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EFFECTS OF THE MENSTRUAL CYCLE ON THE PHYSICAL AND PSYCHOLOGICAL STATE OF AN ACTIVE WOMAN

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Abstract. The main objectives of this research were to analyze the effects of the different phases of the menstrual cycle (MC) on two elements of the physical condition, strength-power and dynamic balance, and on the psychological state of a moderately active woman. A 28-year-old woman participated in this study, who used oral contraceptives. In total, 6 sessions were recorded, corresponding to 2 complete menstrual cycles and each of its phases (menstrual, follicular and luteal). In each session, three tests were carried out to evaluate the physical condition variables (Leg extension in Kineo, Press Bench in Multipower and Y Balance Test) and a test for psychological variables (POMS Test). The results obtained showed that during the luteal phase the participant achieved the lowest values in the 3 physical tests of power and dynamic balance, being the follicular phase (FP) where she obtained the best performance. In the psychological test, the menstrual phase (MP) stands out for having the highest values in the fatigue-inertia dimension, in contrast to the FP where higher values were observed for the vigor-activation dimension. The personal questionnaire on MC revealed the presence of menstrual and premenstrual symptoms in the two cycles studied. It is suggested that the changes produced in the physical and psychological variables of the subject are due to the presence of premenstrual symptoms, without being able to confirm the hormonal influence as blood or urine tests have not been performed.

Keywords: menstrual cycle, woman, strength, balance, mood.

EFECTOS DEL CICLO MENSTRUAL EN EL ESTADO FÍSICO Y PSICOLÓGICO DE UNA MUJER ACTIVA

Resumen. Los principales objetivos de esta investigación fueron analizar los efectos de las diferentes fases del ciclo menstrual (CM) sobre dos elementos de la condición física, la fuerza- potencia y el equilibrio dinámico, y sobre el estado psicológico de una mujer moderadamente activa. En este estudio participó una mujer de 28 años, la cual consumía anticonceptivos orales. En total se registraron 6 sesiones que correspondieron a 2 ciclos menstruales completos y a cada una de sus fases (menstrual, folicular y lútea).

En cada sesión se realizaron tres pruebas para evaluar las variables de la condición física (Leg extensión en Kineo, Press Banca en Multipower e Y Balance Test) y un test para las variables psicológicas (Test de POMS). Los resultados obtenidos mostraron que durante la fase lútea (FL) la participante consiguió los valores más bajos en las 3 pruebas físicas de potencia y equilibrio dinámico, siendo la fase folicular (FF) donde mejor desempeño obtuvo. En la prueba psicológica, se destaca la fase menstrual (FM) por tener los valores más altos en la dimensión de fatiga-inercia, en contraposición con la FF donde se observaron valores más altos para la dimensión de vigor-activación. El cuestionario personal sobre el CM reveló la presencia de síntomas menstruales y premenstruales en los dos ciclos estudiados. Se sugiere que los cambios producidos en las variables físicas y psicológicas de la sujeto, se deban a la presencia de síntomas premenstruales, sin poder confirmar la influencia hormonal al no haberse realizado análisis de sangre u orina.

Palabras clave: ciclo menstrual, mujer, fuerza, equilibrio, estado de ánimo.

Introduction

Over the last decades, the practice of physical exercise and sports participation by women has increased dramatically. The most important characteristic of contemporary female sport is the intense dominance of sport modalities that, until recently, were considered the privilege of men (Konovalova, 2013). Despite this, there are obvious differences between the two genders in many psychological and physiological aspects that influence their response to training. That implies the need to use training methods that suit their individual particularities.

In this sense, one of the processes that most influences a woman is the functioning of her reproductive system, that is, her menstrual cycle (MC). This is a process through which the female gametes (eggs or oocytes) develop and a series of changes take place aimed at establishing a possible pregnancy. The MC consists of four stages (menstruation, pre-ovulation, ovulation, post-ovulation), each characterized by the predominance of certain hormones, including gonadotropins, follicle stimulating hormone (FSH), luteinizing hormone (LH), progesterone, and estrogens.

