Motricidade
2020, vol. **16**, n. **2**, pp. **176-183**

http://dx.doi.org/10.6063/motricidade.18181

Menstrual cycle and use of different doses of oral contraceptive do not affect torque parameters in strength training programs

Manoela Sousa [1,2,3*], Rodolfo Dellagrana [1,4], Morgana Lunardi [1], Mateus Rossato [1,5], Laís Hoinaski [1], Caroline Bento [1], Cíntia Freitas [1]

ORIGINAL ARTICLE

ABSTRACT

The aim of this study was twofold: (a) to verify the effects of different periods of Menstrual Cycle (MC) (menstrual and non-menstrual) of women who use (users) or did not use (non-users) oral contraceptive (OC); (b) to compare the influence of the use of different doses of OCs at these MC moments. Two groups, women who did not use OC (NCG = 13) and women who use OC (CG = 13). The participants were assessed on the 1st or 2nd day of their menstrual period and the 14th or 15th day post-menstrual period. The Peak Torque (PT) and work (W) variables were evaluated at all MC moments. To compare the estrogen dosage, CG was subdivided into two subgroups, (ULCG = 6) that used ultra-low doses of estrogen and a group (LCG = 7) that used low. No interaction (group x period) was observed for $PT_{isometric}$ (F=0.170, p=0.687), $PT_{concentric}$ (F=0.495, p=0.495) and $PT_{eccentric}$ (F=0.348, p=0.566), $W_{concentric}$ (F=0.001, p=0.971) and $W_{eccentric}$ (F=0.075, p=0.790). In addition, no significant interactions (dose x period) were observed in the torque parameters between women who used OC at different estrogen dosages ($PT_{isometric}$: F=0.803, p=0.411; $PT_{concentric}$: F=0.548, p=0.492; $PT_{eccentric}$: F=0.239, p=0.645; $W_{concentric}$: F=0.030, p=0.869, $W_{eccentric}$: F=0.027, p=0.876). In conclusion, using or not using OC seems to have no effect on torque parameters at the different moments of MC. Furthermore, the different doses of the OCs did not seem to promote effects on torque and work during MC.

Keywords: Women, Contraceptive, torque, Resistance training.

INTRODUCTION

The menstrual cycle (MC) of eumenorrheic women, from the physiological standpoint, can be divided into the follicular, ovulatory, and luteal phases (Constantini, Dubnov, & Lebrun, 2005; Frankovich & Lebrun, 2000). Each one of the phases is marked by a fluctuation in the secretion of estrogen, progesterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH) (Constantini, Dubnov, & Lebrun, 2005; Frankovich & Lebrun, 2000). However, from a practical standpoint, the MC can be divided into the menstrual phase (follicular phase) and post-menstrual phase (ovulatory and luteal phases). Going through the different phases of the MC seems to negatively influence a significant percentage of women regarding their circadian rhythm and sleep quality (Baker & Lee, 2018), psychic parameters such as irritability, perception of fatigue and pain, depression (Nogueira et al., 2000) as well as their physical performance (Lebrun, 1993).

Evaluating neuromuscular parameters in different phases of the MC has been the object of several studies over the last few decades (Frankovich & Lebrun, 2000; Fridén, Hirschberg, & Saartok, 2003; Fischetto & Sax 2013; Janse de Jonge et al., 2001; Tsampoukos et al., 2010; Simão et al., 2007). Despite this effort, the results remain inconclusive. While some authors

Manuscript received at June 29th 2019; Accepted at November 21st 2019

[1] *Federal University of Santa Catarina. Brazil.*
[2] *Center of Research, Education, Innovation and intervention in Sport, Faculty of Sport, University of Porto, Portugal.*
[3] *Porto Biomechanics Laboratory, University of Porto, Portugal.*
[4] *Graduate Program in Movement Sciences, Federal University of Mato Grosso do Sul, Brazil.*
[5] *Faculty of Physical Education and Physiotherapy of Federal University of Amazonas, Brazil.*
* *Corresponding author*: Porto Biomechanics Laboratory, University of Porto – LABIOMEP. Porto, Portugal. Pólo Universitário. *Email:* manoelavsousa@gmail.com

