Egypt. J. of Appl. Sci., 39 (3-4) 2024 *15-26*

IMPACT OF MENSTRUAL LUTEAL PHASE ON INSTANTANEOUS MUSCLE TORQUE

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ABSTRACT

During the MC, women are exposed to continuous variations in serum concentrations of several female sex steroid hormones. Estrogen, progesterone, follicle stimulating hormone (FSH), and luteinizing hormone (LH) are essential to regulate the patterns of the ovulatory cycle. The perpose of the current study was to investigate the impact of the menstrual luteal phase on instanteous muscle torque. Observational cross-sectional was used in the present study. Females were selected from the Egyptian Chinese university students. Thirty females within 14 days after last menstruation and during menstruation were recruited in the present study. They were selected from the Egyptian Chinese University students. Patients assigned to one group, the selected 30 females were measured within 14 days after last menstruation and during menstruation, they were all assessed by isokinetic device to detect the strength and instantaneous muscular torques of knee extensor during LP. There was significant decrease in right and left knee extensor strength and Peake muscle torque compared with the menstrual phase. It could be concluded that physical performance is affected by the different phases of menstrual cycle in the defined group. But it may vary according the physiological, psychological and environment condition of each participant.

Key Words: Luteal phase, Menstrual, Muscle Torque.

INTRODUCTION

The menstrual cycle (MC) is an important biological rhythm, whereby large cyclic fluctuations in endogenous sex hormones, such as estrogen and progesterone were observed **(Davis and Hackney, 2017).**

During the MC, women are exposed to continuous variations in serum concentrations of several female sex steroid hormones. Fluctuations in the main four female sex hormones, namely, estrogen, progesterone, follicle stimulating hormone (FSH), and luteinizing hormone (LH) are essential to regulate the patterns of the ovulatory cycle **(Ikeda *et al.*, 2019).**

The fairly predictable (and measurable) fluctuations in estrogen and progesterone across the MC create significantly different transient hormonal profiles, which are used to differentiate between MC phases **(Mihm *et al.*, 2011).**

As such, the MC is commonly divided into three phases, (1) the early follicular phase that characterized by low estrogen and progesterone, (2) the ovulatory phase characterized by high estrogen and low progesterone, and (3) the mid-luteal phase characterized by high estrogen and progesterone **(de Jonge *et al.*, 2019).**

The MC can cause psychological and physical changes in female, which may in turn affect their physical performance **(Bruinvels *et al.*, 2016).**

Although the primary function of these hormones is to support reproduction, research has highlighted that the changing concentrations of estrogen and progesterone across the MC also exert a myriad of diverse and complex effects on multiple physiological systems, including cardiovascular, respiratory, metabolic and neuromuscular parameters, which could have subsequent implications for exercise performance **(McNulty *et al.*, 2020).**

There are range of suggested mechanisms by which the cyclical fluctuations in estrogen and progesterone across the MC might affect performance. Specifically, estrogen thought to have an anabolic effect on skeletal muscle and has to play a role in substrate metabolism changes through increased muscle glycogen storage and increased fat utilization. Additionally, progesterone thought to have anti-estrogenic effects. As such, it is plausible that changes in exercise performance might be observed due to the different hormonal profiles across the MC **(Lebrun *et al.*, 2013).**

Regular fluctuations in ovarian hormone levels, particularly estrogen and progesterone during the normal ovulatory cycle, produce profound alterations on the body homeostasis of women between the age of 13–50 years old. Estrogen and progesterone hormone-induced physiological alterations have the potential to produce considerable differences in performance during exercises. Serum concentrations of estrogen and progesterone fluctuate markedly throughout the MC, which lasts 23–32 days and these fluctuations vary among women. On average ovulation occurs at day 14, and it is preceded by a follicular phase and followed by a luteal phase (on average, 12–14 days each). The hallmark of the early follicular phase (days 1–7) is the low levels of estrogen and progesterone. During the mid-follicular phase (days 7–10), estrogen slowly starts to increase and peaks in the late follicular phase (days 10–

14) followed by a sharp drop just before ovulation. After ovulation, estrogen and progesterone increase during the luteal phase reaching a plateau during the mid-luteal, phase (days 20–26) and later decrease again during the late luteal phase **(Pereira, *et al.*, 2020).**

Besides, from reproductive function female sex hormones are further known to affect numerous cardiovascular, respiratory, thermoregulatory and metabolic parameters. Which may plausibly be expected to have implications on exercise physiology, for example via fluid retention, changes in body temperature, and energy metabolism. Currently, much of the research has investigated these effects on endurance performance **(Julian *et al.*, 2017).**

The current study was conducted to detect the impact of MLP on muscle torque using isokinetic device.

