Effect of Menstrual Cycle on Endurance Capacity of Obese Females in Andhra Pradesh

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ABSTRACT

BACKGROUND

Obesity is associated with irregular menstrual cycle in premenopausal women and both influence the endurance capacity due to fluctuation of fatigue and the negative effect of hormonal fluctuations during menstrual cycle. We wanted to investigate the effect of menstrual cycle on the cardiovascular response to exercise and on endurance capacity of obese females.

METHODS

75 sedentary healthy obese females of 18 to 20 years age group were selected on random basis as per the inclusion and exclusion criteria from the students of 1st year B.Sc. MLT and B.Sc. Nursing Courses of Alluri Sitarama Raju Academy of Medical Sciences, Eluru, Andhra Pradesh. They were divided into Group - F, Group - L and Group - M containing 25 subjects in each group. All of them were asked to exercise in bicycle ergometer with 1 Kg workload till exhaustion. Their resting heart rate, blood pressure before exercise and peak heart rate, recovery heart rate every minute up to 5th minute, blood pressure after 5-minutes post rest were measured. The statistical analysis of the subject was done by SPSS (Statistical Package of Social Sciences), Version 16.0.

RESULTS

In this study, no significant variation ($p > 0.05$) in the endurance capacity was seen during the follicular phase, but, endurance capacity is significantly ($p < 0.001$) reduced in menstrual phase compared to follicular and luteal phases.

CONCLUSIONS

In obese sedentary females, physical endurance is significantly reduced during the menstrual phase as compared to the other two phases of the menstrual cycle.

KEY WORDS

Obesity and Endurance, Menstrual Cycle and Endurance

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DOI: 10.14260/jemds/2020/795

How to Cite This Article:

Bera C, Ghosh S. Effect of menstrual cycle on endurance capacity of obese females in andhra pradesh. J Evolution Med Dent Sci 2020;9(48):3618-3623, DOI: 10.14260/jemds/2020/795

Submission 24-08-2020,
Peer Review 17-10-2020,
Acceptance 24-10-2020,
Published 30-11-2020.

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BACKGROUND

Endurance capacity is one's ability to do prolonged work before getting fatigued. Fatigue means tiredness. With repeated contraction, the muscle is becoming gradually weaker and this is the sign of fatigue. Muscle is a machine for converting the chemical energy to mechanical energy. The immediate source of chemical energy is from the breakdown of ATP (Adenosine Tri-Phosphate). 1 mole ATP can produce 7.3 Cal energy. The ultimate energy source is the intermediate metabolism of carbohydrates and lipids and the rate of it in skeletal muscle is low at rest. The energy sources in exercise also includes phosphocreatine, fatty acid, glycogen and lactic acid. The determining factors of endurance capacity include maximum O₂ consumption, mitochondrial density, performance efficiency and body composition. However, sex differences exist but the basic underlying mechanism that determine performance are the same in the men and women. Maximum O₂ consumption is largely determined by the cardiac output. The term "Obesity" refers to being over fat, and several methods for assessing fatness (skin fold, bio-electrical impedance, under weighing, and dual energy X-ray absorptiometry) are available. However, a more practical approach is to use Body Mass Index (BMI), which is recommended by the national institute of health to classify overweight and obesity and to estimate relative risk of disease. It is calculated as weight in kilogram divided by height in meters squared. BMI can also be estimated by using pounds and inches.¹

$$\text{BMI} = \text{Weight in Kg} / \text{Height in m}^2$$

Overweight is defined as having BMI 25 to 29.9 Kg / m² and those with BMI greater than 30 Kg / m² are considered obese. The National institute of Health Guidelines defined this population as adults with a BMI greater than 30 Kg.m² or those with greater than 25 Kg.m² with a family history of obesity.² The specific health risk caused by obesity includes impaired cardiac function as a result of increased mechanical work and autonomic and left ventricular dysfunction, hypertension and stroke.^{3,4,5,6} Obesity also causes adult onset of diabetes, as about 80 % of these patients are overweight.^{7,8,9,10} The renal disease, pulmonary disease and impaired function resulting from the added effort needed to move the chest wall, problems in administering anaesthetics during surgery, osteoarthritis, degenerative joint disease, and gout, sever types of cancer, abnormal plasma lipid and lipoprotein levels, menstrual health problems i.e. obese woman suffer more menstrual disorders, e.g. the frequency of menstrual disturbance in women with morbid obesity (BMI 40 +) is three times greater than for woman of normal weight.^{11,12,13,14} Obesity in premenopausal women is associated with irregular menstrual cycle and infertility.

