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Effect of Menstrual Cycle on Muscle Strength

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ABSTRACT

Rodrigues P, Correira MA, Wharton L. Effect of Menstrual Cycle on Muscle Strength. **JEPonline** 2019;22(5):89-96. The purpose of this study was to compare the maximal voluntary contraction of lower limbs pre-, during, and post-menstruation periods. Twelve healthy females who have been involved in resistance training for more than 3 yrs were involved in this study. All the subjects presented regular menstrual cycles lasting between 26 and 30 days (mean: 28), and were not taking oral contraceptives. The subjects performed a maximal voluntary contraction test of the lower limbs in a Leg Press 45º during different periods of the menstruation cycle in a randomized order. For the purpose of this research, the timing of data collection was defined as: (a) pre-menstruation period (late luteal phase); (b) during the menstruation period (early follicular phase); and (c) post-menstruation (mid-follicular phase). The maximal voluntary contraction produced in the course of the early follicular phase (237.89 ± 50.15 kg) was significantly greater (P=0.01) than the contraction produced in the course of the late luteal phase (220.97 ± 46.63 kg). Moreover, the maximal strength produced post-menstruation in the mid-follicular phase (248.26 ± 48. 39 kg) was greater (P=0.01) than the force produced during menstruation and pre-menstruation periods. The data suggest that the menstruation cycle can alter the maximal muscle force capacity in women who are not using oral contraceptives. This study may have implications for women involved in resistance training who are undertaking sequential structured periodization training based on the manipulation of repetition maximal loads.

Key Words: Menstrual Cycle, Maximal Voluntary Contraction, Oral Contraceptive

INTRODUCTION

Increased participation in sports by women has raised the interest in their physiological responses to sports and exercise (6,26). Studies that have been carried out to understand the relationship between exercise and menstrual cycle often focus on the mechanism of hormones involved in menstruation (1). The four hormonal markers of the menstrual cycle are estrogen, progesterone, follicle stimulating hormone, and luteinizing hormone each of which changes continuously throughout the cycle (8). The fluctuations in female steroid hormones influence the autonomic nervous system and metabolic functions (10). Thus, studies have investigated the influence of hormonal fluctuations on injury risk (5), flexibility (4), cardiovascular parameters (3,11), anaerobic power (26), sports performance (23), and muscle strength (1,8,15,16). However, the influence of this variation happens only because two hormones, estrogen and progesterone (12).

A primary facet of athletic performance assessment, rehabilitation, health, and fitness is the development of muscular strength (12). Given the increase in the number of recreational and performance-based sports, more women are undertaking strength-based training and assessment mechanisms (13). To measure the effects of the menstruation cycle on muscle strength, previous studies have used handgrip dynamometer (8,25), isometric and isokinetic knee extension/flexion strength tests (8,12), superimposed electrical stimulation on maximal voluntary contraction (25), and traditional strength training machines (e.g., Bench Press and Leg Press) for repetitive eccentric and concentric exercise (9,16), one maximal repetition (1RM) eccentric/concentric exercise tests (15) and 1RM via prediction calculation formula (e.g., multiple repetition to exhaustion) (1). However, the results of such studies are contradictory. While some studies have shown that menstrual cycle influence muscle strength (12,24,25), other studies have shown no effect on maximal strength throughout the different periods of menstrual cycle (8,9,16).

Typically, a menstrual cycle repeats every 28 ± 3 days and spans 30 to 35 yrs of a woman's life (2). However, more often than not, a menstrual cycle is defined by three fundamental phases: (a) follicular phase (from day 1 to day 14); (b) ovulation (the middle of menstrual cycle); and (c) luteal phase (from day 15 to day 28) (7,21). Yet on occasion, the menstrual cycle has been described as a cycle of five different phases: (a) early follicular (between days 1 to 7); (b) mid-follicular (days 7 to 12); (c) mid-cycle or ovulation (days 12 to 18); (d) mid-luteal (days 18 to 21); and (e) late luteal phase (days 21 to 32) (25). However, most studies of this subject matter have referred to the menstruation cycle with the distinction made for the menstruation period (bleeding), the follicular phase, and the luteal phase with little data relating to the pre-menstrual period (12). Given the importance of this knowledge to gym instructors, sports coaches and researchers for prescribing and planning resistance training programs for female athletes and recreational training, this study will focus on the responses of muscle strength on the pre-, during, and post-menstruation periods. Thus, the purpose of this study was to compare the lower limbs maximal voluntary contraction pre-, during, and post-menstruation.