Specifically, many studies have shown that both progesterone and circulating estrogens cause variations in many cardiovascular, respiratory, and metabolic parameters, with consequences on aerobic and anaerobic strength and performance (Constantini et al., 2005).

There are those who claim that the MC does not produce significant alterations in sports performance, even alluding to world and Olympic records obtained in any phase of the cycle (Kapilen and Arrey, 1984; Bone, Leng and Neil, 1979), which reinforces the idea that the higher the level of training the lower the effect of each phase (Ramirez Balas, 2014). This statement also coincides with a much earlier study by Kolka and Stephenson (1982) who concluded that the higher the level of training, the less effect the menstrual cycle has on performance, whatever the test. Recent studies have also found no significant change during the different phases of the cycle (Ramirez, 2014; Wilmore, Costill and Padró, 2010).

On the other hand, other researchers affirm that there are differences to be taken into account depending on the menstrual phase. According to Misael Rivera and Elena Konovalova (2002), during the post-ovulatory and post-menstrual phases of the female biological cycle, physical capacities such as strength, endurance, and speed increase, as

opposed to the menstrual, premenstrual, and ovulatory phases, where they decrease. In the menstrual cycle, during the pre-ovulatory and post-ovulatory phases, the increased production of both estrogens and progesterone are determinant in improving the performance of high-performance athletes. These authors obtained the same conclusions years later in another investigation carried out with 226 female athletes from Valle del Cauca (Colombia) with an average of 16 years of age in 21 sports modalities. (Konovalova & Rivera Echeverry, 2017).

On the other hand, the influence of premenstrual syndrome (PMS) should be highlighted, since women who present it have a greater tendency to decrease their performance (Lebrun, 1993). The presence of this factor and its symptoms are related to an increase in traumatic musculoskeletal injuries during the pre-menstrual and menstrual period (Lebrun, 1993).

In view of the above, the objectives of this work are as follows:

- Test the influence of the different phases of the menstrual cycle on the physical performance of a moderately active woman through power and dynamic balance tests.
- Determine the influence of menstrual phases on their emotional and mood state.

Method

Design

This is a single longitudinal descriptive case study, in which two consecutive menstrual cycles of a woman were followed and various tests were applied in three phases of the cycle (menstrual, follicular, and luteal). In this way we tried to analyze the influence of the different phases on the elements of the physical condition under study (power and dynamic balance) and on the psychological and emotional variables of the subject.

Participant

A 28-year-old woman participated in the study. She was not an athlete or a regular exerciser, but she was moderately active and had healthy lifestyle habits. She had been using oral contraceptives for 12 years. For this study, she was asked not to modify any of her daily habits and to report any change that could affect the results to be taken into account (illness, stressful or traumatizing event, etc.).

Instruments

The Y Balance Test was used to assess dynamic balance and neuromuscular control of the trunk. The material used for the test was a tape measure and 3 Y-shaped lines placed on the floor with adhesive tape, so that an angle of 135º was formed between the anterior line with the posterior-lateral and posterior-medial lines and an angle of 90º between the posterior-lateral and posterior-medial lines. For the analysis of the measurements obtained, the formulas proposed in the study by Shaffer et al. (2013) were used:

- Relative reach distance (RRD, %) = Reach Distance / Leg Length x 100
- Composite range distance (CRD, %) = Sum of the 3 directions of range / 3 times the leg length x 100

The machine 7.0 version Kineo was used to evaluate the power of the lower body, with which a dynamic power test was performed with incremental loads using the Leg Extension exercise.

To perform the upper body power test, the Multipower machine was used to perform the bench press exercise. The test results were evaluated with a linear encoder and analyzed with the Smartcoach program.

To keep track of the days of the menstrual cycle, the participant downloaded the "MY TRAKE" mobile application. In addition, to assess the general characteristics of the MC, the "Personal questionnaire on menstrual cycle and physical activity" was used; the same that was constructed and validated by the Department of Physiology of the Faculty of Sports Sciences of the Universidad de Extremadura Ramírez (2014), which also includes various symptoms of the menstrual cycle.

For the assessment of mood, an index was obtained from the reduced 15-item version of the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971) scale obtained from the MenPas Psychosocial Assessment On-Line platform.