(Pallavi, Urban, & Shivaprakash, 2017; Phillips et al., 1996) report a greater capacity of force production during the menstrual phase, others (Petralia & Gallup, 2002; Phillips et al., 1996; Sarway, Niclos, & Rutherford 1996;) affirm that the greatest force production occurs during the post-menstrual phase. In addition, a number of studies did not show significant differences in strength levels in the different phases of the MC (Constantini, Dubnov, & Lebrun, 2005; Elliot, Caple, & Relly 2005; Fridén, Hirschberg, & Saartok 2003; Hertel et al., 2006; Janse de Jonge, 2003). The methodological difficulties in evaluating the true maximum strength, as well as the age, training level, and the use or not of oral contraceptives (OCs) have been pointed out as some of the factors responsible for these inconclusions (Janse de Jonge, 2003).

As a way to regularize the menstrual cycle, in addition to preventing pregnancy and diseases related to the female reproductive system, many women use contraceptives or oral contraceptives (Brunton, Chabner, & knollmann, 2012). The OCs cause the MC to last 28 days by controlling the endogenous concentrations of sex hormones. In addition, contrary to what was observed for the different phases of the MC, the literature indicates that the use of single-phase OCs does not seem to affect the production of muscular force (Elliot, Caple, & Relly 2005; Ekenros et al., 2013; Nichols et al.,2008; Peter & Burrows, 2006) when compared to women who do not make use of OCs. To the best of our knowledge, no studies have been associated the effect of different dosages of estrogen present in OCs.

Several studies have suggested the estrogens may influence muscle hypertrophy (see Knowles et al., 2019). Authors have found in post-menopausal an increase in the muscle mass due to the increased estrogen (Knowles et al., 2019). Therefore, physiologically, it can be assumed that during high estrogen concentration, women have an increase in force production. Specifically, when bound to its receptors, the estrogen can upregulate intracellular signaling pathways that stimulate skeletal muscle protein synthesis, such as Akt/mechanistic target and rapamycin pathway (mTOR) (Knowles et al., 2019). In addition, estrogen can play a role in muscle repair and regeneration through the activation and proliferation of satellite cells (Kitajima & Ono, 2016). Women who use CO estrogen levels are lower when compared to non-users. Thus, differences in concentrations between users and non-users and the possible influence of estrogen on strength may explain possible differences in strength performance between MC phases and women.

Therefore, it is known that training, planning, and periodization (i.e., volume, intensity, and frequency) are necessary for strength gains (i.e., muscle hypertrophy and increase of muscle mass). Thus, understanding the effects of the MC and the use and non-use of OCs is relevant to potentialize the results in women who practice ST. Thus, the purposes of this study were (a) to verify the effects of different periods of the MC (menstrual and non-menstrual) of women who use or do not use OCs and (b) to compare the influence of the use of different doses of OCs on MC periods (menstrual and non-menstrual). The present study hypothesized that women who did not use OCs would present higher values for torque parameters during the non-menstrual period, whereas women who used OCs would not present such difference, due to having a more controlled MC. On the other hand, women using OCs with lower dosages would present higher values on the parameters evaluated in the study, compared to women taking OCs with higher

METHOD

Participants

All ethical procedures were approved by the institution where the study was carried out (CAEE: 2.143.652). All volunteers that agreed to participate signed the informed consent statement. Thus, twenty-six women took part in this study and were divided into two groups: women who did not use OCs (NCG = 13) and women who did use OCs (CG = 13). The selection of the subjects was of the non-probabilistic intentional type, and the number of participants was based on previous studies regarding the same subject (Drake et al., 2003; Elliot, Caple, & Relly, 2005; Fridén, Hirschberg, & Saartok, 2003; Janse de Jonge et al., 2001; Sung et al., 2014). The inclusion criteria were: a) age between 20 and 30 years; b) experience in strength training of at least 1 year; c) weekly training frequency of at least 3 times; d) absence of any kind of musculoskeletal impairment; e) not making use of food supplements. In addition, to be a part of the NCG, participants would have to have two regular consecutive menstrual cycles between 21 and 35 days and not make use of OCs for at least 6 months. To be a part of the CG, women should be using OCs for at least 6 months and combined OCs (estrogen and progesterone) with a pause of 4 or 7 days. Subsequently, the CG was subdivided into 2 subgroups: a group that used OCs with daily doses of 15 and 20mcg of estrogen, considered ultra-low doses (ULCG = 6) and the group that used OCs with daily doses of up to 35mcg of estrogen, considered low doses (LCG = 7) (Petiti, 2003; WHO, 2015).