METHODS

Subjects

Twelve healthy recreationally trained females (mean ± SD; age: 27.2 ± 3.4 yrs; height: 168.62 ± 5.19 cm; weight: 61.37 ± 6.29 kg) who were involved in resistance training for more than 3 yrs, training 5 to 6 $d \cdot wk^{-1}$ participated in this study. All participants that completed the data collection stage of this study presented regular menstrual cycles lasting between 26 and 30 days (mean: 28) and were not taking any form of hormonal treatment or contraceptive for the 6 months preceding this study. Initially, 15 women volunteered for this study, but 3 did not complete the data collection procedure.

One participant reported that she fell ill (flu) during the study, another reported an irregular cycle, and one did not offer any reason for withdrawing from the study. The data drawn from these 3 participants was not used in this study. The subjects were requested to abstain from any sort of training for 48 hrs prior to the beginning of data collection. This study was approved by the Research Ethics Committee of the Department of Health Science of the University of the Valley of Itajaí (Univali) (protocol: 2.202.278). Following the subjects receiving a comprehensive verbal and written explanation about the benefits and risks of the study, each subject signed the institutionally approved informed consent document.

Procedures

The subjects had to visit a Gym based in Governador Celso Ramos city, Brazil, 4 times to complete the experimental protocol of this study. During the first visit, the subjects' body weight and height were taken and a familiarization session with the maximal voluntary strength test procedures was conducted. During the second, third, and fourth visits, the maximal voluntary contraction test of the lower limbs was completed in different periods of the menstruation cycle (pre-, during, or post-menstruation). Cycle periods were termed: (a) pre-menstruation: 2 or 3 days before evidence of menstruation was visible (late luteal phase); (b) during the menstruation: 1st or 2nd day of menstruation (early follicular phase); and (c) post: 2 or 3 days after the menstrual flow has stopped (mid-follicular phase). The first maximal voluntary contraction test was performed in a randomized order according to the menstruation cycle periods using the research randomizer website (e.g., 1: during; 2: post; 3: pre). Thus, 4 subjects started the experimental sessions in the late luteal phase, 3 started in the early follicular phase, and 5 in the mid-follicular phase. The maximal voluntary contraction tests were conducted randomly between 9 and 10:30 a.m., which was around 1 hr after their regular breakfast.

According to Higgins et al. (14), this is an open label study, blinding of the subjects was not feasible because they knew in which period of their menstrual cycle they were positioned. However, blinding of the researchers was done. One researcher conducted the data collection (MAC), a second researcher (LW) labelled the data changing the name of the subjects and the menstruation periods for coded numbers, and the third researcher (PR) ran the statistics in the SPSS software.

Maximal Voluntary Contraction Assessment

The experimental sessions started with a minimal 48 hr washout period from the familiarization session. The subjects were asked to refrain from caffeine for 12 hrs and alcohol for 24 hrs prior to the second, third, and fourth visits. Individual lower limbs maximal voluntary contraction was determined in a Leg Press 45º (*Righetto*, Campinas, Brazil). For reasons of precaution, given that the subjects were not high-performance athletes, a prediction of 1RM test was adopted where the subjects were encouraged to complete 2 to 10 maximal repetitions with a fixed load until the concentric contraction failure occurred. Thereafter, the load was subjected to the O'Connor, Simmons, and O'Shea (22) equation for determining maximal voluntary contraction: 1RM = weight x [1 + (0.025 x number of repetitions)].

Initially, the subjects performed a specific warm-up that was composed of 5 repetitions of Leg Press 45º with 50% and then 70% of the 1RM load obtained during the familiarization session with a 2-min interval between each set. Then, they were asked to complete 2 to 10 maximal repetitions. If they completed more than 10 repetitions, increments of 2, 3, or 4% was used. A maximal of 3 trials with a 3-min interval between each was allowed to achieve their maximal voluntary contraction. Only the highest value (after the O'Connor, Simmons, and O'Shea equation) among the three trials was used.

Statistical Analyses

The IBM SPSS statistics 25 for Windows (SPSS, Inc., New York, USA) was used for the data analysis. To compare the maximal voluntary contraction during different periods of the menstruation cycle, a Repeated-Measure ANOVA followed by a Bonferroni *post hoc* test (P<0.05) was completed. Results are reported in individual values and mean ± standard deviation. Charts were created using the software GraphPad Prism 8.