Study design, duration, and ethical consideration:

An observational cross sectional design was conducted in accordance with the declaration of Helisiniki (Code of Ethics of the World Medical Association). The study protocol was approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo University, Egypt (No.P.T.REC/000000000) (Appendix I). Patients who participated in this study were authorized by a signed written consent form with Parent's/ Legal guardian's acceptance for participation before starting the study procedures.

I) Subjects: Thirty females within 14 days after last menstruation and during menstruation were recruited in this study. They were selected from the Egyptian Chinese University students.

Subject's selection

Forty-two females in the LP aged from 18-26 years old with a BMI between 18-26 kg/ m^2 were selected to participate in this study. However, during the eligibility assessment, twelve females were excluded as six did not meet the inclusion criteria and six refused to participate in the study.

Inclusion Criteria:

All patients were included if they meet the following criteria:

Thirty nulliparous females, their age range from 18-26 years old **(Mikako *et al.*, 2016),** their body mass index (BMI) ranged from 18 to 26 kg/ m^2, All females had regular menstrual cycle normal length (21-35) days in the last six months **(Julian *et al.*, 2017).**

Exclusion Criteria:

Patients were excluded if they have one of the following **(Oğul *et al.*, 2021).**

Oligo-, polyor amenorrhea or metro menorrhagia, use of Depo-Provera, Norplant or intrauterine medication in the last 12 months, Oral contraceptive use or hormone therapy in the last three months, Endometriosis, polycystic ovary syndrome, uterine fibroids, Smoking, illegal drug use, A calorie-restricted diet, pregnancy, musculoskeletal disease in the last six months, heart disease, inflammatory or autoimmune diseases, diabetes, any endocrine disorder (e.g. hypo-/hyperthyroidism, etc.), anemia, Using medication or nutritional supplements.

All patients were assigned into one group:

One group of selected 30 females were measured within 14 days after last menstruation and during menstruation, recruited from the Egyptian Chinese university students. They were all assessed by isokinetic device to detect the strength and instantaneous muscular torques of knee extensor during LP.

II) Instrumentations:

A- Instruments for evaluation

1. Recording data sheet: All information about female included name, age, weight, last menstrual date….. etc.

2. Determination of the Menstrual phase: Twice a month participant completed a menstruation diary, which included: date of menses, length of menses, and severity of blood flow and discomfort. This information was recorded for a minimum of 6 months, for a valid characterization of an individual's menstrual cycle **(Julian *et al.*, 2017).**

3. Weight & Height: Standard height and weight scale (ZT – 120) (Made in China): The height and weight will be measured for each female. Weight-Height scale will be calibrated. Weight and height will be recorded and BMI will be calculated according to the formula: BMI = Weight (Kg) / [Height. m^2].

4. Isokinetic device: is the most accurate method for evaluation of muscular activity. The measurement was made using the dynamometer with a computerized system that permitarcs movement in constant angular velocity that had determined previously **(Kabacinski *et al.*, 2022).**

III) Procedures:

A- Procedures for evaluation:

Before starting the study, a consent form was taken from each subject as an agreement to be included in the study. A verbal explanation about the importance of the study procedures, main aim and conceptual were explained to each subject.

1. Rerecording data sheet: All data and information of each participant who participated in this study including name, address, age, weight, height, BMI and MC history were recorded in recording data sheet. Asked all participant to answer all the question they were asked according the appendix inestly.

2. Determination of the Menstrual phase: From retrospective analysis, (counting back from previous menses, from month to month, indicating the length of the cycle) the next cycle phase was then prospectively determined and time-point was calculated. For final confirmation of LP sampling time, the participants completed menstruation diaries during the course of testing **(Julian et al., 2017).**

3. Anthropometrics: Weight and height will be measured to calculate body mass index (BMI) (weight Kg / height m^2) used the height and weight scale. It was applied for all patients in each group. All patients were asked to wear light clothes and stand on the scale with their head looked forward and were stood erect till the analogue stop movement then the weight was scored. Then the height was measured by asking the patient to stand erect on the stand board without shoes, feet straight ahead, face was looked forward and the audiometer was lowered so that the hair pressed down, and the height was scored in $meter^2$.