Instruments and Procedures

This study used a quasi-experimental design with a control group. Participants were assessed randomly; some performed the tests on the 1st or 2nd day of their menstrual period and others on the 14th or 15th day after their menstrual period. All participants were instructed to avoid physical efforts within 48 hours prior to data collection, as well as to avoid alcohol and caffeine use. Prior to the tests, the participants took part in a familiarization procedure with the left limb (not evaluated). Considering that the participants' hormonal concentrations were not measured in order to define precisely the periods of the menstrual cycle, we chose to use the "menstrual" and "non-menstrual" periods, respectively. The order of the periods was defined in a randomized fashion. The identification of the date on which the first day of the menstrual period would begin was obtained through a questionnaire applied during the four months prior to the beginning of the evaluations.

Anthropometric Evaluation

The anthropometric evaluation (height, body mass, and BF%) was carried out during the non-menstrual period with all the women. A professional stadiometer (Sani®, Sao Paulo, Brazil) and a digital scale (Pharo® 200, Soehne-Germany) were used to evaluate stature and body mass, respectively. The participants' body density was calculated according to the Pollock and Jackson (1978) equation, which involves 8 skinfolds (subscapular, triceps, biceps, crista-iliac, supraspinal, abdominal, thigh and calf). The skinfolds were evaluated using a scientific compass of the brand Cercorf®, model *Innovare 4*. All the procedures used for the anthropometric evaluation were in accordance with the International Society for the Advancement of Kinanthropometry (Marfell-Jones, Stewart, & de Ridder, 2012). The body fat percentage was measured by using the Siri equation (Siri, 1961).

Evaluation of the torque parameters

All participants, both in the menstrual and non-menstrual periods, had their isometric ($PT_{isometric}$), concentric ($PT_{concentric}$) and eccentric ($PT_{eccentric}$) peak torques, and the concentric ($W_{concentric}$) and eccentric ($W_{eccentric}$) works of right knee extensors ($\sum$ of the work of the 5 contractions) measured by an isokinetic dynamometer (Biodex Medical Systems 4, Shirley, NY, USA). The evaluation protocol (Figure 1) consisted of: a) warm-up (10 concentric submaximal contractions at 120°/s); b) 2 maximal isometric voluntary contractions for the determination of the isometric peak torque (5s duration with the knee positioned at 70° of flexion, considering 0° to be the full extension); c) 5 maximum contractions in concentric-eccentric mode [amplitude of 70° (30° - 100° of flexion, where 0° was the total extension) and speed of 60°/s]. Between all stages of the evaluation, the recovery interval was of 60s. All data were collected at a frequency of 100Hz and filtered directly by the Biodex Advantage software. Lastly, all values were normalized by body mass.

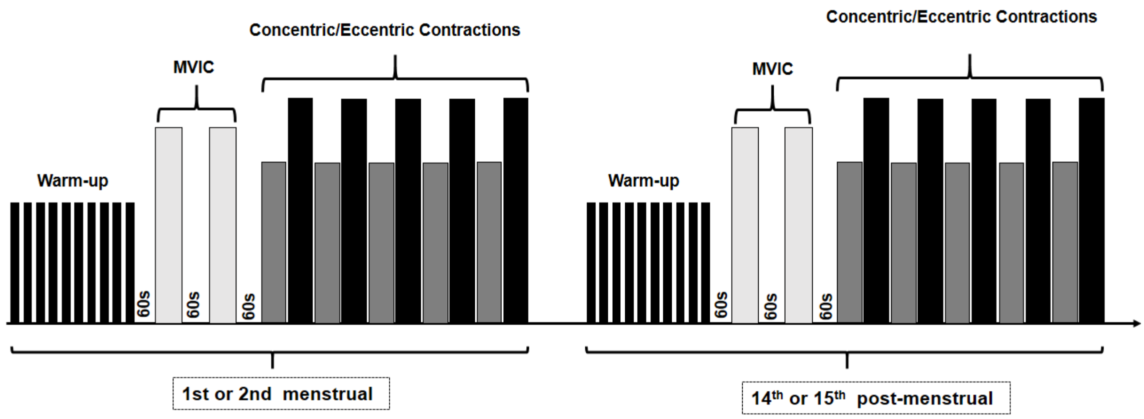

Figure 1. Experimental protocol performed during periods of the menstrual cycle.