RESULTS

The subjects reached their predicted 1RM in 7.08 ± 1.92 repetitions during the late luteal phase (pre-period), in 5.66 ± 1.61 repetitions through the early follicular phase (during the period), and in 5.16 ± 1.80 repetitions during the mid-follicular phase (post-period). The maximal voluntary contraction of the lower limbs produced in the course of the early follicular phase (During) (237.89 ± 50.15 kg) was significantly greater (P=0.01) than the force produced in the course of the late luteal phase (Pre) (220.97 ± 46.63 kg). Moreover, the maximal strength produced post-period (248.26 ± 48. 39 kg) was greater (P=0.01) than the force produced during the menstruation period and pre-menstruation (Figure 1A).

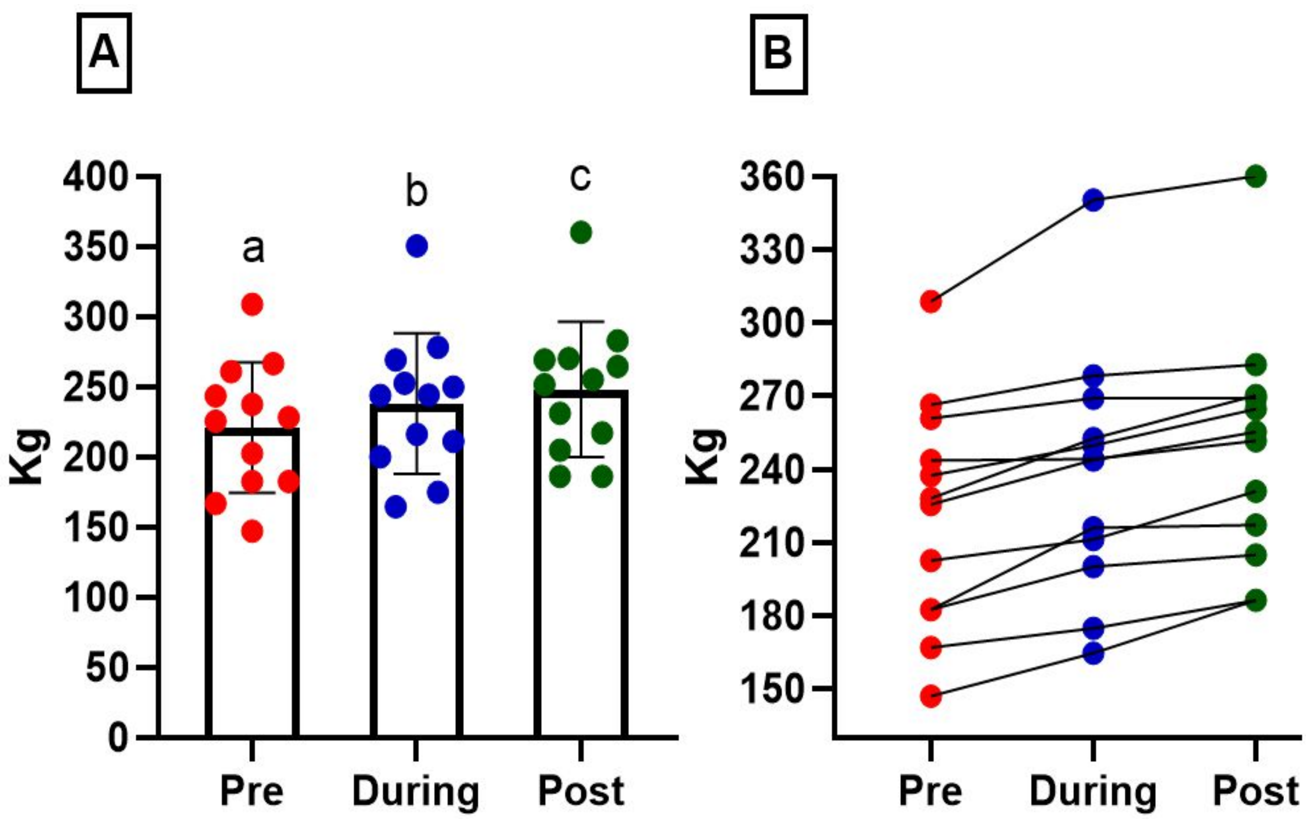

Figure 1. Maximal Voluntary Contraction during Different Periods of the Menstruation Cycle. (A) Individual values and mean ± standard deviation. (B) Time-course of changes in muscle strength capacity, in individual values, through the different periods of the menstruation cycle. **Pre** = Pre-Menstruation Period; **During** = Menstruation Period (Bleeding); **Post** = Post-Menstruation Period. Different letters denotes statistical differences between different periods of menstruation cycle by Repeated-Measure ANOVA (P<0.05).

