reaches its lowest point after ovulation and the corpus luteum begins to secrete progesterone, it rises 0.5-1.08°F and plateaus throughout the luteal phase. In the late luteal phase, the corpus luteum regresses, the serum level of progesterone decreases, and the basal body temperature returns to the lower range, 1-2 days before or just at the start of the menstrual bleeding. This biphasic pattern of basal body temperature retrospectively suggests ovulation.[12]

The lung function of each participant was assessed using the ZAN 100 spirometer (ZAN Messgeraete GmbH, Oberthulba, Germany).[13] It is a valid and reliable tool for assessing lung function.[13, 14]

All infection control measures were carried out before testing. Each participant was instructed not to exercise strenuously within 30min of the test and not to eat a heavy meal within 2h of the test. Each participant was in a standing position during the performance of the test.[15] She placed the nose clip on her nose and her mouth over the mouthpiece ensuring a tight seal was maintained during the test. The participant who was unable to maintain a tight seal used a flanged rubber mouthpiece. Each participant continued breathing normally through her mouth when she placed the soft clip on her nose. This clip closed her nostrils, ensuring that all the air she expelled during the test exited through her mouth to be measured by the spirometer. The lung function tests measured included forced vital capacity (FVC), peak expiratory flow (PEF), forced expiratory volume (FEV), and Tiffeneau index.

FVC is the air volume, exhaled during forced expiration after maximal inspiration to total lung capacity.[16] FEV in one second is the air volume, exhaled during one second in forced expiration after maximal inspiration to total lung capacity.[16] Each participant took a breath as deeply as possible, feeling the lungs were filled to the maximum and then exhaled as hard and fast as possible for accurate measurement of the volume.

PEF is the maximal expiratory flow during forced expiration.[16] It was obtained from the FEV in one second and FVC maneuver, as it was the maximum flow generated during expiration performed with maximal force.

The Tiffeneau index is the ratio of air, exhaled within one second in forced expiration after maximal inspiration to the total lung capacity over a total air volume, exhaled during forced expiration after maximal inspiration to total lung capacity. It ranges between 80% to 82% of FVC. [16]

Lung function was assessed during the three menstrual phases including menstrual phase (1st-3rd day), ovulatory phase (14th-16th), and luteal phase (21st-23rd day). Each participant repeated the breathing pattern at least 3 times with breaks between them to avoid performance errors. [17]

Statistical analysis

The results are expressed as mean±SD. The comparison between different times of measurements was performed using repeated-measures ANOVA followed by Bonferroni test if significant results were recorded. The SPSS computer program (version 19 for windows) was used for data analysis. P-value ≤ 0.05 was considered significant.

Results:

Table 1: Mean values of lung function tests measured during different phases of the menstrual cycle

Variable	Menstrual phase	Ovulatory phase	Luteal phase	F-test	p-value
FEV	3.28 ± 0.20	3.38 ± 0.20	3.49 ± 0.31	12.510	0.001s
FVC	3.64 ± 0.12	3.78 ± 0.22	4.17 ± 0.27	115.654	0.001s
PEF	6.34 ± 0.41	6.67 ± 0.34	7.10 ± 0.30	326.825	0.001s
Tiffeneau index	77.43 ± 4.77	82.87 ± 4.32	88.26 ± 3.99	380.324	0.001s

Data are expressed as mean ± SD; FEV= forced expiratory volume; FVC= forced vital capacity; PEF= peak expiratory flow; S= p≤ 0.05= significant.

Table 1 shows the mean values and repeated measures ANOVA of lung function tests measured during different phases of the menstruation. The mean values of FEV measured in the menstrual, ovulatory, and luteal phases were 3.28±0.20, 3.38±0.20, and 3.49±0.31, respectively. There was a statistically significant difference between the three phases (p= 0.001). The mean value of FEV significantly increased in the ovulatory (p= 0.005) and the luteal phases (p=0.001) compared to the menstrual phase. In addition, it significantly increased in the luteal phase (p=0.027) compared to the ovulatory phase. The increasing percentage of FEV at ovulatory and luteal phases were 3.05% and 6.41%, respectively.

