RBFEx
ISSN Online: 2675-1372

Revista Brasileira de Fisiologia do Exercício

Original article

Menstrual cycle phase does not affect performance in German Volume Training

A fase do ciclo menstrual não afeta o desempenho no German Volume Training

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ABSTRACT

Introduction: Hormonal fluctuations in different phases of the menstrual cycle (MC) can influence performance and strength production capacity. **Objective:** To evaluate whether the phase of the MC affects performance in German Volume Training (GVT) in eumenorrheic women not using contraceptives. **Methods:** Nine young women participated. The MC was 28.78 ± 0.83 days. The phases were determined by estrogen, progesterone, luteinizing hormones, and calendar. Strength was assessed by the 1RM test. For the GVT, a warm up of one set of 10 repetitions was performed, with 50% of the load from the 1RM test. After a two-minute interval, the first series of the protocol (80% of 1 RM) was performed, with 10 series until concentric failure, with a 60-second interval between series on the 45° leg press. The data are presented as (mean ± standard deviation). The Shapiro Wilk test was performed. A two-way analysis of variance (ANOVA) with repetition factor was used for the variables: Volume (number of repetitions * load) per set, and RPE. The Tukey post-test was applied. For the variables: total volume, estrogen and progesterone hormones, the Student's t-test was applied. The ICC for the 1RM retest. The significance level was $p < 0.05$. The program used for statistical analysis was GraphPad Prism (8.4.3). **Results:** The load in the 1RM test was higher ($p = 0.0065$) in the luteal phase (174.67 ± 53.89 kg) compared to the follicular phase (167.67 ± 48.74 kg). There was no significant difference in total session volume and RPE (Rating of Perceived Exertion). **Conclusion:** The phase of the MC does not affect performance in GVT in women.

Keywords: resistance training; follicular phase; luteal phase.

RESUMO

Introdução: As flutuações hormonais em diferentes fases do ciclo menstrual (CM) podem influenciar o desempenho e a capacidade de produção de força. **Objetivo:** Avaliar se a fase do CM afeta o desempenho no German Volume Training (GVT) em mulheres eumenorréicas que não usam contraceptivos. **Métodos:** Nove mulheres jovens participaram. O CM foi de 28,78 ± 0,83 dias. As fases foram determinadas pelos hormônios estrogênio, progesterona, luteinizante e calendário. A força foi avaliada pelo teste 1RM. Para o GVT, foi realizado um aquecimento de uma série de 10 repetições, com 50% da carga do teste 1RM. Após um intervalo de dois minutos, a primeira série do protocolo (80% de 1 RM) foi realizada, com 10 séries até a falha concêntrica, com um intervalo de 60 segundos entre as séries no aparelho Leg Press 45°. Os dados são apresentados como (média ± desvio padrão). O teste de Shapiro Wilk foi realizado. Uma análise de variância (ANOVA) de dois fatores com fator de repetição foi usada para as variáveis: Volume (número de repetições * carga) por série, e PSE. O pós-teste de Tukey foi aplicado. Para as variáveis: volume total, hormônios estrogênio e progesterona, foi aplicado o teste t de Student. O ICC para o reteste 1RM. O nível de significância foi $p < 0,05$. O programa usado para análise estatística foi o GraphPad Prism (8.4.3). **Resultados:** A carga no teste 1RM foi maior ($p = 0,0065$) na fase lútea (174,67 ± 53,89 kg) em comparação com a fase folicular (167,67 ± 48,74 kg). Não houve diferença significativa no volume total da sessão e PSE (Escala de Percepção de Esforço). **Conclusão:** A fase do CM não afeta o desempenho no GVT em mulheres.

Palavras-chave: treinamento de resistência; fase folicular; fase lútea.

Introduction

The menstrual cycle (MC) is a physiological change that occurs in fertile women, characterized by the follicular and luteal phases. The follicular phase occurs from the beginning of the menstrual flow to about 14 days after, with an increase in the action of the hormones Follicle Stimulating (FSH), Estrogen and Luteinizing (LH). The luteal phase occurs around the 14th day after the menstrual flow until the beginning of the next cycle with increases in the concentration of the progesterone hormone [1].