In humans and other primates, in the menstrual cycle the most conspicuous feature is the periodic vaginal bleeding that occurs with the shedding of uterine mucosa (menstruation). The length of the cycle is variable in woman, but an average figure is 28 days from the start of one menstrual period to the start of the next. By common usage the days of cycle are identified by number starting with the first day of

menstruation.¹⁵ The variation in different hormonal levels occurs in menstrual cycle. Among them LH (Luteinizing Hormone), estradiol and progesterone levels are influenced by exercise.

METHODS

In this study, the ethical considerations were taken into account. Before an individual becomes a subject of this study, she shall be notified of the aims, methods, anticipated benefits and potential hazards of the study. Her right to abstain from participation in the study and her right to terminate at any time along with confidential nature of her replies were also explained. No individual were taken as a subject of this study unless she provides a freely given consent that she agrees to participate. No pressure or inducement of any kind was applied to encourage an individual to become a subject of this study. No information revealing the identity or communication of any subject was included in the final report. This experiment was conducted in the research laboratory of the Department of Physiology, Alluri Sitarama Raju Academy of Medical Sciences (ASRAMS), Eluru between 8 am. to 9 am. 75 healthy sedentary female subjects of 18 to 20 years age group, who were having the Waist Hip Ratio (WHR) > 0.80 and Basal Metabolic Index (BMI) > 30, were selected randomly from the students of 1st year B.Sc. MLT and B.Sc. Nursing Courses of ASRAMS. The subjects belong to comparable socioeconomic status and were eating in the same hostel mess. They continued their usual activity throughout the period of the experimental procedure. They were familiarized with the bicycle ergometer for 1 - 2 days to allay their apprehension and nervousness during the actual procedure.

Exclusion Criteria

Subjects suffering from any menstrual irregularities, painful menstruation and any cardiorespiratory disorder or any upper or lower motor neuron disorder or any major illness or brain disease, subjects taking any kind of drugs etc.

Inclusion Criteria

Healthy, non-smoker, with no cardiorespiratory disorders. Subject not doing any type of physical exercise.

Sample Size

75 female students were randomly divided into 3 groups—
Group F = 25 students in follicular phase
Group L = 25 students in luteal phase
Group M = 25 students in menstrual phase

Apparatus Required

Bicycle ergometer, Weighing Machine (Kg), Height Measuring Scale (cm), Sphygmomanometer (mmHg) and Stethoscope, Measuring Tape (inch), Electronic Stopwatch (seconds and milliseconds).

Determination of Anthropometric Parameters

Before the starting the study, the physical parameters i.e. height in cm and weight in Kg of the selected subjects were noted down (without shoes) by using the height measuring scale and weighing machine. The waist circumference (between the costal margin and iliac crest) and hip circumference (over the buttocks) were measured in cm by using measuring tape. The WHR was calculated.

After measuring the parameters, the subjects were allowed to take rest for 15 – 20 minutes in recumbent position on the couch. The experimental protocol was explained to them before test and the written consent was obtained.

After relaxation, the pre-exercise heart rate in beats / minute was noted down by using electronic stop watch and blood pressure (mmHg) was noted down by using stethoscope and sphygmomanometer.

Subjects were allowed to do cycling with 1 Kg workload at a frequency of 30 cycles / minute in the bicycle ergometer till exhaustion. At the moment of starting, the time was noted down. They were considered as fatigued when they were unable to continue the exercise with the frequency of 30 cycles / minute. The duration of exercise was noted down at the moment of cessation of exercise. After getting exhausted they were instructed to stop exercise and the time duration of exercise was recorded in minutes. The duration of exercise till onset of fatigue was considered as the endurance capacity.