The mean values of FVC measured in the menstrual, ovulatory, and luteal phases were 3.64±0.12, 3.78±0.22, and 4.17±0.27, respectively. There was a statistically significant difference between the 3 phases (p= 0.001). The mean value of FVC significantly increased in the ovulatory (p= 0.001) and luteal phases (p= 0.001) in comparison to the menstrual phase. Also, it significantly increased in the luteal phase (p=0.001) compared to the ovulatory phase. The increasing percentage of FVC in the ovulatory and luteal phases were 3.85% and 14.56%, respectively.

The mean values of the Tiffeneau index measured in the menstrual, ovulatory, and luteal phases were 77.43±4.77, 82.87±4.32, and 88.26±3.99, respectively. There was a statistically significant difference between the three phases (p=0.001). The mean value of the Tiffeneau index significantly increased in the ovulatory (p=0.001) and luteal phases (p=0.001) compared to the menstrual phase. Moreover, it significantly increased in the luteal phase (p=0.001) compared to the ovulatory phase. The percentage increases in the Tiffeneau index in the ovulatory and luteal phases were 7.03% and 13.99%, respectively.

The mean values of PEF measured in the menstrual, ovulatory and luteal phases were 6.34±0.41, 6.76±0.34, and 7.10±0.30, respectively. There was a statistically significant difference between the three phases (p= 0.001). The mean value of PEF significantly increased in the ovulatory (p= 0.001) and luteal phases (p=0.001) compared to the menstrual phase. Furthermore, it significantly increased in the luteal phase (p=0.001) compared to the ovulatory phase. The increasing percentage of PEF at the ovulatory and luteal phases were 6.62% and 11.99%, respectively.

Discussion:

The dynamic cyclical changes in the levels of various hormones at different phases of the menstrual cycle affect the function of different systems of the body, including the respiratory system. This study aimed to determine changes in lung function during different phases of the menstrual cycle in swimmers.

In the present study, results showed that the mean values of FVC, FEV, Tiffeneau index, and PEF significantly increased during the luteal phase and ovulatory phase as compared to the menstrual phase. Also, they significantly increased in the luteal phase as compared to the ovulatory phase.

The results of the present study are consistent with the results of Nandhini and Subhashini [3] in which, they reported that the mean of the FVC, FEV, and the peak flow during the luteal phase were more than the follicular and menstrual phases in adolescent girls. Also, this study supports the results of the investigation by Goyal et al. [9] in which there was an increase in FVC values in successive phases from menstrual to secretory phase.

The results of the present study agreed with Jasrotia et al. [18] who reported that pulmonary functions, as well as respiratory efficiency, were significantly improved in the luteal phase of the menstrual cycle due to the bronchodilator effect of progesterone, whose levels remain higher during this phase.

Mannan et al. [19] stated that changes in the pulmonary function in different phases of the menstrual cycle were owing to the action of the hormone progesterone, which reduced the contractile response of these respiratory muscles and this result is consistent with our study. Moreover, Anderson and Babcock [20] stated that the rise in the expiratory resistance during the follicular phase could contribute to the changes in the pulmonary system of females. The increased ventilation observed in the luteal phase may be due to high levels of progesterone, which increased bronchial smooth muscle relaxation and inspiratory muscle endurance.

However, the results disagreed with Bruno et al. [21] who reported that FVC, FEV, and FEV/FVC did not change during different phases of the menstrual cycle in young women. Only peak expiratory flow was different at the cycle phases. Also, Rajesh et al. [22] did not find any significant relationship between phases of the menstruation and pulmonary function.

The results are interpreted in the background of limitations that the respiratory muscle strength of the swimmers may be a source of variation in FEV and FVC results. [23] Therefore, there is a need for further study to assess the effect of different menstrual cycles on respiratory muscle strength in the swimmers.

This study showed that all lung function parameters were minimal in the menstrual phase and maximal in the luteal phase. An increase in pulmonary function helps swimmers maintain their buoyancy. [24]

Conclusion

This study showed that there are fluctuations in pulmonary function between the three phases of the menstrual cycle. These changes should be considered to design the best program regarding intensity, repetitions, and time of exercises in each phase of the menstrual cycles.

Acknowledgment

The authors would like to thank all athletic females who participated in the study.

Declaration of conflicting interest

There are no conflicts of interest.

Funding

The authors received no financial support for the research and/or authorship of this article.

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