Statistical Analysis

The presentation of the results was made through descriptive statistics (means and standard deviations). Testing of data normality was carried out using the Shapiro-Wilk test. The comparison between groups for the anthropometric data was performed using the t-student test for independent samples. A mixed model [groups (NCG and CG) and periods (menstrual and non-menstrual)] analysis of variance (ANOVA) was used to compare torque parameters (PT and W). In order to evaluate the subgroups (ULCG and LCG), the mixed model analysis of variance (ANOVA) [doses (ultra-low estrogen dose and low estrogen dose) and periods (menstrual and non-menstrual)] was used to compare the torque parameters (PT and W). In the case of significant differences, the Bonferroni post hoc test was used. The G*Power 3.1.7 software (University of Kiel, Kiel, Germany) was used to calculate the effect size (ES) by partial eta (η^2) of ANOVA and determine the power of analysis. A significance level of 5% ($p<0.05$) was adopted for all tests, and the software used was the SPSS, version 18.0.

RESULTS

No significant differences were found between the NCG and CG groups for characterization variables (Table 1).

Table 2 presents the values of PT and W for the NCG and the CG. No interactions were found between the groups and the periods (F= 0.170, p= 0.687, ES= 0.119, observed power= 0.502) for the $PT_{Isometric}$. Furthermore, there was no significant difference between the groups (F= 0.335, p= 0.574, ES= 0.166, observed power= 0.510) and periods (F= 3.043, p= 0.107, ES= 0.503, observed power= 0.839). Regarding the $PT_{concentric}$, no interactions were found (F= 0.495, p= 0.495, ES= 0.204, observed power=0.523), as well as no differences between the groups (F= 1.396, p= 0.260, ES= 0.340, observed power= 0.637) and periods (F= 0.547, p= 0.474, ES= 0.214, observed power= 0.528). Also, for the $PT_{eccentric}$ there were no interactions (F= 0.348, p= 0.566, ES= 0.169, observed power= 0.511), and no differences were found for the groups (F= 0.218, p= 0.649, ES= 0.135, observed power= 0.504) and periods (F= 0.005, p= 0.944, ES= 0.031, observed power= 0.500). Regarding the $W_{concentric}$ and the $W_{eccentric}$, no interactions were observed (F= 0.001, p= 0.971, ES= 0.031, observed power= 0.500; F= 0.075, p= 0.790, ES= 0.077, observed power= 0.500) and there was also no difference between the groups (F= 0.240, p= 0.147, ES= 0.447, observed power= 0.774; F= 0.131, p= 0.723, ES= 0.105, observed power= 0.501) and the periods (F= 1.027, p= 0.331, ES= 0.291, observed power= 0.585; F= 0.272, p= 0.611, ES= 0.149, observed power= 0.507), respectively.

Table 1

Characterization of the participants. Group Non-Contraceptive (NCG) and Group Contraceptive (CG) (n = 26).

	NCG	CG	p-value
Age (years)	24.46 ± 2.8	24.11 ± 3.2	0.77
Practice of Time (years)	4.08 ± 2.2	4.04 ± 1.9	0.96
Body Weight (kg)	59.8 ± 7.5	61.9 ± 4.4	0.42
Height (cm)	162.0 ± 4.9	162.6 ± 6.4	0.83
Body Fat Percentage (%)	21.5 ± 4.5	23.3 ± 4.2	0.29

Table 2

Mean values and standard deviations regarding the isometric ($PT_{Isometric}$), concentric ($PT_{Concentric}$), and eccentric ($PT_{Eccentric}$) peak torques and concentric ($W_{Concentric}$) and eccentric ($W_{Eccentric}$) work for the NCG and the CG in the menstrual and non-menstrual periods.