4. Assessment of knee extensor muscle torque: (Pourasiri *et al.*, 2023):

Participants in the study were instructed to avoid eating heavy meals, drinking caffeine beverages and exercising at least four hours before the assessment to minimize the potential effects of digestion or thermo regularity activity and to create a stable hemodynamic state.

- Each subject was examined medically in order to exclude any abnormal medical problem, which previously mentioned.
- Measurements were taken within 14 days after last menstruation and during menstruation.
- All participants conducted two standardized test sessions on the isokinetic device (five to ten days apart). Each session consisted of one familiarization trial followed by three trials of peak isometric knee extension per each leg. Per trial, peak and mean knee extension force (N) and torque (Nm) were measured at 90° flexion.
- After calibration of the dynamometer, females were seated in the adjustable chair and thigh, hip, and chest were stabilized using straps. The dynamometer shaft was visually aligned with the axis of the knee joint and stabilized by straps so that only the knee to be tested was moving with a single degree of freedom. The female’s leg was placed at 90° and the device was set so that the amplitude of the extension was 90° (range of knee motion from 90° to 180°). The females performed a familiarization and a testing session, each consisting of a

standardized warm up and several extension trials. During the familiarization session, no data were recorded.

- All measurements, at a fixed velocity, were completed before the velocity was changed, separated each by 3-minute passive recovery period. Following the testing of one leg, the testing of the other leg began under the same conditions. The dominant leg was considered as the leg used to kick a ball. All the tests were performed at the same time of day to avoid the effects of circadian rhythms

Statistical analysis:

- Descriptive statistics were utilized in presenting the subjects demographic and collected data. Normal distribution of data was checked using the Shapiro-Wilk test. Paired t test was conducted for comparison of knee extensors force and peak torque between luteal phase and post menstruation. The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS) version 25 for windows.

RESULTS

Subject characteristics:

Thirty healthy females participated in the current study. The mean ± SD age, weight, height and BMI of study group were 22.07 ± 2.65 years, 63.18 ± 3.35 kg, 165.38 ± 4.38 cm and 23.12 ± 1.28 kg/m² respectively. Participant characteristics is presented in Table (1).

Table 1. Participant characteristics.

	Mean ± SD	Minimum	Maximum
Age (years)	**22.07 ± 2.65**	**18.00**	**26.00**
Weight (kg)	**63.18 ± 3.35**	**59.00**	**70.23**
Height (cm)	**165.38 ± 4.38**	**159.40**	**177.70**
BMI (kg/m²)	**23.12 ± 1.28**	**20.60**	**25.89**

SD, Standard deviation

Comparison of knee extensors force and peak torque between luteal phase and post menstruation:

There was a significant decrease in right and left knee extensors force during luteal phase compared with that post menstruation ($p < 0.001$). The per cent of change of in right and left knee extensors force was 5.71 and 8.38% respectively. (Table 2, Figure 1).

There was a significant decrease in right and left knee extensors peak torque during luteal phase compared with that post menstruation ($p < 0.001$). The per cent of change of in right and left knee extensors peak torque was 8.59 and 6.27% respectively. (Table 2, Figure 2).

Table 2. Mean knee extensors force and peak torque during luteal phase and post menstruation:

	Luteal phase	Post menstruation				
	Mean ± SD	Mean ± SD	MD	% of change	t- value	p - value
Knee extensors force (N)						
Right	244.75 ± 24.19	258.73 ± 22.27	-13.98	5.71	-5.88	0.001
Left	234.16 ± 29.38	253.78 ± 22.07	-19.62	8.38	-4.07	٠.001
Knee extensors peak torque (Nm)						
Right	111.49 ± 8.35	121.07 ± 8.66	-9.58	8.59	-51.03	0.001
Left	108.08 ± 8.28	114.86 ± 8.60	-6.78	6.27	-27.19	0.001