The fluctuations of women's sex steroid hormones, in the different phases of the menstrual cycle (MC), can influence performance and the ability to produce strength [2]. A study conducted by Simão *et al.* [3] showed that there was an increase in performance in the 45-degree leg press exercise (8 maximum repetition test). The phases of the MC were analyzed: menstruation, follicular phase (between the sixth and tenth day), ovulatory (14 days after menstruation). The performance in the last two phases was statistically higher compared to the first [3].

However, evidence shows conflicting results when evaluating the influence of the MC on muscle strength and power performance in thirteen triathletes, with no significant difference observed during the MC [1]. Another study showed no significant difference in muscle strength, fatigue and contractile properties in the different phases of the cycle [4].

The above results may be related to the protocols for determining the phases of the MC, not using blood dosages. In this sense, Janse de Jonge *et al.* [4] emphasize the need to use three methods to verify the phases of the MC: (calendar, increase in luteinizing hormone and serum analysis of estrogen and progesterone).

However, it is important to emphasize that hormonal variations coincide with changes in the central nervous system that can affect aspects of motor performance [2].This is due to the role of the estrogen hormone and its neuroexcitatory effects, being associated with an increase in voluntary activation in the late follicular phase. On the other hand, the increase in progesterone leads to an increase in intracortical inhibition and a decrease in voluntary activation [5].

It was observed that fatigue can be influenced by the phase of the MC, since eumenorrheic women presented a longer time until failure in the middle luteal phase when compared to the follicular phase. This longer time may be related to the increase in progesterone concentration [6].

The use and interest in training methods, and especially their effects, have significantly increased. However, studies on training methods are still scarce, particularly for women. These methods manipulate various training variables with the aim of promoting a higher volume of repetitions and increasing metabolic stress [7].

Training variables can be manipulated in different settings to promote desired adaptations [8]. In this sense, strength training methods have been widely studied and applied by physical education professionals, for example: bi-set; tri-set; drop-set among others [9].

GVT has been studied as a method to promote muscle hypertrophy. This method is characterized by its high volume and high intensity of short duration, and can be used with 10 series and 10 repetitions with a short interval, between 30 to 60 seconds. A study that used this method showed that over 6 and 12 weeks of training it was able to promote significant hypertrophy [10,11]. However, it was observed that the adapted format of the same method of 5 series promoted greater hypertrophic increases in men.

The increased interest of the female public in aesthetic aspects promoted by different strength training methods and the understanding of the results promoted in performance in these methods makes it interesting to investigate the different phases of the MC. The literature is scarce when it relates strength training methods and menstrual cycle, nor does it evidence the need to demonstrate what the influence of the different phases of the menstrual cycle is, in strength training methods for women. Thus, we hypothesize that women in the follicular phase will perform better in GVT. Therefore, the objective of this study was to evaluate the strength, training volume and subjective perception of effort of eumenorrheic women who do not use contraceptives using the GVT training method in the late follicular and medium luteal phases.

Methods

Experimental design

A sample size of 8 participants was calculated a priori adopting Cohen's f = 0.35, a power of 80% and an alpha of 5% [12]. Two phases for within-subjects comparison and ten repeated measures using the G*Power 3.1.9.7 software. Expecting a dropout rate of 40%, 14 women were recruited and 5 did not complete the study [13].

The randomized design was not carried out, all participants started the tests from the identification of the first day of the menstrual cycle and the increase in luteinizing hormone (LH), this is the main marker of ovulation and phase change of the cycle. The recruitment of participants was carried out through social networks and personal invitations. All participants were analyzed in both phases of the menstrual cycle.

Nine women (age 25.88 ± 3.13 years; height 1.65 ± 0.05 meters; body mass: late follicular phase: 65.29 ± 16.97 kg; mid-luteal phase: 65.46 ± 17.12 kg; body mass index (BMI): follicular phase: 23.82 ± 5.43 kg/m2; luteal phase: 23.88 ± 5.48 kg/m2). Each participant attended the laboratory five times throughout the MC for the necessary collections. Inclusion criteria: experience in resistance training for at least one year, with a weekly frequency of at least three times a week, who did not use contraceptives. Average menstrual cycle 28.78 ± 0.83 days.