	NCG		CG	
	Menstrual	Non-menstrual	Menstrual	Non-menstrual
$PT_{Isometric}$ (Nm)	3.34±0.38	3.48±0.38	3.25±0.53	3.33±0.58
$PT_{Concentric}$ (Nm)	2.54±0.35	2.70±0.29	2.47±0.38	2.43±0.42
$PT_{Eccentric}$ (Nm)	3.15±0.48	3.18±0.57	3.36±0.36	3.20±0.67
$W_{Concentric}$ (J)	9.50±1.90	9.94±1.61	8.67±1.97	9.14±1.71
$W_{Eccentric}$ (J)	11.10±3.37	11.70±3.38	11.71±2.60	11.91±3.30

Table 3

Mean values and standard deviations regarding the isometric ($PT_{Isometric}$), concentric ($PT_{Concentric}$) and eccentric ($PT_{Eccentric}$) peak torque and the concentric ($W_{Concentric}$) and eccentric ($W_{Eccentric}$) work for the ultra-low contraceptive group (ULCG) and the low contraceptive group (LCG) in the menstrual and non-menstrual periods.

	ULCG		LCG	
	Menstrual	Non-menstrual	Menstrual	Non-menstrual
$PT_{Isometric}$ (Nm)	3.43 ± 0.61	3.38 ± 0.50	3.13 ± 0.50	3.28 ± 0.68
$PT_{Concentric}$ (Nm)	2.73 ± 0.25	2.66 ± 0.41	2.26 ± 0.33	2.31 ± 0.40
$PT_{Eccentric}$ (Nm)	3.48 ± 0.29	3.33 ± 0.79	3.30 ± 0.42	3.25 ± 0.70
$W_{Concentric}$ (J)	9.11 ± 2.27	9.62 ± 1.77	8.30 ± 1.76	8.72 ± 1.68
$W_{Eccentric}$ (J)	11.42 ±1.81	11.36 ± 4.04	11.95 ± 3.33	12.39 ± 2.77

Table 3 presents the analysis that took into account the different daily dosages of estrogen present in the OCs (ultra-low *vs.* low). For the $PT_{Isometric}$ no interactions were reported between the groups and the periods (F= 0.803, p= 0.411, ES= 0.400, observed power= 0.620). Furthermore, no significant differences were found between the groups (F= 0.164, p= 0.702, ES= 0.181, observed power= 0.507) and the periods (F= 0.257, p= 0.634, ES= 0.226, observed power= 0.517). Similar results were also observed for the $PT_{concentric,}$ in which no interactions were found (F= 0.548, p= 0.492, ES= 0.331, observed power= 0.567), as well as no differences between groups (F= 4.890, p= 0.780, ES= 0.988, observed power= 0.973) and periods (F= 0.006, p= 0.940, ES= 0.031, observed power= 0.500). Also, for the $PT_{exccentric}$, there were no interactions (F= 0.239, p= 0.645, ES= 0.219, observed power= 0.515), as well as for the groups (F= 0.014, p= 0.910, ES= 0.054, observed power= 0.500) and periods (F= 0.169, p= 0.698, ES= 0.184, observed power= 0.508). Regarding the $W_{concenrtric}$ and the $W_{eccentric}$, no interactions were observed (F= 0.030, p= 0.869, ES= 0.077, observed power= 0.500; F= 0.027, p= 0.876, ES= 0.070, observed power= 0.500), as well as no differences between the groups (F= 0.335, p= 0.588, ES= 0.259, observed power= 0.528; F= 0.352, p= 0.579, ES= 0.265, observed power= 0.531) and periods (F= 4.015, p= 0.101, ES= 0.895, observed power= 0.956; F= 0.004, p= 0.954, ES= 0.184, observed power= 0.500), respectively.

DISCUSSION

The results of the present study indicated that the use or no use of OCs seem to have no effect on the torque parameters on different MC periods. In addition, the use of different dosages of estrogen (ultra-low vs. low) does not seem to promote effects on peak torque and work values during the different MC periods. Thus, the novelty of this study is that MC period and use of

OC did not affect the torque parameters in trained women.

We observed that when groups and periods of MC were compared (Table 2), no significant differences were found in the torque parameters (peak torque and work). For women who do not use OCs, some authors (Constantini, Dubnov, & Lebrun, 2005; Pallavi, Urban, & Shivaprakash, 2017; Rechichi, Dawson & Goodman, 2008; Sung et al., 2014) affirm that during the non-menstrual period, due to the estrogen concentrations being higher, the capacity of force production would be increased (Simão et al., 2007). However, in the present study, no differences were observed between MC periods for women who did not use OCs. Therefore, it seems that hormonal variations during the MC are not capable of affecting muscle strength levels. When we take into account the use of OCs, our results corroborate those of Janse de Jonge et al. (2001), considering that these authors also did not observe variations in strength and contractile properties of the muscle in women who do not use OCs in different periods of MC. It is believed that the results found may be associated with the level of training of the women evaluated, that is, women who can be considered active (see Table 1) and, therefore, the hormonal variations of MC are not able to affect the torque parameters in women with plenty of strength training practice time.