Procedure

All sessions were always held in the same place, a training room, and generally during the same time slot (12:00 a.m.), due to the greater availability of the participant. In addition, a series of pre-test requirements were stipulated in an attempt to reduce the influence of other variables:

- Sleep a minimum of 8 hours
- Do not eat anything for at least two hours before, but do not fast.

For each menstrual cycle, considering the start on the first day that menstruation appeared to the participant, three measurement sessions were carried out, coinciding with the three phases to be analyzed:

- Menstrual Phase (day 2-3): low estrogen and progesterone levels
- Follicular phase (12-13): high estrogen and low progesterone levels.
- Luteal Phase (21-22): high progesterone levels

Before the physical tests, the participant always completed the POMS test. After this, the participant performed a warm-up previously registered for each session. The warm-up consisted of:

- 5' of elliptical at moderate intensity
- General joint mobility, from head to toe.
- 5 full squats and 3 finishing with a jump
- Kneeling on the floor with knees supported (6 repetitions)

The first test performed was the Leg Extension on the Kineo machine. Before starting, 2 sets of 10 repetitions were always performed with low loads of 5 and 6 kg as a way of activating the limbs, leaving 30" of recovery between them. After this, the test was started with a load of 8 kg, which was progressively increased by 3 kg at a time until the subject could not mobilize any more.

The second test was the bench press on the Multipower machine, which was performed after 5' of recovery with the previous exercise. The activation was done with the same series and repetitions as before and without load. Then the test began, which consisted of 4 sets x 4 repetitions. In each series, the weight was progressively increased from 5 kg, 10 kg, 15 kg and 20 kg. Between sets, 3' of recovery time was left.

The last test was the Y Balance Test, which was also started after 5'of recovery. To begin with, 3 warm-up attempts were made with each leg in the 3 directions, also leaving a few moments of recovery between them. The participant had to stand barefoot

in the center of the figure where she rested the heel of her foot and with her hands on her hips, she had to reach as far as possible over the line. To mark the distance, she used the tip of her big toe, which she had to rest lightly on and then return to the starting position.

The order of directions was first the anterior, then the posterior-medial and finally the posterior-lateral. Of the three attempts, the best one was selected with each foot and in each direction. The reach direction was not valid if:

- She could not support her finger to mark the distance.
- She would not return to the starting position without losing control
- She did not keep her hands resting on her hips throughout the movement
- She did not keep the support of her foot fully supported or lost balance.

Data analysis

The Microsoft Office program, Excel 2016, was used for the descriptive analysis of the data. The statistics used were the mean and standard deviation, the results of which were reflected in tables and graphs.

Results

The following is a description of the results obtained in the three physical tests, which are presented in tables and graphs showing the averages of each phase.

The data obtained in the Leg extension test (Figure 1) show that in the follicular phase (FP) the subject reached the highest values in all the parameters analyzed, followed by the menstrual phase (MP) and finally the luteal phase (LP), which only surpasses the menstrual phase in the mobilized load (LP: 21 ± 1.41 and MP: 20 ± 0).

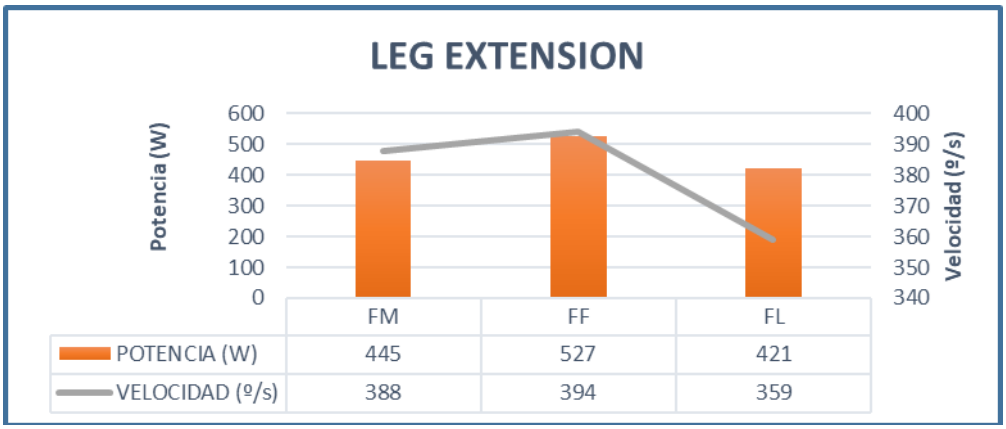

Figure 1. Average values of Leg extension

In the bench press test, the data obtained (Figure 2) also show that the phase with the highest power levels is the FP, followed by the MP and finally the LP with the lowest values achieved, although there is not a great difference between this and the MP.