For this study, the following non-inclusion criteria were adopted: women who had any orthopedic problem, were using any type of medication or drink that could influence physical performance in exams, heart rate and that could cause MC.

The exclusion criteria were: women who did not present ovulation (diagnosed by a urine test) and an increase in the hormone progesterone (analyzed by blood).

Participants were instructed not to perform any physical activity 48 hours before the strength test and the GVT protocol. Participants were informed about the benefits and risks of the study before signing the Informed Consent Form (TCLE). All procedures were carried out in accordance with the National Health Council. The project was approved by the Human Research Ethics Committee of the Federal University of Espírito Santo - CAAE:14250719.0.0000.5542.

Determining the concentration of estrogen, progesterone, and ovulation test:

Sample and blood analysis

Blood samples were obtained from the antecubital vein in Vacuette brand tubes with a separator gel (manufacturer Greiner Bio One). It was collected by a professional trained for this function. A collection of 5 ml was made to analyze the hormones estrogen and progesterone. These samples were centrifuged at 3,500 rpm for 15 minutes at 8 degrees Celsius.

Estrogen and progesterone hormones

The blood collection to identify the hormones estrogen and progesterone was carried out on the day of the GVT protocol, in both phases of the MC. The method used was the Atellica assay, which is a competitive immunoassay that uses direct chemiluminescent technology [4].

Ovulation test

To accurately characterize the phases of the MC and whether the participants ovulated, the Clearblue Digital ovulation test was used (the brand belongs to Swiss Precision Diagnostics GmbH (SPD) located in Geneva, Switzerland, 2007). This detects the increase in luteinizing hormone (LH) in urine. This test was started as soon as the participant noticed an increase in vaginal secretion and by the Flo flem® mobile app, this procedure was monitored for at least 4 days. During this monitoring, the following procedures were guided and adopted by the participant: take the test upon waking up and use the urine flow directly, place the tip of the device's absorbent pointing down in the urine flow for 5 to 7 seconds. As soon as the instrument showed positive ovulation detection, subsequent experimental procedures were adjusted [4]. (Figure 1).
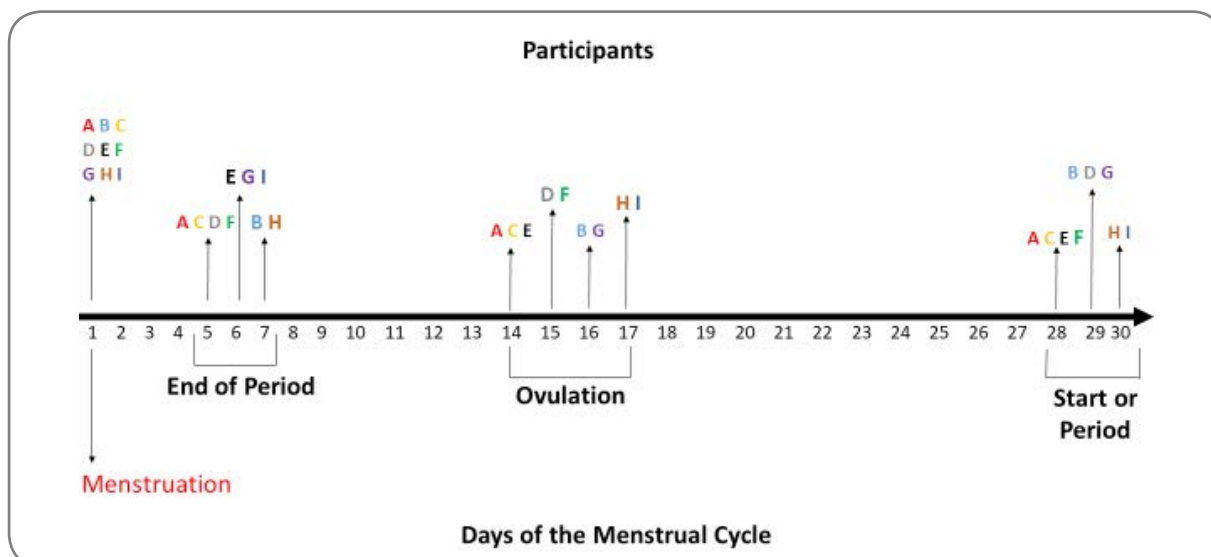
Figure 1 - The numbers represent the days of the menstrual cycle and the letters represent each participant. (Participant 1 = A; participant 2 = B; participant 3 = C; participant 4 = D; participant 5 = E; participant 6 = F; participant 7 = G; participant 8 = H; participant 9 = I)

