Original Article

Effects of menstrual cycle phases on elasticity index in female soccer players

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ABSTRACT

The aim of this study was to determine the influence of the menstrual cycle on the elasticity index in female soccer players. A quasi-experimental analysis was carried out with a time series design, with a sample of 14 female players between 16 and 23 years (18.50 ± 1.74) where during all the phases of a menstrual cycle they had to perform the Squat Jump and Counter Movement Jump tests in order to calculate the elasticity index. Descriptive, normality, sphericity test and a repeated measures ANOVA with a Bonferroni type Post-Hoc test were performed. The most relevant aspect was that there were significant differences in the elasticity index between the Follicular Phase and the Ovulatory Phase, obtaining higher percentages of elasticity index in this second phase, but there were no significant differences between the other phases. The results obtained determine that the elasticity index is higher in the Ovulatory Phase than in the rest of the phases and this could be mainly due to the oestrogen peak and that there are no significant differences in the Luteal Phase demonstrates the relevance of this hormone with respect to explosive strength and the elasticity index. This study will allow the use of strategies with the intention of being able to optimally place the loads during plyometric training in reference to the menstrual cycle. While menstrual discomfort is subjective, they should be taken into account. Conversely, the elasticity index provides a reliable objective data that assists in designing personalized training programs.

Keywords: Sport medicine, Health, Menstrual cycle, Elastic index, Women's soccer, Jumping, Performance.

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INTRODUCTION

Soccer is one of the most popular sports. In recent decades, there has been an increase in the popularity of the female branch worldwide (Williams et al., 2019). Actions related to explosiveness, or the stretch-shortening cycle are key in the performance of soccer players (Hennessy & Kilty, 2001). Likewise, different authors also highlight sprint actions, changes of direction and jumps (Faude et al., 2012). In fact, researchers have focused a lot on plyometric training (Sánchez et al., 2020) which is based on the training of jumping with own body weight and through the action of the stretch-shortening cycle performed by the lower segments (Maciejczyk et al., 2021).

In order to determine the relevance of these actions many aspects must be taken into account, but one of the most relevant when investigating female athletes is the possible influence of the menstrual cycle (Julian et al., 2021). Although it has been assumed that adaptations to exercise are equal between genders (Sims & Heather, 2018), the current literature presents some controversy in this regard and more so when inquiring about the influence of the menstrual cycle on performance (García-Pinillos et al., 2021). In addition to this controversy, it should be noted that studies related to the impact of the menstrual cycle on soccer performance are very scarce (Igonin et al., 2022).

Having high physical performance is not just about jumping higher or running faster, but also about maintaining a low injury rate throughout the season.

Just as fatigue symptoms are taken into account when prescribing exercise, menstrual symptoms should be considered in the case of female athletes.

A regular menstrual cycle in young healthy women is approximately 28 days long (Mihm et al., 2011), although it can show average variations of between twenty-one and thirty-five days (McNulty et al., 2020). It can be divided into different phases and vary depending on the author. In this regard, the study by McNulty et al. (2020) fragments the menstrual cycle into three different phases: the follicular phase, ovulation and the luteal phase. However, Julian et al. (2017) subdivides the follicular phase into two: the early Follicular Phase and the late Follicular Phase, where points out that the main difference lies in the oestrogen surge during the latter.

The Follicular Phase begins with menstruation and lasts until the onset of Ovulation and the Luteal Phase begins with Ovulation and ends with the onset of new bleeding (Igonin et al., 2022).

In the Follicular Phase, Follicle Stimulating Hormone levels reach their highest levels with the intention of proliferating ovarian follicle granulosa cells (Mihm et al., 2011) secreting increasing amounts of oestrogen (Park et al., 2002). Luteinizing hormone reaches a pulse four times higher than in the other phases (Mihm et al., 2011) and promotes the conversion of androgens to oestrogens which in the last days of this phase are very high (Erickson et al., 1989).

Although there are multiple studies related to soccer and performance, very few are found that accurately determine aspects related to the menstrual cycle and performance in soccer players (Armour et al., 2020).

In the conditional field, aerobic and anaerobic requirements should be combined with agility allowing a high number of high intensity actions throughout the match (Mujika et al., 2009) considering its intermittent nature with loads that combine capabilities such as strength, power and endurance (Igonin et al., 2022).

According to Carmichael et al. (2021), strength and power should decrease in the luteal phase due to the increase in progesterone and experience an improvement in the later parts of the follicular phase, where the oestrogen peak is reached. When we focus on global strength, this statement is contradicted by the study of dos Santos Andrade et al. (2017) conducted in female soccer players, which states that the ratio of maximal torsional strength between hamstrings and quadriceps of the non-dominant lower extremity was higher during the luteal phase with respect to the follicular phase.

Actions such as jumping, has been shown to have a significant relationship with successful actions in soccer and therefore in the performance and level of female players (Datson et al., 2014). Besides, the elasticity index is the relationship between performance in the Counter Movement Jump (CMJ) and Squat Jump (SJ) which are used to test the stretching shortening cycle of the lower limbs (Kipp et al., 2021), allowing the quantification of the percentage of elastic energy produced during the execution of jumping actions (Bosco et al., 1983). Although there are no ideal values regarding the results of the elasticity index, it is determined that when the values are low, the elastic storage should be improved and when they are high, the strength levels should be improved (Kozinc et al., 2021).