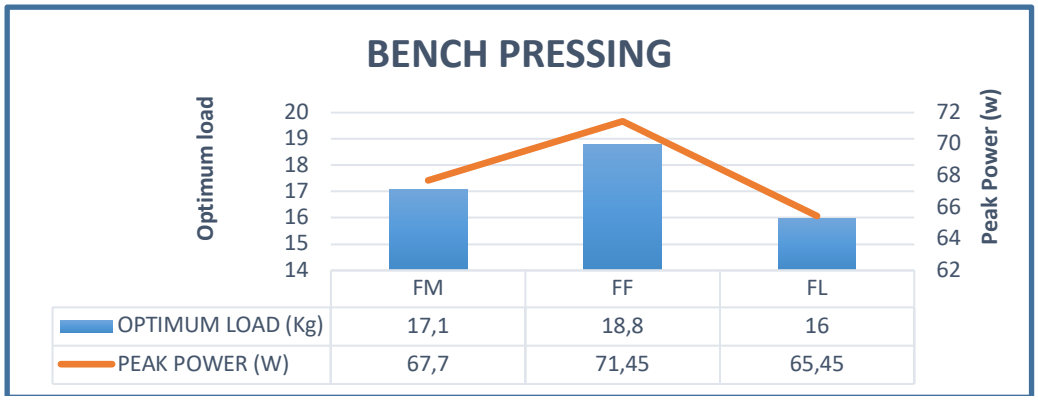

Figure 1. Average values of the Bench Press

In the Y Balance Test (Figure 3), it was again found that the FP had the greatest range for the three directions with both feet. The direction with the least changes between phases was the posterior-medial. On the other hand, in the anterior and posterior-lateral directions there are greater variations. The right foot presents greater distances in all directions in both the FP and MP, while in the LP the left foot has a greater anterior reach. There are no marked differences between the two feet in each phase, except in the FP, where there is a variation of 4.93% for the posterior-lateral reach.