Familiarization

The familiarization session with the 45° Leg Press device took place on the first visit and three sets of ten repetitions were performed with a 1-minute interval between each set without the addition of load.

1 Repetition Maximum (1RM) Test

The participants were asked about the load they used to perform ten maximum repetitions on the 45° Leg Press device. After the answer, the load referring to 1RM was estimated [14]. From this, 50% and 80% of the estimated maximum load was determined. A measure of 90º of knee flexion was performed with a goniometer. The participants were instructed to perform knee flexion up to the determined angle. The participants performed the warm-up on the 45° Leg Press device, being two sets: one set of 10 repetitions with 50% of the estimated load and a recovery interval of two minutes. The second set was performed with 80% of the estimated maximum load.

1 Repetition Maximum (1RM) Test Protocol

Five attempts were used to establish the maximum load. A recovery interval of five minutes was established between each set. The progression of the load, if necessary, respected the quality of movement, the feedback from the volunteers about the condition to do one or more repetitions with the load imposed by the OMNI-RES PSE. The load was increased by 20% if the participant mentioned a subjective perception below five (OMNI-RES). If the value was higher, the load was increased by 10% [14]. The highest load obtained in the five attempts was defined as 100% of the maximum load. After 48 hours, a retest was performed. These collections were carried out in the late follicular phase and in the middle luteal phase.

German Volume Training – Warm Up

The series of 10 repetitions was performed with 50% of the load obtained in the 1 RM test. A 60-second interval was given from the warm-up to the start of the protocol.

German Volume Training – Protocol

Ten series were performed until concentric failure with a one-minute interval between each series using 80% of 1RM. At the end of each series, the PSE and the number of repetitions were noted. The volume of each series (number of repetitions * number of series * load (kg)) and the total volume of the session (total number of repetitions * total number of series * load (kg)) were calculated. These collections were carried out in the late follicular phase and in the middle luteal phase.

Rating of Perceived Exertion (RPE) Scale

The Omni-RES scale was used to assess the subjective perception of effort at the end of each set [14].

Statistical analysis

The data are presented as mean ± standard deviation. The Shapiro Wilk normality test was performed. In addition, as normality was observed among the data, the following analyses were carried out: a two-way analysis of variance (ANOVA) with a repetition factor was used, which evaluated the effect of the interaction on the following variables: Volume (number of repetitions * load) per set, and subjective perception of effort. The Tukey post-test was adopted to identify differences between the phases of the menstrual cycle and between moments (sets). For the total volume variables and concentration of the hormones estrogen and progesterone, the Student's t-test for paired samples was applied. The intra-class correlation index (ICC) was calculated for the 1RM retest. A significance level of $p < 0.05$ was considered. The program used for static analysis was GraphPad Prism (8.4.3).

Results

The 1RM results showed a load of 174.67 ± 53.89 kg in the luteal phase, which was significantly higher ($p = 0.0065$) compared to the follicular phase (167.67 ± 48.74 kg). Therefore, with the aim of confirming the reproducibility of the test, an analysis of the intra-class correlation coefficient (ICC = 0.98; excellent) was carried out.

No significant interaction effect between time and menstrual cycle phases was observed on volume per series. There was a significant difference between series 1, 2 of both follicular and luteal phases compared to series 4, 5, 6, 7, 8, 9, and 10 in the same phases ($p < 0.05$) (Figure 2).