Despite the relevance of the elasticity index, no studies have been found that relate it to the different phases of the menstrual cycle in female soccer players. The aim of the present study was to determine the influence of the menstrual cycle on the elasticity index in female soccer players.

The hypothesis proposed was that the phase of the menstrual cycle in which the female soccer player is in will affect her jumping performance and, therefore, there will be differences in the elasticity indexes according to the week.

METHODS

Participants

Fourteen female soccer players (M = 18.5 ± 1.74 years) who are part of the second team of the Valencia C.F. women's section were evaluated. The general inclusion criteria were: the players must belong to or be in training and competition dynamics with the Valencia C.F. women's second team, be present on all the days on which the evaluations were carried out, not take any type of contraceptive pills and have regular menstrual cycles. The protocols and procedures of this study were approved by the Ethics Committee of the Universidad Católica de Valencia with code UCV/2022-2023/127 and comply with the principles established by the Helsinki Declaration of 1964.

Procedures

The design of the study is quasi-experimental with a time series design because the evaluations were carried out continuously and respecting the established protocols. The players performed the jumps in each of the three phases of the menstrual cycle referred to by (McNulty et al., 2020): the follicular phase, ovulation and the luteal phase. The recordings were carried out in the gymnasium of the Valencia C.F. and the data collection was carried out on the same day of the menstrual cycle and between 15:45 and 16:15 in the afternoon.

Before starting the session, the players performed a warm-up adapted from the study by Krawczyk et al. (2021):

- In the first phase of the activation, two series of 10 intensive Lateral Bounds were performed, one-legged L-shaped jumps where two series of four jumps were performed per side and two series of

four lateral jumps with another posterior frontal one with the intention that the activation at the neuromuscular level was progressive.
- In the second phase, the players performed four SJ with maintenance in squat position for three seconds and four CMJ where they were allowed to swing their arms. This final part brought the player closer to the execution of the tests, allowing her to adjust the movement pattern with the intention that the execution would be correct at the time of the evaluations.

The recording protocol was performed on an expandable polyethylene surface and was based on the one performed by Krawczyk et al. (2021) where the players performed 2 CMJ with a rest interval of 1 minute between them in order to recover from the initial effort and, after the execution of the second jump, a 2-minute rest was performed so that the recovery was even more complete. Two SJ were performed continuously, with a 1-minute rest interval between them. For data collection, the best jump of the CMJ modality was selected, as well as the best jump of the SJ modality.

In the CMJ test, the players started the jumping action in an upright position and with their hands on their hips during the jump and landing phase (Merino et al., 2021) and in the SJ the players were positioned standing with knee flexion and disabling the upper segments by placing the hands on the hips, then they had to maintain that position for 3 seconds to then perform a jump with knee extension and falling within the zone where the sensors interacted (Stanković et al., 2022).

Materials and instruments

The Mycalendar® application was used to record and predict the period, as well as to calculate the phases of the menstrual cycle. In the present study, it was used to record the menstrual cycle and the phase through which the players were passing. Once the length and regularity of the menstrual cycle were identified, a Google Forms questionnaire was used to send this information to the research group and then the tests were adjusted to the phase in which the players were.

Vertical Jumps

In order to perform CMJ and SJ tests and obtain the jump height in centimetres, an Optojump TX10 (Bolzano, Italy) was used. This system, consisting of a transmitting and a receiving bar, allows measuring flight and contact times (Santos-Lozano et al., 2014), is portable, and adjustable to limited spaces (Gherghel et al., 2021).

Elastic Index

To determine the effect of the stretch-shortening cycle, valid and reliable tests are needed, such as the SJ and CMJ tests, which, with the relation of their results through the elasticity index formula (McGuigan et al., 2006), allow us to identify the percentage of athletes' elastic energy utilization (Equation 1):

$$\textbf{Elasticity Index} = (\text{CMJ}-\text{SJ})/\text{SJ}*100$$

Note. Taken from McGuigan et al. (2006).

Equation 1. Elasticity index formula.

Analysis

Data are presented as means and standard deviations (mean ± SD). Normality assumption was analysed using the Shapiro-Wilk test ($p < .05$) and then the sphericity test was performed ($p < .05$). Comparisons

between the three menstrual phases were performed using the repeated measures ANOVA test and the Bonferroni post-hoc test to analyse the effects of the menstrual cycle (follicular phase, Vs oscillatory phase, Vs luteal phase) on the jump height of the CMJ and SJ tests, and the on the effects on elasticity index.

Data were analysed using JASP statistical tool (v. 0.17.1). The significance level was set at $p < .05$, and CI was stablished at 95%.

