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Original Article

Physiology Section

Assessment of Musculoskeletal Strength and Levels of Fatigue during Different Phases of Menstrual Cycle in Young Adults

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ABSTRACT

Introduction: Some of the physiological factors and athletic performance might show variation along the phases of menstrual cycle. The alterations seen in these physiological parameters of various systems relating to oscillations in hormonal levels do affect the autonomic nervous system and metabolic functions. Former studies heave inconclusively about the influence of hormones on exercise performance, predominantly muscle strength and rate of fatigue during different phases of the menstrual cycle. Studies regarding influence of these variations during bleeding phase were not done.

Aim: To evaluate the muscle strength variations and also the rate of fatigue during various phases of the menstrual cycle in young adults.

Materials and Methods: This was a prospective study conducted among 100 healthy adult female volunteers aged 18-24 years, with normal regular menstrual cycles persistent between 26- 32 days (average of 28 days), for a minimum of last 6 months. Muscle strength was assessed by calculating the work done and fatigue rate using Mosso's ergograph and by handgrip dynamometer strength. Each subject was evaluated consecutively for two menstrual cycles in all three phases which were classified as Phase 1- Menstrual phase, Phase 2- Follicular phase and Phase 3- Luteal phase.

The data obtained was analysed by statistical tool One-way ANOVA followed by a post-hoc Tukeys test. A p-value of ≤ 0.05 was considered significant.

Results: The amount of work done and handgrip strength was significantly higher in phase 2 ($p<0.001$) and relatively reduced in phase 1 and 3 ($p<0.001$) of menstrual cycle. In terms of fatigue rate percentage, phase 2 showed significantly lesser values ($p<0.001$) as compared to phase 1 and 3 of menstrual cycle.

Conclusion: We conclude that the cyclical variation in endogenous reproductive hormones increases the muscle strength in follicular phase of the menstrual cycle. Thus provide support for the influence of these hormones in regulation of these parameters in the premenopausal age group.

Keywords: Ergograph, Exercise, Fatigue rate, Handgrip, Menstruation

INTRODUCTION

Women are different from men in terms of physiological function. Due to their short and painstaking reproductive age, they are more vulnerable physically during the different phases of the menstrual cycle. Fluctuations in some of the physiological parameters of various systems may be related to oscillations in the hormonal levels found in different phases of the menstrual cycle. These oscillations seen in female steroid hormonal levels do affect the autonomic nervous system and metabolic functions. Due to fluctuations of some of the physiological parameters along the phases of menstrual cycle could change the athletic performance.

Studies have reported the effect of menstrual cycle due to hormonal fluctuations on physical changes [1-5] where the results presented is controversial [3-5]. In these, the authors suggest that oestrogen to be having a stronger strengthening effect on skeletal muscle, though the basic mechanism is not clearly known. Variations in the endurance performance during menstrual phase may possibly be a consequence of changes due to exercise metabolism which are again attributed to the fluctuations seen in ovarian hormone concentrations.

The study on demonstrating the haematological parameters variations, oxygen consumption, lactate threshold and ventilation did not notify significant changes across the various phases of menstrual cycle [1] while studies found no alteration in muscle strength though the hormonal variations were confirmed [2,6,7]. Study done for assessing large muscular groups influence in two multi-articular resisted exercises found no significant alterations among different phases of menstrual cycle [8]. On the contrary, a similar study on same two multi-articular resisted exercises found significant fall in muscle strength during follicular phase of menstrual cycle [9]. A study noticed variations in isometric strength, where the author correlate the findings with muscular temperature variations associated with menstrual cycle and possibly due to its direct effects on circulation and musculature [10]

Variations in the secretions of sex hormones during the different phases of menstruation may have variation in both their physical and psychological performances. Sex hormones affect the metabolism markedly; it also has an appropriate outcome on performance of many systems in the body accordingly. As these physiological functions vary with hormonal secretions, it is noteworthy to study the musculoskeletal strength and fatigue among the young women during the different phases of the menstrual cycle.