After cessation of exercise immediately peak heart rate was recorded by feeling carotid pulsation for 15 sec period by using electronic stopwatch. After that the recovery heart rates were noted down by feeling carotid pulsation for 15 sec period in each minute by using electronic stopwatch up to 5th minute. 5 minutes after the cessation of exercise arterial blood pressure was noted down.

Study Design

The subjects were asked to come to the research laboratory in Department of Physiology at 8 am sharp. The entire experiment was done in 03 days, one day for each group. After coming to lab, the anthropometric parameters of the subjects were measured. Then the subjects were allowed to take rest for 15 – 20 minutes. After relaxation, the resting heart rate and blood pressure were measured. Then the subjects were allowed to do cycling bicycle ergometer with 1 Kg workload, till exhaustion. After exercise the peak heart rate, recovery heart rate and post exercise blood pressure were measured.

Statistical Analysis

The statistical analysis of the subject was done by SPSS (Statistical Package of Social Sciences), Version 16.0, designed by the TISS (Tata Institute of Social Studies).

RESULTS

In this study on obese subjects, no significant variation ($p > 0.05$) in the endurance capacity was seen during the follicular phase, but, endurance capacity is significantly ($p < 0.001$) reduced in menstrual phase compare to other two phases (Table 1). No significant variation ($p > 0.05$) was also observed in the resting heart rate during the follicular phase and luteal

phase of the menstrual cycle. But the resting heart rate is significantly ($p < 0.001$) high in menstrual phase compare to other phases (Table 2). There was also no significant difference ($p > 0.05$) in the peak heart rate in 3 different phases of the menstrual cycle in (Table 2). No significant variation ($p > 0.05$) in the recovery heart rate is seen during the follicular phase and luteal phase of the menstrual cycle but recovery heart rate is significantly ($p < 0.001$) slower in menstrual phase compare to other two phases (Table 2).

Variation of Endurance Capacity (minute) during Menstrual Cycle				Compared Groups	P-Value	Inference
Phase	Mean	SD	SE			
ECF	9.587	0.994	0.198	ECF vs. ECL	0.453	Not Significant
ECL	9.654	0.906	0.181	ECL vs. ECM	0.0001	Highly Significant
ECM	7.879	0.950	0.190	ECM vs. ECF	0.0001	Highly Significant

Table 1. Comparison of Endurance Capacity in 3 Different Phases of Menstrual Cycle within the Obese Group

Heart Rate Profile	Variation of Resting Heart Rate (Beats / Minute) during Menstrual Cycle				Compared Groups	P Value	Inference
	HR	Mean	SD	SE			
Resting Heart Rate	RHRF	78.64	3.251	0.650	RHRF vs. RHRL	0.472	Not Significant
	RHRL	79.28	3.048	0.610	RHRL vs. RHRM	0.0001	Highly Significant
	RHRM	83.68	3.092	0.618	RHRM vs. RHRF	0.0001	Highly Significant
Peak Heart Rate Profile	PHRF	167.67	5.981	1.196	PHRF vs. PHRL	0.722	Not Significant
	PHRL	168.32	5.406	1.081	PHRL vs. PHRM	0.417	Not Significant
	PHRM	169.60	5.228	1.046	PHRM vs. PHRF	0.245	Not Significant
Recovery Heart Rate Profile	rHR ₁ F	148.80	7.094	1.419	rHR ₁ F vs. rHR ₁ L	0.965	Not Significant
	rHR ₁ L	148.88	6.326	1.252	rHR ₁ L vs. rHR ₁ M	0.0001	Highly Significant
	rHR ₁ M	159.92	5.930	1.186	rHR ₁ M vs. rHR ₁ F	0.0001	Highly Significant
	rHR ₂ F	127.04	7.530	1.506	rHR ₂ F vs. rHR ₂ L	0.801	Not Significant
	rHR ₂ L	127.52	6.252	1.250	rHR ₂ L vs. rHR ₂ M	0.0001	Highly Significant
	rHR ₂ M	138.88	4.936	0.987	rHR ₂ M vs. rHR ₂ F	0.0001	Highly Significant
	rHR ₃ F	109.68	6.073	1.215	rHR ₃ F vs. rHR ₃ L	0.844	Not Significant
	rHR ₃ L	110.00	5.567	1.114	rHR ₃ L vs. rHR ₃ M	0.0001	Highly Significant
	rHR ₃ M	120.32	5.406	1.081	rHR ₃ M vs. rHR ₃ F	0.0001	Highly Significant
	rHR ₄ F	96.96	4.363	0.873	rHR ₄ F vs. rHR ₄ L	0.755	Not Significant
	rHR ₄ L	97.37	3.988	0.798	rHR ₄ L vs. rHR ₄ M	0.0001	Highly Significant
	rHR ₄ M	105.12	5.102	1.020	rHR ₄ M vs. rHR ₄ F	0.0001	Highly Significant
	rHR ₅ F	84.04	4.800	0.960	rHR ₅ F vs. rHR ₅ L	0.678	Not Significant
	rHR ₅ L	84.48	2.993	0.705	rHR ₅ L vs. rHR ₅ F	0.0001	Highly Significant
	rHR ₅ M	93.84	5.684	1.137	rHR ₅ M vs. rHR ₅ F	0.0001	Highly Significant