It is well reported in the literature that the use of OCs regulates the menstrual cycle to 28 days, attenuating the estrogen peak, making it more stable (Bell et al., 2011; Burrows & Peter, 2007; Petiti, 2003; Rechichi, Dawson, & Goodman, 2008). Based on this, it was expected that the use of the synthetic hormone did not affect the ability to produce force, and in the present study, no differences in torque were found at any point in the MC for women who used OCs. These results corroborate with Sawar, Niclos, and Rutherford (1996), who did not find significant differences in strength production in the different stages of the MC for women who used OCs. Therefore, it is believed that the results found can be justified, due to the fact that the OC regulates the MC, which results in stable hormonal concentrations that consequently do not affect the torque parameters. In addition, the group of OC users was also considered well trained, which may further justify such findings.

Although the constant hormone dosage of estrogen promoted by the use of OCs can level the force production in the different periods of MC, the influence of different dosages of OCs is not known. According to Freitas et al. (2011), OCs with lower dosages of estrogen may have lower MC control, closer to the MC of women who do not use OCs. Thus, the hypothesis was that women using OCs with ultra-low dosages (daily estrogen dose between 15 and 20 mcg) would present higher values in the torque parameters when compared to women who used OCs with a low dosage of estrogen daily up to 35mcg). However, this hypothesis was rejected, since there were no differences in PT and work between users of ultra-low and low dosage OCs.

No studies demonstrating the effects of different dosages of estrogen on OCs on the ability to produce force have been observed in the literature. Future researches on the effects of different dosages of estrogen present in OCs on the production of strength are extremely important for women who practice resistance exercises, especially since it is the most used contraceptive method Farias et al. (2016), and also because it is a method that presents several brands with different dosages of estrogen (Elliott-Sale et al., 2013).

In the present study, the MC and the use and non-use of OCs did not influence the results, so it is clear that the fluctuations of the female hormones do not affect the capacity of trained women, and thus, the planning and periodization of the training can be executed regardless of MC periods and the use or no use of OCs. The lack of hormonal monitoring for the identification of MC phases, lack of homogenization regarding OC brands, and the small sample size can be considered limitations of the present study. However, regarding the positive aspects of the present study, randomization, quality of torque measurements (isokinetic dynamometry), homogeneity of groups in relation to the experience with strength training, and the investigation of different dosages of estrogen present in OCs should be highlighted.

CONCLUSION

Based on the results, our conclusion is that either the use or no use of OCs does not affect the torque parameters in different periods of the MC (menstrual and non-menstrual). In addition, the use of OCs with ultra-low or low estrogen dosages seems not to affect the torque parameters. However, future research could verify whether the results found in the present study are confirmed using hormonal monitoring to identify the MC period, as well as increase the sample size (women trained).

Acknowledgments:
Nothing to declare.

Conflict of interests:
Nothing to declare.

Funding:
This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 1.

REFERENCES

Baker, F. C., & Lee, K. A. (2018). Menstrual cycle effects on sleep. *Sleep Medical Clinics*, *13*(3), 283-294. doi.org/10.1016/j.jsmc.2018.04.002.

Bell, D. R., Blackburn, J. T., Ondrak, K. S., Hackney, A. C., Hudson, J. D., Norcross, M. F., & Padua, D. (2011). The effects of oral contraceptive use on muscle stiffness across the menstrual cycle. *Clinical Journal of Sport Medicine*, *21*(6), 467–473. doi.org/10.1097/JSM.0b013e318230f50a.

Burrows, M., & Peters, C. E. (2007). The influence of oral contraceptives on athletic performance in female athletes. *Sports Medicine*, *37*(7), 557-574. doi.org/10.2165/00007256-200737070-00001.

Brunton, L. L., Chabner, B. A & knollmann, B. C. (2012). *As bases farmacológicas da terapêutica de Goodman & Giman*. (12th ed). New York: McGraw-Hill.