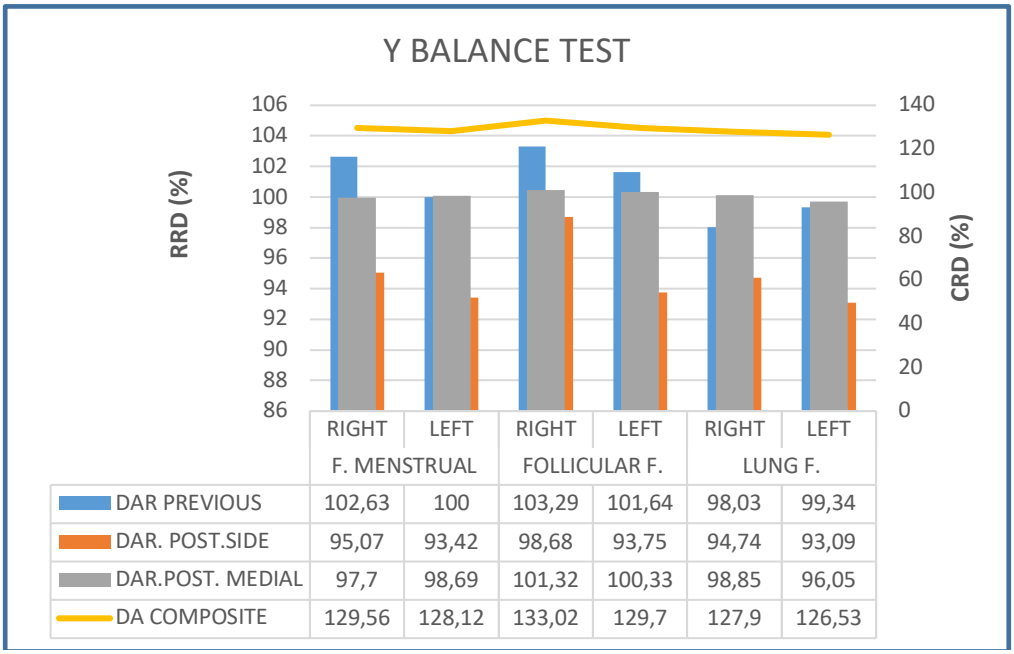

Figure 2. Mean values of the Y Balance Test

In the POMS test (Figure 4), it is observed that the MP stands out for presenting the highest values in the fatigue-inertia dimension and the lowest in the vigor-activation dimension, followed by the LP. On the other hand, the FP shows the opposite, higher values in the vigor-activation state and lower values in fatigue-inertia.

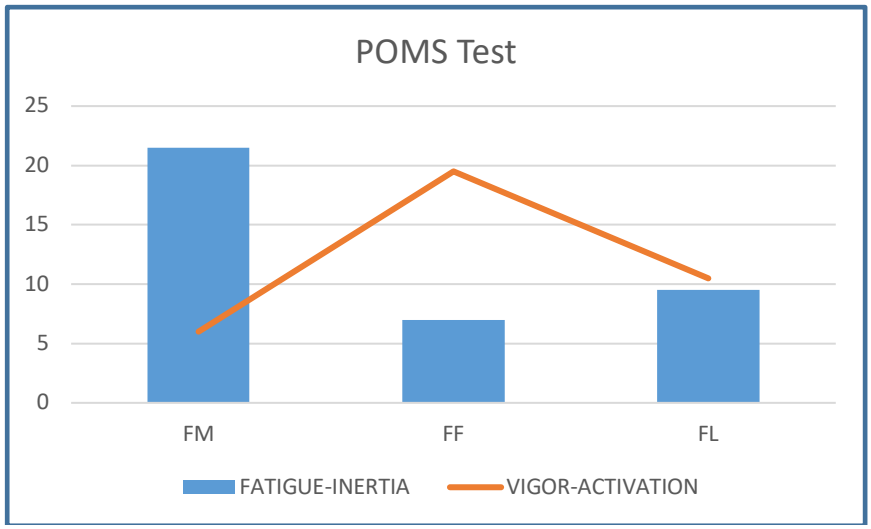

Figure 3. Mean values of the POMS test

In relation to the questionnaire on the characteristics of the MC (Table 1), it can be observed that the subject suffered in both MCs a great variety of symptoms both in the menstrual and premenstrual phases, which are shown in both tables. The 2nd MC stands out for presenting a greater number of symptoms.

Table 1

Menstrual and premenstrual symptoms

Premenstrual symptoms	**1st MC**	**2nd MC**
Headache	YES	YES
Breast pain and swelling	NO	YES
Fluid retention or weight gain (feeling bloated)	YES	YES
Alterations in the psychic area (bad mood, depressed, indifferent, etc.).	YES	YES
Menstrual symptoms	**1st MC**	**2nd MC**
Nausea	NO	NO
Low tension	NO	YES
Intestinal disorders	NO	YES
Low back pain	YES	YES
Thigh pain and weakness	NO	NO
Abdominal pain	YES	YES
Sweating	NO	NO
Headache	NO	YES

Discussion

The hypothesis of this study suggests that the different phases of the MC could induce differences in the power levels, dynamic balance, and mood of the studied subject derived from the hormonal fluctuations that occur throughout the different phases of the cycle.

Most of the research that has analyzed the effect of the menstrual phases of the cycle on cardiovascular, ventilatory, thermoregulatory, and metabolic responses, both at rest and during aerobic, anaerobic, and recovery exercise has mostly shown that there are no differences, except in specific aspects, although there are contradictory results (Janse

de Jonge, 2003). Therefore, in this study we want to determine whether there are appreciable differences over two MCs in the different physical capacities and also in the state of mind evaluated.

