The influence of gonadal hormones on muscle metaboreflex and endurance to a single bout of static isometric exercise

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Abstract

There are unanswered questions with respect to participation of females in competitive sports whether the fluctuating sex steroid levels of menstrual cycle affect the muscle contractility, endurance as well as the metaboreflex generated out of it.

Aim: To study the impact of different phases of menstrual cycle on select muscle properties like MVC, MET, time to fatigue as well as HR and BP responses to the static isometric exercise metaboreflex.

Materials and Methods: Thirty eumenorrhic females were enrolled during different phases of menstrual cycle. The subjects were asked to maintain the grip on the Jamar hand grip dynamometer at 30% MVC, the endurance time and time to fatigue were calculated and cardiovascular responses arising out of it like Heart rate, BP were recorded.

Statistical Analysis: Data was analyzed statistically using student's paired t-test.

Results: The luteal phase showed higher values for all the baseline characteristics like HR, SBP and DBP. The (210±12.51) sec endurance time in the follicular phase was greater than (196±19.15) sec in the luteal phase, the MVC value (162±16.45) Newton was significant in the follicular phase as compared to luteal phase value of (158±20.34) Newton, The HR was (90±26.45) bpm in the follicular and (98.2±32.34) bpm in the luteal phase using isometric HGD.

Conclusion: The luteal phase of menstrual cycle emphasized that the muscle was easily fatigued vis-a –vis the follicular phase where the muscle exemplified a greater contractile strength. The pressor response to the ergonomically generated metaboreflex for a bout of static isometric exercise was higher during the luteal phase.

Keywords: Follicular, HGD, Isometric, MVC.

Introduction

The menstrual cycle is a rhythmic endogenous cycle characterized by periodic shedding of the uterine endometrium and cyclical changes in the ovary which is orchestrated by fluctuating sex steroid hormones. The ovarian hormones especially have widespread effects on multitude of organ systems, one of them being been attributed to their ability to affect the lipid metabolism, muscle contractile properties as well as autonomic transmission. The presence of oestrogen receptors in the heart, VSM, and NTS, as well as certain areas in the medulla which regulate autonomic activity[2] and changes in density of adrenoreceptors,[3] changes in the level of second messenger involved in sympathetic transmission i.e -cAMP levels,[4] and levels of the enzyme involved in synthesis of NO i.e-q NOS activity which affect local skeletal muscle blood flow[5] point towards a definite interaction of the cardiovascular system and the ANS. Oestrogen is reported to activate the Ergoreflex, alter the autonomic responses generated out of it, attenuate accumulation of waste product of muscle metabolism.[6,7] Oestrogen has proved its efficacy in animal studies that there is a decrease cardiac baroreflex sensitivity due to vagal activation in response to exercise.[8-10]

There is a huge body of research on the endogenous sex steroids on muscle properties with a decline in the muscle mass and force generating ability at menopause which can be reversed substantially with hormone replacement therapy corroborating the role of endogenous gonadal hormones on muscle strength and fatigability across the cycle.[11] Hand Grip dynamometry is a standard exercise stressor used in clinical practice to simulate static isometric exercise. Use of a simple non- invasive physical stressor like HGD can be used to study the autonomic responses, contractile muscle strength, endurance time and fatigability in humans.

Muscular performance can be assessed in terms of maximum voluntary contraction using the hand grip strength and the Endurance time for the same.

There are array of conflicting nature of studies who found that HR and BP responses to a hand-grip exercise were similar during both the phases, although there was a reduction in muscle sympathetic nerve activity during the Luteal phase.[12] while some others have reported greater SNS transmission during the second half of menstrual cycle, progesterone being a thermogenic hormone also increases the cardiac excitability and hence influences the HR and BP responses.[13-15] Studies conducted using HRV as a measurement tool have documented a grater vagal facilitation during the first half of menstrual cycle.[16] Results of a study have demonstrated no effect on the response to static hand grip exercise while some others have found a stronger handgrip strength during the menstrual phase, attributed to the lower oestrogen and progesterone levels during the bleeding phase.[13,17] It is clear that contractile strength, endurance time and the cardiovascular responses generated to the exercise stressor determine individuals work capacity. Conflicting data surrounding the effect of sex steroids on athletic performance and the conflicting intricacies involved in the same require further investigation.