SD, standard deviation; MD, mean difference; p-value, probability value

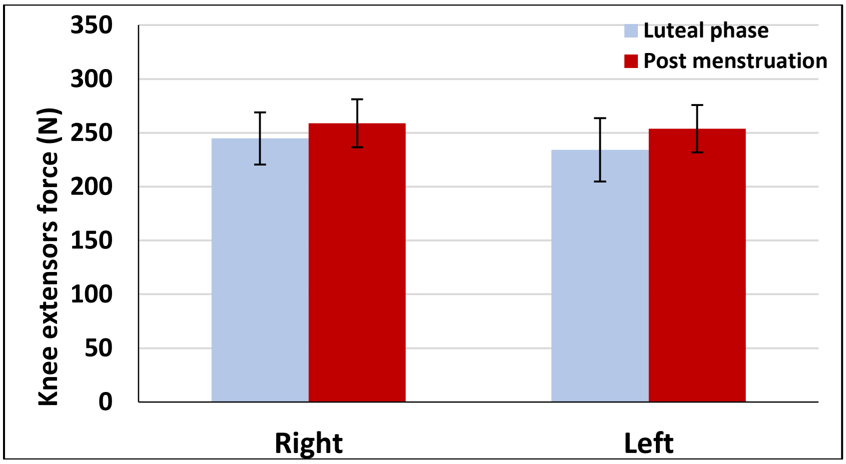

Figure (1). Mean knee extensors force during luteal phase and post menstruation.

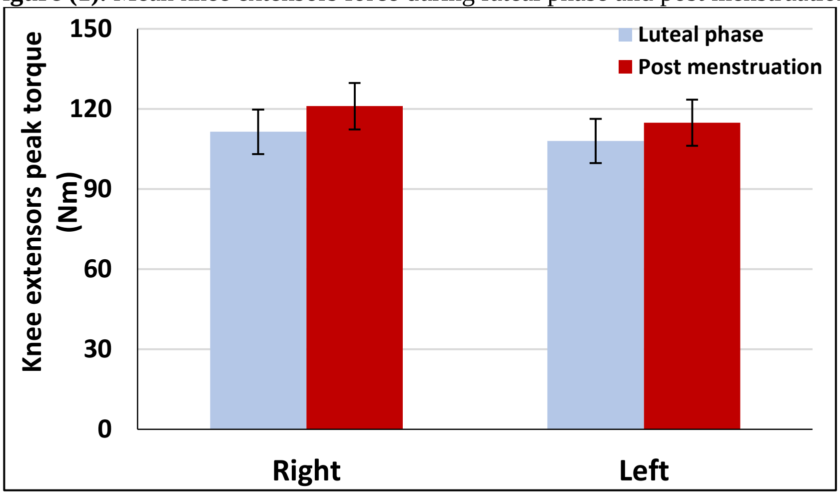

Figure (2). Mean knee extensors peak torque during luteal phase and post menstruation.

DISCUSSION

This study was conducted to investigate the influence of menstrual luteal phase on instantaneous muscle strength regarding knee extensors force and peak torque during luteal phase and 14 days during menstruation.

Sex steroid hormone concentrations fluctuate during the menstrual cycle. Consequently, researchers argued that women's physical performance parameters could also fluctuated throughout the menstrual cycle **(Oğul *et al.,* 2021).**

The results of the present study revealed that there was a significant decrease in right knee extensors force during luteal phase compared with that post menstruation ($p < 0.001$) .The per cent of change was 5.71%, Also, there was a significant decrease in left knee extensors force during luteal phase compared with that menstruation ($p < 0.001$) with a per cent of change 8.38%.

These decline in knee flexor and extensor muscle force during the luteal phase compared with the menstruation phase may be due to estrogen and progesterone levels in the luteal stage. The strength immediately declines following the reversal of the estrogen-progesterone ratio.

These results are in agreement with **Liu *et al.,* (2023**), who reported that**,** the semitendinosus muscle exhibits a significantly delayed activity during the luteal phase compared to the follicular one which by its role it decreases the strength of the muscles.

Also, the results of the present study are in consistent with the study of **Sung *et al.,* (2014),** who found the more pronounced increase in muscle strength and muscle diameter in menstrual phase compared to luteal phase.

Lee *et al.,* (2018), reported that the fluctuation of sex hormones during the various phases of the menstrual cycle may influence neuromuscular and biomechanical characteristics. Estrogen and progesterone may affect the neuromuscular function of connective tissues if the fluctuations in the concentrations of the hormones change motor behavior around the knee joint.

Also, the result of the current study disagree with **Jonge *et al.,* (2001),** who evaluated isokinetic knee flexion and extension muscle strengths in early follicular, late follicular, and luteal phases, and found no significant changes.

Another study evaluated isokinetic knee flexor and extensor muscle strength ratios of 26 female athletes in the luteal and follicular phases. The hamstring-to-quadriceps muscle strength ratio was not different among phases in the dominant limb, but was significantly reduced during the follicular phase in the non-dominant limb ($p< 0.011$) **(Andrade *et al.,* 2017).**

The variance of results in literature is partly ascribed to differences in isokinetic measurement methods, assessment parameters, and differences in evaluated menstrual cycle phases. Studies with comparable methodologies are required for more conclusive results.