MATERIALS AND METHODS

This study was conducted in one of the research institute of coastal Karnataka, Research laboratory, Department of Physiology, KVG Medical College and Research Institute, Karnataka, India during the period June 2011 to September 2012. In this prospective study, 100 healthy female volunteers aged between 18-24 years were selected to participate. The volunteers were selected based on the inclusion criteria with normal regular menstrual cycles lasting between 26 to 32 days (mean 28 days), for atleast last 6 months and having similar

patterns of dietary habits were included. The volunteers were either untrained or moderately trained students and performed at least 1-2 hours of regular physical training a week. A thorough medical history was recorded through a preformed questionnaire, those who reported a history of irregular menstrual cycle, on oral contraceptive pills, history of musculoskeletal disorders, any psychiatric illness or chronic drug intake were excluded from the study. After obtaining the Institutional Ethics Committee clearance, the subjects were told about the aims and procedure of the study. Before the start of the tests, a written informed consent was taken from the subjects. All the subjects were studied for 2 consecutive cycles in 3 phases which were grouped as Phase 1- Menstrual phase, Phase 2- Follicular phase and Phase 3- Luteal phase.

Assessment of Muscle Strength

To test the muscle strength, Mosso's Ergograph and Handgrip dynamometer was chosen as the testing tool. The usage of instruments and procedure of the tests was well explained to the subjects before the start of the test. Three trials of recording were done and the best of it was taken for analysis. The subjects were verbally encouraged with the purpose to keep their motivation level high during the procedure. The subjects were oriented not to ingest any kind of energy drink including caffeine and alcohol, as well as not to perform any sort of physical activity one day before or on the day of the tests.

STATISTICAL ANALYSIS

Statistical software SPSS 20 version was used for the analysis of the data. Results thus obtained are expressed as mean and Standard Deviation (SD). One-way ANOVA (Analysis Of Variance) and Post-Hoc test (Tukey) was carried out to test the significance. A p-value was considered significant at ≤ 0.05.

RESULTS

At the end of the study, 100 healthy volunteers were enrolled and their data were analysed. The volunteers were with the mean age of 18 years and demographic characters within the range for their age [Table/Fig-1].

The mean of work done were significantly greater during the follicular phase compared to the other two phases (luteal and menstrual). The variations in work done were also significantly higher during the luteal phase compared to menstrual phase. The fatigue rate expressed as a percentage was highest during the menstrual phase followed by the luteal phase and the follicular phase. Thus, the follicular phase has the least fatigue rate. The dynamic strength as measured by a handgrip dynamometer was highest during the follicular phase compared to luteal and menstrual phase. The menstrual phase has the least strength compared to the other two phases. The change in the work done and the handgrip strength shows significance during the follicular phase than in the luteal phase, and lowest values during the menstrual phase [Table/Fig-2].

DISCUSSION

The female sex hormones apart from their reproductive function affects various physiological systems and while during exercise they have a role seen in association with exercise performance. Though a lot number of studies report to have found exercise performance

Parameters	Mean±SD
Age (yr)	18.4±0.7
Height (mt)	1.5±0.06
Weight (Kg)	50.0±4.9
BMI (kg/m^2)	21.1±1.5

[Table/Fig-1]: Demographic characters of study participants.

Parameters	Phase 1	Phase 2	Phase 3
Work Done (J)	15.2±1.8	26±2.8$^{*\#}$	19.6±2.2*
Fatigue rate %	63.6±4.2	51.6±4$^{*\#}$	56±4*
Handgrip strength(kg)	22.5±3.4	33.04±3.7$^{*\#}$	27.3±3.4*

[Table/Fig-2]: Comparison of Musculoskeletal strength parameters within phase 1, phase 2 and phase 3 of menstrual cycle.
Values are expressed as Mean±SD. Phase 1=Menstrual, Phase 2=Follicular, Phase 3=Luteal.
*Phase 1 v/s Phase 2 and Phase 3. p<0.001 (highly significant)
#Phase 3 v/s Phase 2. p<0.001 (highly significant)
Data analysed by One-way ANOVA followed by a post-hoc Tukeys test.

to vary across the different phases of menstrual cycle, but there are also the same number of studies concluding to be found no variation across the menstrual cycle [1-5]. Reviewing the literature they have well documented the variations seen in serum concentrations of luteinizing hormone, follicular stimulation hormone, estradiol and progesterone during the menstrual cycle and also the level of androstenedione and testosterone reach their peak preceding to or during ovulation. Several studies have been conducted to understand the physiological changes during the reproductive age group in females as a result of the hormonal alterations during the menstrual cycle [1,4,11]. The data available is conflicting in nature as to whether the endocrine oscillations affect performance during exercises or not. Though some of the studies have shown that to cause an effect on physical performance, there are not sufficient alterations seen in oestrogen-progesterone serum concentrations [12,13], other experiments demonstrate better performance in some phases of the menstrual cycle [9,10]. It is considered that the increased muscle strength and endurance is attributed to high oestrogen levels especially, during the follicular phase [14]. In the present study, there was a remarkable difference noted in muscle strength and fatigue rate during bleeding phase, which can be attributed to the psychological component of the subject such as the bleeding has itself a negative effect on their performance due to the preconceived distress of bleeding. It can also relate to the physical performance as loss of blood also may affect the same.