Aim

1. To study the influence of different phases of menstrual cycle on Muscle contraction and Endurance time.
2. To investigate into the cardiovascular responses like HR, BP changes to the static isometric exercise metaboreflex.

Materials and Methods

Study Design

Cross-sectional.

Duration

December 2011 till February 2012

Source of Data

In the present study the data was collected from the students of first year M.B.B.S for the academic year 2011.

Sample Size

Thirty eumenorrhic girls aged 17 -20 years of age studying their first year MBBS course were selected.

Sample Size Estimation

Expected Reduction-(Mean) =d=20.

SD=40 =σ

ά = 0.05 One sided Z ά = 1.65

β = 0.2 Power 80% Z β = 0.84

$n = [(Z ά + Z β) σ / d]^2 = 24.8 = 25 =30$

Based on sample size calculation 30 MBBS phase 1 females aged 17-20 years who are eligible were enrolled at the time of data collection.

Inclusion Criteria:[16]

Thirty eumenorrhic girls aged 17 -20 years of age studying their MBBS course with regular menstrual cycle duration of 28 days at least 2 months prior to the study, having no medical or gynecological problems, no well-defined premenstrual tension were enrolled.

Exclusion Criteria:[16]

Subjects who had irregular menstrual cycles, dysmenorrhea, menorrhagia, endocrine disorder or consuming over the counter drugs like cough suppressants, hormonal replacement therapy, drugs that alter the functioning of the cardiovascular system were not enrolled in the study.

The study was approved by IEC of the college and the participants voluntarily signed the written informed consent. A detailed menstrual history which included the no of days, regularity and total duration of cycle was collected prior to enrolment of every participant.

If the first day of bleeding is considered as Day 1, the phases marked out were and confirmed by basal body temperature monitoring:

1. Follicular (10^{th} day)
2. Luteal (20^{th}day).

Instrument- Jamar Hand Grip Dynamometer, Inc, Ambala (0-60) Kgs

Study Procedure:[16]

The subjects sat on a chair, flexed their elbows and with the wrist in neutral position they grasped the Jamar hand grip dynamometer maximally. Sets of five consecutive trials were given and the highest value noted as MVC. 30% MVC was then calculated. Participants sustained submaximal contractions of handgrip strength at 30% MVC, as long as possible voluntarily or at least for 4 mins if possible. Endurance time for the 30% MVC was noted and strength expressed in Newtons.[16,18]

BP was measured in the opposite arm at the end of1st, 2^{nd} & 4th (or if the time duration was less than 4 mins then the BP was recorded just before release of the grip).

BP response to sustained handgrip test >= 16 mm Hg was taken as normal.

>=11 -15 mm Hg as Borderline

<= 10 mm Hg as Abnormal

Statistical Analysis

The analysis of the results was as Mean±SD. Student paired t-test was used to compare results between the two phases and a “p’ value less than 0.05 was considered significant.

Results

The current study used variables like heart rate, B P responses which arise out of activation of the metaboreflex in response to isometric HGD exercise. Using the same the MVC, Endurance time and time to Fatigue were calculated

Table 1: Shows the distribution of demographic variables

Age (yrs.)	18.3±0.66(17-20)
Weight (kg)	56.7±7.55(47-65)
Height (m^2)	1.56±0.04(1.51-1.68)

Table 1: The participants are of the average age group of 18 years and average weight of 56 kgs.

Table 2:[16] Baseline HR and Blood pressure responses between the two phases of menstrual cycle

	Follicular (mean ±SD)	Luteal (mean ±SD)	P value
HR (bpm)	78.8 ±7.48	84 ± 8.17	0.003*
SBP(mm HG)	113.9 ± 6.63	115.8 ±5.91	0.005*
DBP(mmHg)	72.8 ±6.90	76.5 ± 6.82	0.002*

*-Significant, NS-non significant.

Table 2 Shows that the baseline HR as well as SBP and DBP are higher during the luteal phase.