There was no significant difference in the total volume of the training session between menstrual cycle phases ($p = 0.5353$) (Figure 3).
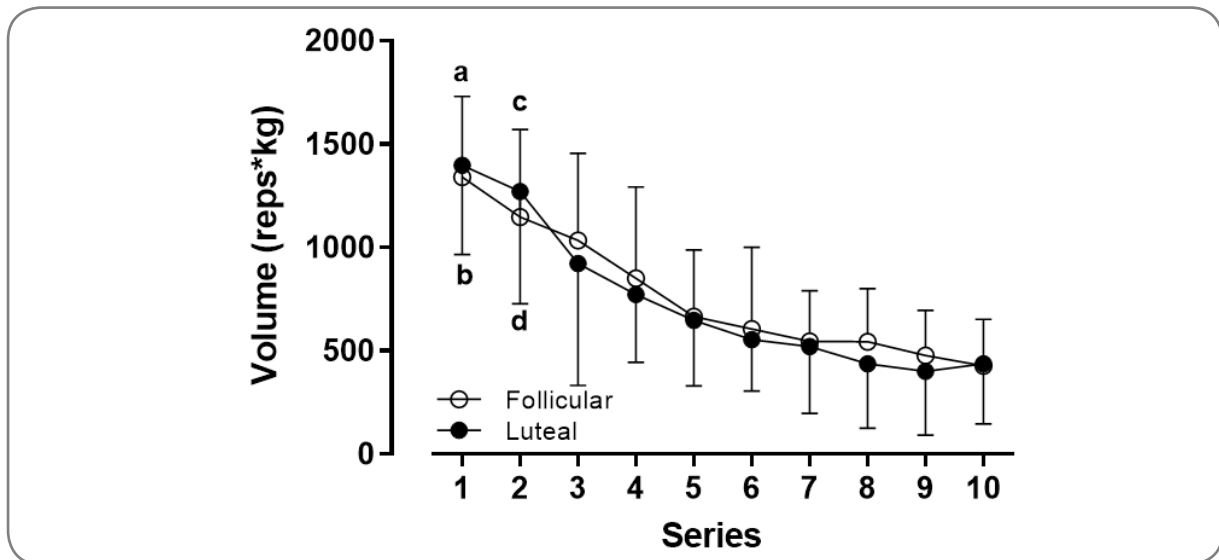
The numbers from 1 to 10 correspond to the training sets. The letter (a) shows a statistical difference in the time of set 1 (follicular phase) in relation to sets 5 to 10 (follicular phase). The letter (b) shows a statistical difference in the time of set 2 (luteal phase) in relation to sets 4 to 10 (luteal phase). The letter © shows a statistical difference in the time of set 2 (follicular phase) in relation to sets 7 to 10 (follicular phase). The letter (d) shows a statistical difference in the time of set 2 (luteal phase) in relation to sets 5 to 10 of the same phase.
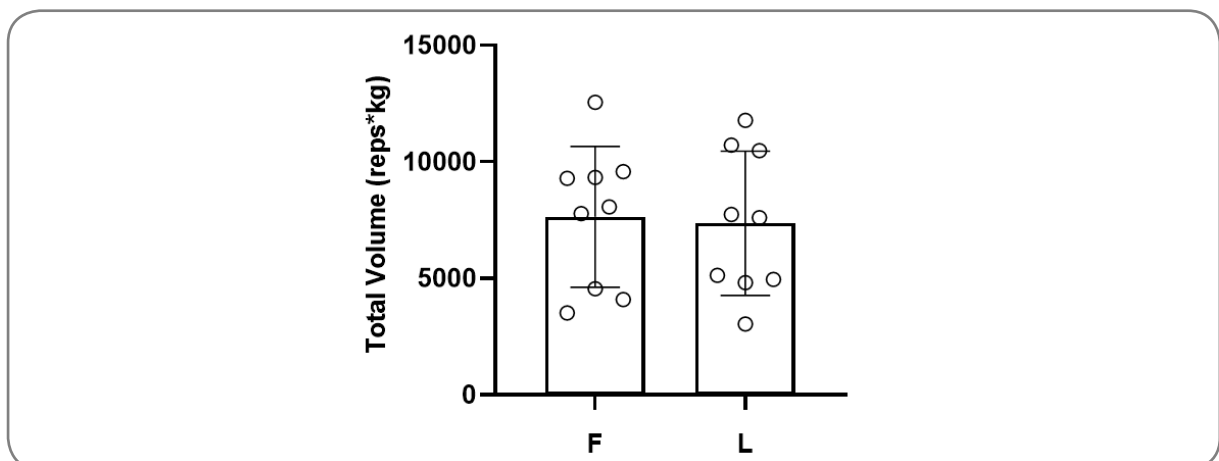**Figure 2 -** Volume (number of repetitions * load) per set