Most of the studies that have assessed lower body power have not found variations in the MC, such as that of Nácher et al. (1995) with female students of the INEF of Catalonia, who were evaluated by means of the arm-free CMJ. No changes in lower body power were observed in the different phases of the menstrual cycle, nor with athletes who were members of national handball and rhythmic gymnastics pre-selections with the same CMJ test but without the help of hands (Izquierdo and Almenares, 2002). Another study in which active women participated and the same CMJ test was applied, but without the help of arms, it did not find significant changes either (Ramírez, 2014).

In contrast, in the study by Giacomoni et al, (2000) in which 17 women were evaluated using three anaerobic tests (strength-velocity, multiple jump, and squat jump tests) and hormonal analyses to determine the phases, no significant differences were found between phases, but there was an 8% reduction in maximal jumping power in menstruation relative to FP in those women suffering from premenstrual syndrome, regardless of contraceptive use or not. It was concluded that the reason for the decline in power may be due to hormonal changes and the presence of premenstrual symptoms, both of which could have an effect on the shortening and stretching cycles of tendons and ligaments (Giacomoni et al., 2000).

Giacomoni et al. (2000) cite that Wearing et al. (1972) in a study in which the phases of the menstrual cycle were not identified by hormonal analysis, showed that performances in the long jump and isometric strength were poorer during the menstrual phase and/or the late luteal phase, the latter being generally attributed to the existence of menstrual and premenstrual symptoms.

On the other hand, although phase hormone levels were not tested in this study, it is known that during early MC (MP) there are low levels of estrogen and progesterone; and that in the late follicular phase (FP) there is a peak in estrogen levels, followed by another peak in estrogen and progesterone in the middle of the luteal phase (LP) (Darlington, Ross, King, & Smith, 2001; and Friden et al., 2006).

Related to this, there are studies where it has been proposed that estrogens may have a skeletal muscle strengthening effect, which would benefit muscle strength through an underlying mechanism based on estrogen receptors that would improve the intrinsic quality of skeletal muscle, by binding myosin tightly to actin during contraction (Lowe, Baltgalvis and Greising, 2010), but it has also been suggested that progesterone may have an antagonistic effect to these and restrict muscle strength levels during the LP (Dos Santos Andrade et al., 2017).

All of the above could explain the findings found in this test. First, due to the characteristics of the subject, who presented premenstrual and menstrual symptoms in her 2 MCs, which according to the literature reviewed could affect her performance in the LP and MP, where the lowest power levels occurred, especially in the LP. And secondly, due to hormonal fluctuations, since the tests with the worst performance coincide with the times of lower estrogen and progesterone levels (MP) and when the levels of these two hormones are high (LF), and there could be, as mentioned, an antagonistic effect between both hormones. Although the latter cannot be conclusive due to the lack of hormonal analysis and more scientific evidence to support it.

In the upper body power test, there was again a drastic decrease in the levels achieved in the LP compared to the FP, in which the highest results were obtained, followed by the MP.

After reviewing the scientific literature, no study has been found that has evaluated upper body power. Most of the investigations have carried out manual dynamometer tests to assess maximum isometric strength or strength endurance tests. Therefore, the relationship of the data obtained with those of other studies has been quite controversial since they do not analyze the same capacity. In spite of this, different conclusions have been reached in relation to grip strength and MC. On the one hand, some have found that muscle strength (e.g., grip strength and bench press strength) does not seem to fluctuate significantly during MC (Constantini et al., 2005). But in another later study, a higher peak of strength was shown just before ovulation, in the quadriceps strength and manual dynamometer hand grip test. Concluding that the possible cause of this change is due to increased estrogen levels occurring before ovulation (Sarwar, Niclos and Rutherford, 1996).

The contradictions found in the results of the studies reviewed have not allowed us to reach a clear conclusion on the cause of the variations in upper body power. It is likely that the same pre-menstrual and menstrual symptoms, suffered by the subject, have caused the results in this test, as in the anterior (Leg extension), to be worse in the LP and lower in the MP compared to the FP.