Table 2. Comparison of Heart Rate Profiles in 3 Different Phases of Menstrual cycle within the Obese Group

In this study we also found that the post exercise SBP is also significantly ($p < 0.05$) higher in the obese females, in all 3 phases of the menstrual cycle. Before exercise, no significant difference ($p > 0.05$) was seen in SBP (Systolic Blood Pressure) and DBP (Diastolic Blood Pressure), during the different phases of the menstrual cycle in both obese groups (Table 3).

After exercise, no significant difference ($p > 0.05$) was seen in SBP and DBP, during the different phases of the menstrual cycle in obese groups (Table 3).

Exercise	Blood Pressure in Different Phases of Menstrual Cycle				Compared Groups	P Value	Inference
	BP	Mean	SD	SE			
Before Exercise	B _x SBPF	124.64	3.252	0.650	B _x SBPF vs B _x SBPL	0.896	Not Significant
	B _x SBPL	124.72	2.993	0.599	B _x SBPL vs B _x SBPM	0.786	Not Significant
	B _x SBPM	124.88	3.166	0.633	B _x SBPM vs B _x SBPF	0.986	Not Significant
	B _x DBPF	83.520	2.600	0.520	B _x DBPF vs B _x DBPL	0.903	Not Significant
	B _x DBPL	83.440	2.200	0.440	B _x DBPL vs B _x DBPM	1.000	Not Significant
	B _x DBPM	83.442	3.166	0.633	B _x DBPM vs B _x DBPF	0.908	Not Significant
	A _x SBPF	144.80	3.215	0.643	A _x SBPF vs A _x SBPL	0.928	Not Significant
	A _x SBPL	144.72	3.311	0.662	A _x SBPL vs A _x SBPM	0.857	Not Significant
	A _x SBPM	144.56	2.859	0.572	A _x SBPM vs A _x SBPF	0.787	Not Significant
	A _x DBPF	80.96	2.389	0.478	A _x DBPF vs A _x DBPL	0.894	Not Significant
After Exercise	A _x DBPL	80.88	1.922	0.384	A _x DBPL vs A _x DBPM	0.790	Not Significant
	A _x DBPM	81.04	2.010	0.402	A _x DBPM vs A _x DBPF	0.892	Not Significant

Table 3. Comparison of Blood Pressure in Different Phases of Menstrual Cycle within the Obese Group before and after Exercise

DISCUSSION

Endurance capacity was significantly lower at the menstrual phase compared to other two phases of the menstrual cycle in the obese females. Different scientists had investigated the influence of the menstrual cycle on exercise and cardiovascular responses. Most of them concluded from their findings that exercise capacity was reduced during the menstrual phase.^{17,18,19,20,21,22,23,24,25}

Endurance capacity will be more in the individuals whose resting heart rate is less.^{26,27,28} While discussing the endurance capacity we should correlate it with the cardiovascular parameter that is resting, peak and recovery heart rate. The resting heart rate of any individual is determined by the parasympathetic tone (vagal tone). At any moment due to physiological cause or pathological cause, if the sympathetic tone is increased, the resting heart rate is also increased. Obesity causes increase in sympathetic tone and causes increase of resting heart rate.^{29,30,31} In the obese, insulin stimulated glucose uptake in the skeletal muscle decreases, that causes early muscular fatigue.³² Both the lactate accumulation and decreased glucose uptake by muscles reduce the endurance capacity in the obese females.