These disagreements may be that the muscle force may differ during different condition and situations, not only a hormonal effect but also genetic factors, nutritional statues and environment factors.

The current study has found that there was a significant decrease in right knee extensors peak torque during luteal phase compared with that post menstruation ($p < 0.001$) with a per cent of change 8.59%. Also, there was a significant decrease in left knee extensors peak torque during luteal phase compared with that post menstruation ($p < 0.001$) and the per cent of change 6.27%.

Numerous studies have examined the relationship between menstrual cycle and aerobic capacity, anaerobic power, and muscle strength with neglection in assessing muscle peak torque.

In the current study, a significant diurnal variation was observed for maximal voluntary contraction of knee extensors on postmenstrual phase compared with luteal phase but only when percutaneous electrical twitches were superimposed **(Bambaeichi *et al.,* 2004).**

Skeletal muscle expresses functional estrogen receptors, suggesting that skeletal muscle is sensitive to estrogen. Estrogen regulates skeletal muscle mass in developing rats and maximum contraction torque. Estradiol concentrations in the post menstrual and mid-LP correlate with changes in cross sectional area in the quadriceps muscle of humans ($r = 0.85$, $p > 0.05$) **(Sakamaki-Sunaga *et al.,* 2016).**

The result of present study come in consistent with the study of **Oğul *et al.,* (2021).** Who, found that there was a significance decrease in knee extensors peak torque during luteal phase compared with that post menstruation with ($P > 0.05$).

Many studies have concluded that performance does not vary between MC phases. In the studies that did observe a MC effect to performance, there were inconsistencies in findings but strength and aerobic performance were most commonly reported to be impaired during the late luteal phase, and anaerobic performance was most frequently reduced in the late follicular phase **(Solli *et al.,* 2020).**

Also**, Romero-Moraleda *et al.,* (2019),** reported that it seems that the mean and peak force, velocity and power output performance in the Smith machine half-squat for eumenorrheic women is not affected by different phases of the menstrual cycle.

This debate of current study with the previous studies may be the difference procedures of the assessment as in the present study works on isokinetic contraction of knee extensor muscle only while in the study of **Romero-Moraleda *et al.*, (2019),** they worked on the closed chain isometric contraction of knee flexor and extensor muscle. Also, there was another difference as their sample was athletes while our sample , in the current research was from the normal health women, and the final difference is that they worked with eumenorrheic women but in present study, this point was neglected.

Finally, it might concluded that physical performance is affected by the different phases of menstrual cycle in the defined group. But it may vary according the physiological, psychological and environment condition of each participant in addition, it should not to be forgotten that there are variations in hormonal changes between individuals, level of fatigability and seasonal ones, so each individual should be evaluated individually.

CONCLUSION

Physical performance is affected by the different phases of menstrual cycle in the defined group. But it may vary according the physiological, psychological and environment condition of each participant in addition, it should not to be forgotten that there are variations in hormonal changes between individuals, level of fatigability and seasonal ones, so each individual should be evaluated individually

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تأثير الطور الأصفري أثناء الحيض علي عزم العضلات اللحظي

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تتعرض المرأة اثناء الحيض الي تغيرات مستمرة في تركيزات الهرمونات الجنسية الأنثوية وهم الاستروجين، البروجيستيرون، هرمون المحفذ للتخصيب و الهرمون اللوتيني حيث تعود اهميتهم الي تنظيم أنماط دورة التبويض. لدراسة تأثير الطور الاصفري أثناء الحيض علي عزم العضلات اللحظي تم عمل دراسة ملاحظية مستعرضة. تم إختيار الإناث من طلاب الجامعة المصرية الصينية. شارك في هذة الدرسة ٣٠ انثي في مجموعة دراسة واحدة بعد الحيض الاخير باربعة عشر يوما وأثناء الحيض. تم تقييمهن جميعا بواسطة جهاز مستوي الحركة للكشف عن القوة وعزم الدوران العضلي اللحظي للعضلة الباسطة للركبة أثناء الطور الأصفري للحيض. اظهرت النتائج وجود انخفاض ملحوظ في القوة والعزم لدي العضلى الباسطة للركبة في الطور الاصفري مقارنةً بمرحلة الحيض. يمكن استنتاج تأثير الأداء البدني بمراحل الددورة الشهرية المختلفة في المجموعة الواحدة ولكنهن قد تختلف حسب الحالة الفيسولوجية والنفسية والبيئية لكل مشاركه.