Constantini, N., Dubnov, G., & Lebrun, M. C. (2005). The menstrual cycle and sport performance. *Clinics in Sports Medicine*, *24*(2), 51-82. doi.org/10.1016/j.csm.2005.01.003.

Drake, S. M., Evetovich, T., Eschbach, C., & Webster, M. (2003). A pilot study on the effect of oral contraceptives on electromyography and mechanomyography during isometric muscle actions. *Journal of Electromyography and Kinesiology*, *13*(3), 297–301. doi.org/10.1016/S1050-641(03)00024-5.

Ekenros, L., Papoutsi, Z., Fridén, C., Wright, D., & Hirschberg, L. (2016). Expression of sex steroid hormone receptors in human skeletal muscle during the menstrual cycle. *Acta Physiological*, *219*(2), 486-93. doi.org/10.1111/apha.12757.

Elliott-Sale, K. J., Smith, S., Bacon, J., Clayton, D., McPhilimery, M., Goutianos, G., … Sale, C. (2013). Examining the role of oral contraceptive users as an experimental and/or control group in athletic performance studies. *Contraception*, *88*(3), 408-412. doi.org/10.1016/j.contraception.2012.11.023.

Elliot, K. J., Caple, N. T., & Relly, T. (2005). Does oral contraceptive use affect maximum force production in women? *British Journal of Sports Medicine*, *39*(1), 15-19. doi.org/10.1136/bjsm.2003.009886.

Farias, M. R., Leitel, S. N., Tavares, N. U. L., Oliveira, M. A., Arrais P. S. D., Bertoldi, A. D., ... Mengue, S. S. (2016). Utilização e acesso a contraceptivos orais e injetáveis no Brasil. *Revista de Saúde Pública*, *50*(2), 14s. doi.org/10.1590/s1518-8787.2016050006176.

Fischetto, G., & Sax, A. (2013). The Menstrual Cycle and Sport Performance. *New Studies in Athletics*, *28*(3/4), 57-69. doi.org/10.1016/j.csm.2005.01.003.

Frankovich, R. J., & Lebrun, M. C. (2000). Menstrual cycle, contraception, and performance. *Clinics in Sports Medicine*, *19*(2), 251-271. doi.org/10.1016/S0278-5919(05)70202-7.

Freitas, F., Rivoire, W., Menke, C. H., & Passos EP. (2011). *Rotinas em ginecologia*. (5th Ed.) Porto Alegre: Artmed, 2011.

Fridén, C., Hirschberg, A. L., & Saartok, T. (2003). Muscle strength and endurance do not significantly vary across 3 phases of the menstrual cycle in moderately active premenopausal women. *Clinical Journal of Sport Medicine*, *13*(4), 238-241. doi.org/10.1097/00042752-200307000-00007.

Hertel, J., Williams, N. I., Olmsted-Kramer, L. C., Leidy, H. J., & Putukian, M. (2006). Neuromuscular performance and knee laxity do not change across the menstrual cycle in female athletes. *Knee Surgery, Sports Traumatology, Arthroscopy*, *14*(9), 817-822. doi.org/10.1007/s00167-006-0047-4.

Janse de Jonge, X. A. K., Boot, C. R. L., Thom, J. M., Ruell, P. A., & Thompson, M. W. (2001). The influence of menstrual cycle phase on skeletal muscle contractile characteristics in humans. *Journal Physiology*, *530*(1), 161-166. doi.org/10.1111/j.1469-7793.2001.0161m.x.

Janse de Jonge, X. A. K. (2003). Effects of the menstrual cycle on exercise performance. *Sports Medicine*, *33*(11), 833-851. doi.org/10.2165/00007256-200333110-00004.

Kitajima, Y.; & Ono, Y. (2016). Estrogens maintain skeletal muscle and satellite cell functions. *Journal of Endocrinology*, *229*(3), 267-275. doi.org/10.1530/joe-15-0476

Knowles, O. E., Aisbett, B., Main, L. C., Drinkwater, E. J., Orellana, L., & Lamon, S. (2019). Resistance Training and Skeletal Muscle Protein Metabolism in Eumenorrheic Females: Implications for Researchers and Practitioners. *Sports Medicine*. 1-14. /doi.org/10.1007/s40279-019-01132-7.