Figure 3 - Total training volume (Number of repetitions x number of sets x load (kg)) F= phase follicular and L= phase luteal

There was no significant interaction effect between time and menstrual cycle phases on the subjective perception of effort. There was a significant difference between series 1 in the follicular phase compared to series 3 to 10 in the same phase. In the luteal phase, there was a significant difference ($p = 0.05$) between series 1 and series 2 to 10 in the respective phase. Additionally, series 2 in the follicular phase showed a significant difference compared to series 6 to 10 in the respective phase ($p < 0.05$) (Figure 4).

The concentration of the hormone progesterone was significantly higher ($p = 0.0001$) during the luteal phase. There was no significant difference in estrogen concentration ($p > 0.05$) (Figure 5).
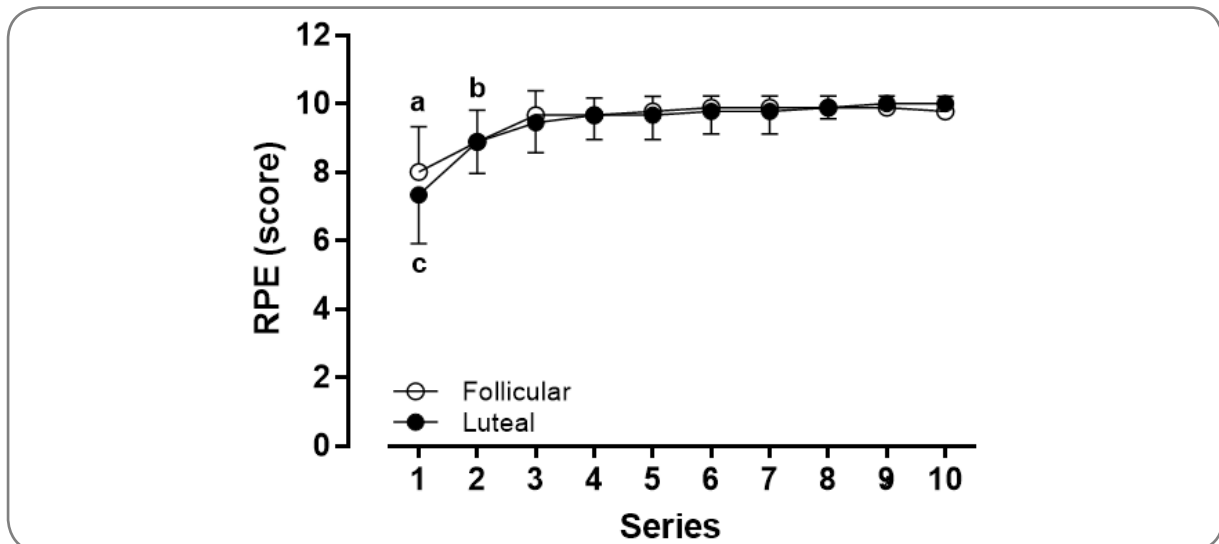
The numbers correspond to the training sets. The letter (a) shows a statistical difference in the time of set 1 (follicular phase) in relation to sets 3 to 10 (follicular phase). The letter (b) shows a statistical difference in the time of set 2 (follicular phase) in relation to sets 6 to 9 (follicular phase). The letter (c) shows a statistical difference in the time of set 1 (luteal phase) in relation to sets 2 to 10 (luteal phase)
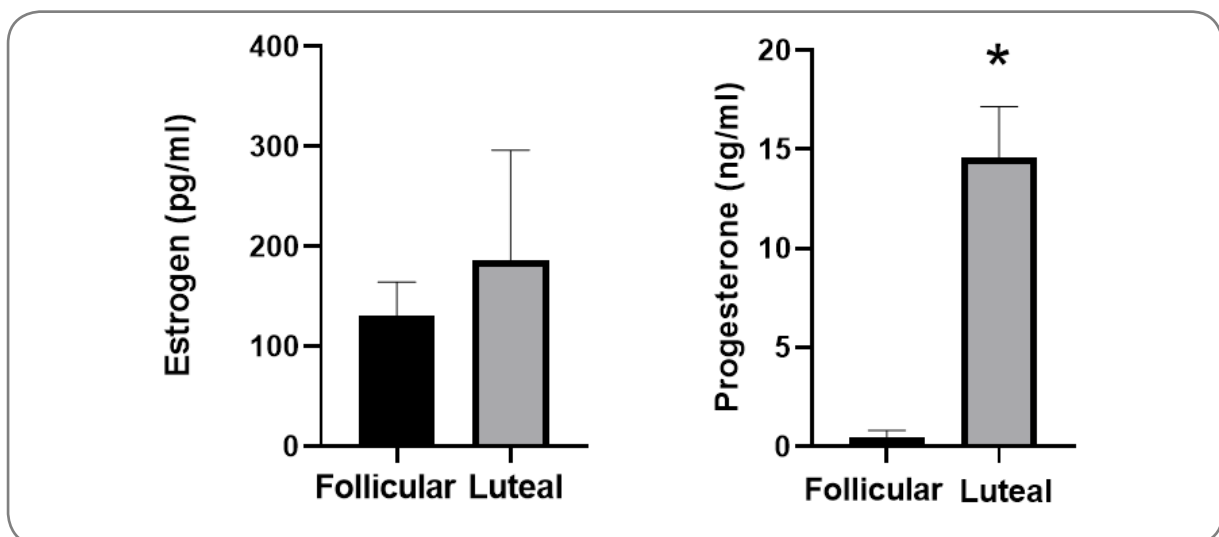**Figure 4 -** Resultado da Avaliação da Percepção Subjetiva de Esforço (PSE)