DISCUSSION

The purpose of this study was to compare the maximal voluntary contraction of the lower limbs before, during, and after the menstruation periods. The results showed that women in different periods of the menstruation cycle produced different levels of muscle strength. The late luteal phase is the period where they presented the least muscle force capacity and the mid-follicular phase was the moment where the subjects presented their greatest values of maximal muscle strength. Even starting the experimental sessions in a randomized order, Figure 1 (B) shows a clear increase of individual values through the data collection moments from the pre-menstruation to the post-menstruation period.

In contrast, other studies have found no effect of the menstrual cycle on muscle strength (1,8,9,15,16). However, in some of these studies (9,16), the subjects were taking oral contraceptives that probably masked the effect of menstruation cycle. Gordon and colleagues (12) define the use of oral contraceptives as pseudo-menstrual cycle. According to these authors, there are non-significant changes in physiological or metabolic responses in women who take oral contraceptives that contain a combination of estrogen and progesterone. Giving support to this statement, three studies (12,24,25) compared the effect of menstruation cycle on muscle strength in women taking oral contraceptives to women who were not taking any form of hormonal contraceptives and in each study the results were the same. While the women taking oral contraceptive recorded no changes on muscle strength, the women who were not taking contraceptives demonstrated that strength was affected by the menstruation cycle. On the other hand, Azari and colleagues (1) and Jonge and colleagues (8) found no changes in muscle strength even in women not taking oral contraceptives, which keeps this subject controversial.

Nevertheless, not one of the aforementioned studies found changes in muscle strength in women who regularly used oral contraceptive. This keeps the discussion only on women who do not use contraceptives and maintain their normal hormonal fluctuations during the menstruation cycle. The present study observed an increase in muscle strength during the mid-follicular phase when compared to the maximum voluntary contractions produced during the course of the late luteal phase and the early follicular phase. The results of this study concur with the results produced in earlier studies (12,24,25). During menstruation, estrogen levels are reduced (12) and in the mid-follicular phase estrogen levels are increased (24) and reach the highest concentration levels just prior to ovulation (26). According to Gordon et al. (12), there is a concept that the estrogen hormone has a strength enhancing effect. These strength generating properties appear to be magnified in response to varying concentrations of estrogen. Also, it has been proposed that skeletal muscles are estrogen responsive tissues (12,17). The myosin is directly affected by estrogen concentration (17) and when estrogen levels are reduced there is a decrease in the number of active myosin heads bound to actin, thus decreasing the muscle strength capacity (19).

Regarding the pre-menstruation period, the study by Gordon et al. (12) did not find difference in the post-menstruation period on muscle strength nor on estrogen levels. However, the present study had similar results to Sawar et al. (25) that tested isometric quadriceps strength (IQS) and handgrip strength (HS). They reported that the lowest muscle strength was produced during the late luteal phase (IQS: 446.89 N; HS: 309.86 N), the higher values during the earlier follicular phase (IQS: 462.39 N; HS: 329.95 N), and values higher than late luteal and earlier follicular during the mid-follicular phase (IQS: 480.10 N; HS: 338.50 N) in no contraceptive taker women (data taken via WebPlotDigitizer). There is no clear evidence yet why muscle strength might be lower during the pre-menstruation period, but it can be related to the fact that pre-menstrual period is associated with traumatic (18) and anterior cruciate ligament injuries (20) and symptoms of irritability/irascibility, swelling/discomfort in the breasts, and congestion in the abdomen (18).

Limitations in this Study

The results of this study must be interpreted with caution and cannot be extrapolated to all types of exercise. This study tested only the lower limbs multi-joint strength that was measured on a Leg Press 45º traditional machine. Isometric, isokinetic, single-joint, and upper limbs exercise were not investigated. Furthermore, this study did not involve subjects who were taking oral contraceptive as a control group, so it is not possible to assume from our data that the women using contraceptives would have a different response through the menstruation cycle on Leg Press repetition maximal test.

Hormonal responses were not performed during this study. For that reason, it is not possible to infer a direct association between muscle strength and hormones. We only controlled the moments of data collection by the menstruation periods and the relations made by muscle strength and estrogen are based on previous studies. Finally, the present study did not measure muscle strength during the ovulation and mid-luteal phases, thus no comparison can be made with other studies that measured muscle strength at these moments.

CONCLUSIONS

The data in this study suggest that the menstruation cycle can alter the maximal muscle force capacity of lower limbs in no contraceptive user women. It might have implications for athletes or recreational trained females in resistance training who are undertaking sequential structured periodization training based on the manipulation of repetition maximal loads.

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