Lebrun, C. M. (1993). Effect of the different phases of the menstrual cycle and oral contraceptives on athletic performance. *Sports Medicine*, *16*(6), 400-30. doi.org/10.2165/00007256-199316060-00005.

Marfell-Jones, M. J., Stewart, A. D., & de Ridder, J. H. (2012). *International standards for anthropometric assessment*. Wellington, New Zealand: International Society for the Advancement of Kinanthropometry.

Nichols, A. W., Hetzler, R. K., Villanueva, R. J., Stickley, C. D. & Kimura, I. F. (2008). Effects of combination oral contraceptives on strength development in women athletes. *Journal of Strength Conditioning Research*, *22*(5), 1625-1632. doi.org/10.1519/JSC.0b013e31817ae1f3.

Nogueira, C. W. M., & Silva, J. L. P. (2000). Prevalência dos sintomas da síndrome pré-menstrual. *Revista Brasileira de Ginecologia e Obstetrícia*, *22*(6), 347-351. doi.org/10.1590/S0100-72032000000600005.

Pallavi, L. C., Urban, J. S., & Shivaprakash, G. (2017). Assessment of musculoskeletal strength and levels of fatigue during different phases of menstrual cycle in young adults. *Journal of Clinical & Diagnostic Research*, *11*(2), CC11-CC13. doi.org/10.7860/JCDR/2017/24316.9408.

Peters, C., & Burrows, M. (2006). Androgenicity of the progestin in oral contraceptives does not affect maximal leg strength. *Contraception*, *74*(6), 487-491. doi.org/10.1016/j.contraception.2006.08.005.

Petitti, D. B. (2003). Clinical practice. Combination estrogen-progestin oral contraceptives. *The New England Journal of Medicine*, *349*(15), 1443-1450. doi.org/10.1056/NEJMcp030751.

Petralia, S. M., & Gallup Jr, G. G. (2002). Effects of a sexual assault scenario on handgrip strength across the menstrual cycle. Evolution and Human Behavior, *23*(1), 3-10. https://doi.org/10.1016/S1090-5138(01)00085-X.

Pollock, M. L., & Jackson, A. S. (1978). Generalized equations for predicting body density of men. *The British Journal Nutrition*, *40*(3):497-504. doi.org/10.1079/BJN19780152.

Phillips, S. K., Sanderson, A. G., Birch, K., Bruce, S. A., & Woledge, R. C. (1996). Changes in maximal voluntary force of human adductor pollicis muscle during the menstrual cycle. *The Journal of Physiology*, *496*(2), 551-557. doi.org/10.1113/jphysiol.1996.sp021706.

Rechichi, C., Dawson, B., & Goodman, C (2008). Oral contraceptive phase has no effect on endurance test. *International Journal of Sports Medicine*, *29*(4), 277-281. doi.org/10.1055/s-2007-965334.

Sawar, R., Niclos, B. B., & Rutherford, O. M. (1996). Changes in muscle strength, relaxation rate and fatigability during the human menstrual cycle. *The Journal Physiology*, *493*(1), 267-272. doi.org/10.1113/jphysiol.1996.sp021381.

Simão, R., Maior, A. S., Monteiro, A. P. L., & Chaves, C. P. G. (2007). Variations in Strength Muscle for Upper and Lower Body in the Different Phases of the Menstrual. *Revista Brasileira de Ciência e Movimento*, *15*(3), 47-52. Available from: https://portalrevistas.ucb.br/index.php/RBCM/article/view/759.

Siri, W. E. (1961). Body composition from fluid spaces and density: analysis of methods. *Nutrition*, *9*, 480–491. Available from: https://escholarship.org/uc/item/6mh9f4nf.

Sung, E., Han, A., Hinrichs, T., Vorgerd, M., Manchado, C., & Platen, P. (2014). Effects of follicular versus luteal phase-based strength training in young women. *Springerplus*, *668*(3), 5-10. doi.org/10.1186/2193-1801-3-668.

Tsampoukos, A., Peckham, E. A., James, R., & Nevill, M.E. (2010). Effect of menstrual cycle phase on sprinting performance. *European Journal of Applied Physiology*, *109*(1), 659-67. doi.org/10.1007/s00421-010-1384-z.

World Health Organization. (2015). *Medical eligibility criteria for contraceptive use*. (5th Ed.). Geneva. Available from: https://www.ncbi.nlm.nih.gov/books/NBK321153.