Figure 5 - Result of blood concentration of estrogen and progesterone hormones. *statistical difference compared to the follicular phase

Discussion

The present study evaluated the strength levels and performance of eumenorrheic women in the 1RM test and GVT during different phases of the menstrual cycle (MC). The results demonstrated a higher load in the 1RM test during the luteal phase compared to the follicular phase. No significant differences were observed between the MC phases in the following variables: number of repetitions, total volume, and subjective perception of effort.

A study assessed isometric strength, fatigue, and contractile properties of skeletal muscle in different phases of the MC in women not using oral contraceptives. The knee extensor and flexor strength were evaluated using isokinetic testing. The results showed no difference between the MC phases [4].

Interestingly, the body of scientific evidence that evaluates muscle function uses isokinetic dynamometers as the gold standard. However, it is necessary to explore the weightlifting machines used in the gym and the prescription of resistance training, taking into account the phases of the MC. In this sense, a study conducted by Simão et al. [3] evaluated the performance of eumenorrheic women without contraceptive use in the 8RM test during the mid-follicular, late-follicular, mid-luteal, and menstrual day phases, applied to the Leg Press and Front Lat Pulldown exercises. The load used was statistically lower during the menstrual phase compared to the other three phases. On the other hand, no statistical difference was observed in the Front Lat Pulldown exercise. Another study by Loureiro et al. [15] analyzed the effect of different MC phases on the performance of women using contraceptive methods. In this study, the 10RM test was used in the following periods: (first to seventh day after menstruation), (eighth to 14th day after menstruation), and (15th to 28th day). The different periods did not affect performance. A limitation of the studies conducted by Simão et al. [3] and Loureiro et al. [15] is that the MC phases were determined by the calendar method, which disregards possible hormonal variations and their effects in each phase of the MC.