A previous work concluded that there was significant reduction in anaerobic performance during the luteal phase in women who did not make use of oral contraceptive compared to the group which used the ovarian steroid [4]. Conversely, another study did not observe fluctuations in anaerobic performance during the menstrual cycle inspite of the use of oral contraceptive pills. They concluded that the presence or absence of pre-menstrual symptoms or dysmenorrhea could affect performance. Such symptoms are attributed to fluctuating levels of oestrogen-progesterone during the menstrual cycle. The luteal phase being associated with an increase in the serum concentration of progesterone, is indicative of this hormone which may influence the performance negatively. The post menstrual phase in which there is an increase in oestrogen and nor-adrenaline levels is associated with performance improvement [15].

Loss of muscle strength after the onset of menopause has led to conclusions that oestrogen may have an inotropic effect on muscle strength. It has been proposed, that oestrogen has a profound effect on the muscle strength while progesterone does not seem to have any notable effects on muscle strength or function. These variations seen in muscle strength may largely be attributed to exercise metabolism which are roused due to oscillations in the concentrations of ovarian hormones. The literature intends that the levels of oestrogen which is seen peak during follicular phase may promote muscle strength by varying carbohydrate, protein and fat metabolism in the body. While in the luteal phase with increased levels of progesterone often to be antagonistically acting to oestrogen on muscle strength [16]. The change in the muscular strength, capacity of the exercise endurance performance, temperature of the body, blood flow and metabolism in the body have been associated with disturbances seen in the hormonal balance all throughout the phases of menstrual cycle [17].

The levels of oestrogen seen during late follicular and early luteal phase stimulates glucose availability and uptake of glucose into type I muscle fibers which act as fuel during short duration exercise, and the action of which is inhibited by progesterone [16]. In one of the study which found increased muscle strength in terms of maximum voluntary contraction more during luteal phase compared to menstrual and follicular phase though not statistical significant on the other hand statistically significant difference was seen for time to fatigue at 30% of maximum voluntary contraction between menstrual and follicular phase [18].

Another study explored the effects of training during follicular phase and the luteal phase on muscle strength, muscle volume and microscopic parameters. There was an increase in muscle strength and muscle diameter in follicular training phase compared to luteal phase reasoned by the higher concentrations of testosterone and free testosterone during the follicular phase [19]. In one of the study conducted on well trained female athletes to study the influence of menstrual cycle, just before the menstruation phase 71% of them felt nastiest, during menstruation the performance level remained same among 62.2% and the performance was poorer for 21.2% of the athletes. It was reported that following menstrual phase in the first 14 days, the athletes felt improved compared to the subsequent 14 days ($p<0.01$) [20].

Review of the literature, confirms that the component of strength performance during the different phases of the menstrual cycle is conflicting in nature [1,3]. This can be partially reasoned based on the fact that an insufficient number of experimental controls were used in certain studies. There was a wide variation in methodology used for determination of different phases of menstrual cycle and lack of hormonal documentation [9]. In many of the studies the basis of selection of inclusion criteria were not clearly defined and at times even the calibration and combination of pre exercise along with fixed diet and level of activity were also ill defined [4,21,22]. In the present study, though lacks documentation of the hormonal levels during the different phases of menstrual cycle, the selection criteria of the requisites has been met regarding age, physical aptitude, sample size, menstrual cycle history and degree, or gynaecologic problem etc. The selection criteria including even dietary status of the subjects involved was met who were taking food from the common hostel mess. With all this the subjects showed better strength and force during follicular phase followed by lesser strength during the luteal phase which further deteriorated during the menstruation phase.

LIMITATION

In this study, assessment of hormonal levels was not done which would have been much more relevant in classifying different phases of menstrual cycle. As this study was done among limited number of medical students, further studies with larger population with confirmation of fluctuations in hormonal levels is suggested for generalizing the results for the community.

CONCLUSION

The muscle contractions were significantly higher, forceful and less fatigable during the follicular phase compared to luteal phase and during menstrual phase. The muscles showed highest fatigue rate during menstrual phase compared to follicular phase and luteal phase. The changes seen during normal menstrual cycle could affect the exercise performance, and thus have to be considered during athletic training and selection program. Hence evidently, a woman's menses cycle is a crucial element to contemplate when involved in training for and racing in endurance events.

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