Table 3: Shows the comparison of cardiovascular responses to exercise metaboreflex at 30% of MVC Just before release of grip between follicular and luteal phases of menstrual cycle

	Follicular (mean ±SD)	Luteal (mean ±SD)	P value
HR (bpm) at 30% of MVC	90±26.45	98.2±32.34	<0.005*
SBP (mm HG)at 30% of MVC	124±12.27	130±14.35	0.005*
DBP (mmHg) at 30% of MVC	91±11.5	95.7±17.76	0.004*

*-Significant, NS-non significant, MVC-maximum voluntary contraction

Table 3 Shows that the HR, SBP and DBP are higher in response to exercise induced Ergoreflex during the luteal phase pointing towards a greater sympathetic activity to a physical stimuli.

Table 4: Shows the comparison of MVC and Endurance time at 30% of MVC between follicular and luteal phases of menstrual cycle

	Follicular (mean ±SD)	Luteal (mean ±SD)	P value
MVC (Newtons)	162±16.45	158±20.34	<0.005*
Endurance time (secs)	210±12.51	196±19.15	0.004*

*-Significant, NS-non significant

Table 4 Shows that the MVC in Newtons is lower while the time for onset of fatigue in the muscle is early in the luteal phase.

Discussion

In the present study we examined whether certain muscle properties like MVC, endurance and fatigue as well as cardiovascular responses evoked by activation of exercise induced metaboreflex seems orchestrated by fluctuating levels of gonadal hormones. In the current study the resting HR and BP are raised during the second half of menstrual cycle and in response to a bout of static isometric exercise i.e.-30% of MVC the cardiovascular responses like HR and BP responses were higher in the second half of menstrual cycle which proves that there is a greater Pressor response to a physical stimuli during the same. The contractile properties like Maximum voluntary contraction as well as endurance time was greater in the second half of menstrual cycle which proves that the fluctuating levels of sex steroids namely oestrogen and progesterone are implicated in the cardiovascular as well muscle contractile force and fatigue to a single bout of static isometric exercise. There are studies of the consenting opinion that the progesterone dominated phase of menstrual cycle i.e- the second half of menstrual cycle is characterized by a greater sympathetic activity[18,19] and reinstates the role of oestrogen as a Para sympathomimetic agent as oestrogen facilitates the turnover of the rate limiting enzyme acetyl choline transferase, key agent in the vagal modulation of the reduced heart rate during the follicular phase.[20] Muscle fatigability and its contractile strength are subjected to interaction with the sex steroids, where the muscle is more slower and fatigable as compared to the follicular phase but stronger which are similar to the results published by other authors.[21,22]

Oestrogen promotes glycogen storage at the level of muscle as well as liver which could be the reason behind greater MVC.[23] Oestrogen during the follicular phase would provide fuel to the exercising muscle by providing glucose and free fatty acids as well as the oxidative capacity, favoring endurance performance.[22] The endurance time is related inversely to the exercise induced metaboreflex. Muscle is dependent on its blood flow for supply of oxygen & glucose & greater contraction of muscle leads to also by hampered venous drainage of waste products (H+, Pi, H2SO4) which is majorly vindicated in case of muscle fatigue.[24,25]

The Oestrogen induced reduced SNS activity leads to vasodilatation, hence the muscle remains better perfused & there is prolongation of endurance time.[12,26] Studies have proved that the rising levels of progesterone during the second half of menstrual cycle inhibits the neuromuscular cross linking while oestrogen actually accentuates the linkage.[27] In our study, the ischaemic muscle would be more reliant on muscle glycogen stores for energy which is provided by oestrogen.[28]

Conclusion

The metaboreflex involving HR and BP responses to static isometric exercise showed a steep rise indicating that the luteal phase is characterized by greater adrenergic neurotransmission. The muscle showed a tendency towards greater endurance time as well as reduced vulnerability to fatigue during the follicular phase. Hence it can be stated without doubt that the gonadal hormones affect the muscle properties as well as the exercise metaboreflex.

Implications and Future Scope

Hardly any literature on the effects of oestrogen on muscle properties is rather surprising considering the widespread involvement of women in high performance sports. The results derived from our study could enlighten us regarding the physiological and clinical conditions like premenstrual syndrome, premenstrual tension, cyclical edema, orthostatic intolerance .Further investigations are required to explore the possible biomechanisms underlying in trained athletes and compare it with sedentary females.

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Conflict of Interest: None.

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