In the obese it is observed, especially in menstrual phase, physical discomfort might be the cause of more sympathetic tone causing a higher resting heart rate. The peak heart rates did not vary significantly in the three phases of menstrual cycle in our obese subjects. The increase in heart rate occurs as soon as exercise begins or may be seen even before the exercise begins (anticipatory tachycardia).

The heart rate increases at the time of exercise due to:

- Sympathetic discharge that originates centrally, whenever there is an increase in motor activity and is

responsible for tachycardia. Even the thought of exercise stimulates the hypothalamic defence area, bringing about increase sympathetic discharge and causing the anticipatory tachycardia.²⁸ When the noradrenergic sympathetic fibres to the nodal tissues are stimulated, it causes the release of nor-epinephrine from the nerve endings that will bind to the β_1 -adrenergic receptor. It in turn will cause the increasing of intracellular concentration of cAMP and facilitates the opening of long lasting Ca^{2+} channels.⁸ Thus, there will be an increase in steepness of phase-4 (pacemaker potential) of action potential of pacemaker tissue, which will increase the heart rate.

- Peripheral reflexes, originating from exercising muscle (muscle spindles, muscle-tendon receptors) and joints are responsible for the increase in heart rate which occurs as soon as exercise begins.
- Local metabolic factors, contributes to the sustained increase in heart rate during prolonged exercise. Muscle tissues have nociceptor (free nerve ending) which is stimulated by lactic acid, potassium ions and other metabolites which collect in exercising muscle. Thus, the increased heart rate can also be explained as an effect of increase collection of lactic acid.
- Adrenaline, noradrenaline from the sympathetic nerve endings and thyroid hormones during exercise also contribute to the increase in heart rate during sustained exercise.²⁸
- Intrinsic factors increase the heart rate during exercise by stimulating the SA (Sino-Atrial) node in the right atrium through increasing the venous return and Bainbridge reflex.
- Increased activity of the heart during exercise increases the myocardial temperature, which in turn stimulates the SA Node of the heart and causes increase in its rhythmicity.

The heart rate starts decreasing after cessation of exercise (recovery heart rate) but takes considerable time to achieve resting level. This is likely due to the effect of persisting local metabolites, hormonal factors and increased temperature. Gradually the resting sympathetic tone is established. In our obese subjects, the recovery of normal heart rate was significantly slower in the menstrual period, due to higher sympathetic discharge.

In our obese subjects, pre-exercise systolic blood pressure in different phases of menstrual cycle did not varies significantly, but after exercise, SBP significantly increases in all phases with insignificant inter phase variation. The diastolic blood pressure was not significantly different in our subjects in the three phases of menstrual cycle both before and after exercise, but after exercise, DBP was little lower than before exercise in all phases of menstrual cycle. SBP is always raised by exercise since it depends upon the cardiac output which increases in exercise. The SBP remains elevated during the exercise and is not reflexly corrected by baroreceptor reflex, because, numerous descending tracts from hypothalamic defence centre inhibit the baroreceptor afferents. DBP primarily depends upon the peripheral resistance that may decrease or remain unchanged during exercise. Mostly the vasodilatation in the skeletal muscle

balances the vasoconstriction in other tissues, so DBP is not changed much

CONCLUSIONS

From this study it is concluded that in obese sedentary females, physical endurance is significantly reduced during the menstrual phase as compared to the other two phases of the menstrual cycle. The resting heart rate was significantly higher in the menstrual phase than the other two phases. The recovery heart rate was significantly slower in menstrual phase. But the menstruation had no influence on post exercise SBP and DBP.

Data sharing statement provided by the authors is available with the full text of this article at jemds.com.

Financial or other competing interests: None.

Disclosure forms provided by the authors are available with the full text of this article at jemds.com.

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