In the results obtained in the Y Balance Test, variations were observed in the reach distances during the phases of the 2 MCs analyzed, finding that the greatest differences occurred in the anterior and posterior-lateral directions, with the posterior-medial direction being more equal in all cases. The FP stands out for presenting the greatest distances reached for the 3 directions and the LP for having the smallest distances and the greatest difference with respect to the other two phases. This would indicate that the postural control in the LP is more altered, resulting in a lower dynamic balance and worse reaches in the mentioned directions.

In relation to these findings, there are studies that verify changes in postural control as a consequence of the MC (Friden et al., 2003; Friden et al., 2005; Friden et al., 2006).

The study by Friden et al. (2003) investigated the influence of MCs and premenstrual syndrome (PMS) on postural sway and knee joint kinesthesia in 13 women. In it, it was shown that women with PMS had greater postural sway and higher knee joint motion detection threshold in the middle of the luteal phase than women without PMS. This was confirmed in a later study (Friden et al., 2005). These statements were again reinforced in the study by Friden et al. (2006) in which they evaluated the neuromuscular control of 32 moderately active women, obtaining that the best performances were in the late follicular phase compared to MP and LP. In all three studies the phases were determined by hormonal analysis, and although in this study it was not done, the results found here coincide with those described, which can be related due to the presence of premenstrual symptoms.

In contrast, Ericksen and Gribble (2012) investigated sex differences, hormonal fluctuations in the pre-ovulatory and post-ovulatory phase, ankle stability, and dynamic postural control using the Star-Excursion-Balance test. The results found showed that, although women had greater ankle laxity in inversion-eversion and less dynamic postural control than men, hormonal fluctuations in both phases did not have a significant influence on these differences.

Mood changes such as anxiety, emotional instability, irritability, lethargy, among others, have long been associated with the menstrual cycle (Moos, 1977). Specifically, the premenstrual phase has been associated with an increase in these negative psychological and physical aspects (headache, fatigue, etc.) (Angst, Sellaron, Merikangas, & Endicott, 2001; Schmidt & Rubinow, 1997; and Nillni, Toufexis, & Rohan, 2011). But studies have also been found that allude to the combined effect of daily physical health status, perceived stress, and social support as the variables that best explain women's daily mood, rather than MP phases (Romans et al., 2013). Regarding this, in our study we did observe a variation in mood, highlighting the negative aspects, in LP and MP, but especially in the latter, which would be related to the premenstrual symptoms suffered by the subject in her two MCs. These results agree with those found by Corney and Staton (1991), who reported that 63% of women experience mood changes up to 3 days after the onset of menstruation, while 5% claimed to have debilitating effects until the end of menstruation.

This study had a series of limitations that should be taken into account. To begin with, after reviewing the existing scientific literature on the subject, no study with similar methodological characteristics was found. Both the instruments and the power tests used in this study differ from those used in others, since most of them have performed jumping tests to assess this capacity in the lower body or manual grip tests for the upper body. Therefore, the relationship of these findings with those of other studies may not be entirely conclusive.

On the other hand, in this study only a descriptive assessment of the observed results was made, but no statistical programs were used to verify whether the degree of variation in the tests performed during the two MCs were truly significant. Another limitation refers to the determination of the beginning and end of each of the MC phases. In this study an indicative calculation was made taking the first day of bleeding as the starting time, but no blood or urine tests were performed, which is relevant when checking for hormonal influences and would have given greater consistency to the results.

Finally, in this study the sample taken was small compared to others, since the subject was only evaluated during 2 consecutive MCs due to technical problems with the assessment instruments. It would have been preferable to have evaluated more cycles to check the variations between them, in addition to controlling or eliminating other possible variables that could affect the results.

Conclusion

In this study, variations were observed in the power (upper and lower body), dynamic balance, and mood of the subject studied during the 3 phases of the 2 MCs analyzed. Of the 3 phases of the cycle, the LP was the one that presented the worst values in all the tests analyzed. It is suggested that the reason for the decrease in physical performance and the worsening of mood during the LP may be due to the presence of premenstrual symptoms derived from hormonal influence, although the latter could not be empirically confirmed since no confirmatory blood or urine tests were performed.

In view of the above, it is suggested that in future studies a longer follow-up should be carried out, including a greater number of menstrual cycles, as well as a biochemical analysis to determine hormone levels in the different phases of the cycle.

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