The present study evaluated maximal strength in the follicular and luteal phases to establish the load to be used in GVT. The load achieved during the luteal phase (174.67 ± 53.89 kg) was statistically higher compared to the follicular phase (167.67 ± 48.74 kg). This difference may be due to the learning effect promoted by the execution of the protocols. Additionally, the hormonal characteristics of the periods are different.

Estrogen is increased during the luteal phase compared to the follicular phase [4,16] suggesting that estrogen can increase muscle strength. However, during the luteal phase, muscle strength may decrease due to the effect of increased progesterone inhibiting the effects of estrogen. It is important to mention that Sarwar et al. [16] is based on a study where hormonal concentrations were not measured, which can lead to misinterpretations.

Furthermore, a mechanism that can explain these findings is that the estrogen hormone is more anabolic, favoring higher circulating levels of growth hormone (GH), greater protein synthesis, recovery, and muscle regeneration. On the other hand, progesterone has an antagonistic role to estrogen, being known as a catabolic hormone [1,17].

As suggested by Janse de Jonge et al. [4], our study used three control methods to define the cycle phases: calendar counting, luteinizing hormone increase, and estrogen and progesterone measurements. Therefore, the results of the present study contradict Sarwar et al.'s hypothesis [16].

When analyzing the participants' performance in GVT, no statistical difference was observed between the MC phases in the variables of number of repetitions, total volume, and subjective perception of effort. Interestingly, a higher total volume was observed in the follicular phase compared to the luteal phase, although not significantly different.

In this regard, the GVT method has been studied in men chronically, focusing on increasing strength and muscle hypertrophy [10,11]. Evidence shows that 6 and 12 weeks of GVT lead to increased strength and hypertrophy. The mentioned study conducted two protocols: the traditional GVT (10 sets of 10 repetitions with 60 seconds of rest) and the adapted GVT (5 sets of 10 repetitions with 60 seconds of rest). The adapted training resulted in greater strength and hypertrophy gains compared to the group that performed traditional GVT. Both studies used a load of 60% 1RM. Despite these results, the literature is still scarce regarding the use of high-volume and high-intensity strength training methods, such as GVT, in women [10,11].

The only study that assessed women's performance in GVT investigated the supplementation of citrulline malate on performance in this method. The load corresponding to 80% 1RM was used, with 10 sets of 10 repetitions and a 60-second rest interval in the barbell curl exercise. However, the study included both men (n = 12) and women (n = 7), and it is not mentioned in which phase of the MC the women were, thus not allowing a correct interpretation of the findings. Moreover, the results are not stratified by sex, combining men and women [18].

Therefore, there is a need to establish the relationship between hormonal fluctuations in different phases and the performance of trained women in resistance training. Once these relationships are established, the training prescription becomes more specific and efficient. As a limitation, the participants in our research had different training durations, which can influence their ability to perform more intense and voluminous high-intensity methods. In this study, it was observed that 66.7% of the participants had been practicing weightlifting for at least 2 years. The remaining participants (33.3%) had one to two years of experience.

Another relevant aspect concerns the learning effect in the 1RM test. Despite the data showing a high ICC, the fact that the participants did not report experience with the test may have influenced these results. Future studies should be conducted with a larger number of participants. Additionally, attention should also be focused on other resistence training methods, different variations, as well as the possible influences of the MC on the hypertrophy process.

Conclusion

The phase of the menstrual cycle does not affect performance in GVT in eumenorrheic women without contraceptive use. However, there was an increase in strength during the luteal phase compared to the follicular phase.

Knowing that the phase of the menstrual cycle does not affect performance in German training (a method of high volume, intensity, and short duration strength training), professionals in the field of resistance training can use this knowledge when prescribing for this group of women. Therefore, the use of strength training methods can be another tool for planning for this audience that is increasingly seeking these training methods to improve performance and aesthetics.

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