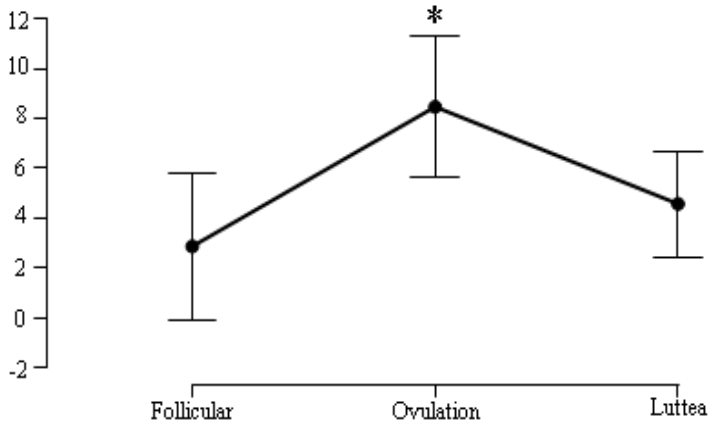
RESULTS

Table 1 shows the descriptive data regarding the jump height in centimetres obtained in each phase of the menstrual cycle after the execution of the CMJ, SJ, and the percentage of elasticity index.

Table 1. Descriptive statistics.

Menstrual Cycle phases	Follicular Phase	Ovulation	Luttea Phase	h^2_p	*p*
Counter Movement Jump	28.15 ± 4.65	29.28 ± 4.29	28.57 ± 4.08	*.296*	.114
Squat Jump	27.46 ± 4.62	27.04 ± 4.15	27.36 ± 3.94	*.296*	.60
Elasticity Index	2.85 ± 6.55	8.46 ± 3.38	4.56 ± 4.41	*.296*	.010

ANOVA showed no main effects of menstrual cycle on jump height during CMJ [F(14) = 2.36, $p = .14$] and SJ [F(14) = .42, $p = .60$] tests. Conversely, ANOVA performed for elasticity index showed main effects of menstrual cycle [F(14) = 5.46, $p = .01$]. Post-hoc Bonferroni analysis showed significant differences ($p = .01$) between Follicular Phase (M = 2.85; SD = 6.55) and Ovulatory Phase (M = 8.46; SD = 3.38) and Luteal Phase (M = 28.57; SD = 4.08), but not between Follicular Phase and Luteal Phase ($p = 1.00$), neither between Ovulatory Phase nor Luteal Phase ($p = .10$) (Figure 1).



*Note. * indicates statistical significance (p < .05).*

Figure 1. Elasticity index results.

DISCUSSION

The main objective of the present study was to determine the influence of the menstrual cycle on the elasticity index in female soccer players. The main results of the present investigation were that the menstrual cycle modifies the elastic index of female soccer players.

Specifically, the data analysed show that the elastic index increases between the Follicular Phase and Ovulation, which would confirm the experimental hypothesis. This fact could be related to the statement of Faryniarz et al. (2006) where they determine that the increase in elasticity occurs with the peak of oestrogen concentration as in the case of the Ovulatory Phase and the Luteal Phase, which does not happen in the Follicular Phase, although they also state that it decreases with the peak of progesterone that occurs in the final phases of the Luteal Phase.

Although the experimental hypothesis has been accepted. In the case of explosive strength, determined by the SJ test, it is evident that the differences between the phases are not significant. This fact agrees with the study by Sánchez et al. (2021) where they state that the levels of explosive strength produced by the lower segments did not lead to significant differences depending on the phase of the menstrual cycle neither when the players performed vertical jumps nor when they were horizontal. García-Pinillos et al. (2021) also found no significant differences in jumping or in actions related to explosive strength such as sprinting or neuromuscular performance.

The results obtained in reference to the influence of the different phases of the menstrual cycle and the height of the jump in the CMJ test determine that there are no significant differences between the jumping capacity. This fact can be reinforced by the study of Julian et al. (2017) applied on female soccer players where they determine that the ability to perform the CMJ does not vary according to the phase of the menstrual cycle in which the players are.

After obtaining the data in the present study, it is determined that in order to obtain more reliable results, studies that can relate the influence of the different phases of the menstrual cycle with the elasticity index should continue to be carried out, as well as the need to create a greater number of studies related to the menstrual cycle so that science is even more conclusive regarding its impact on the performance of female athletes.

CONCLUSIONS

Studies relating the menstrual cycle with performance and basic physical capacities are increasing and are not free of contradictions when comparing results from different authors. In the present study we have sought to determine the relationship between the different phases of the menstrual cycle and the percentage of the elasticity index by means of the execution of the CMJ and SJ tests.

In the analysis carried out, it was found that the differences in terms of jump height in centimetres when comparing the data obtained by means of the CMJ did not report significant differences, nor were they obtained after the comparison between the SJ tests. When the percentage of the Elasticity Index was compared according to the phase of the menstrual cycle, it was reported that there were no significant differences between the Follicular Phase-Luteal Phase and the Ovulatory Phase-Luteal Phase, although significant differences were found between the results obtained between the Follicular Phase and the Ovulatory Phase, the results being superior in the latter phase. This last statement leads to the acceptance of the experimental hypothesis proposed in the study.

This finding will allow the technical bodies of women's teams to rethink the use of different strategies with the intention of being able to optimally place the loads in terms of explosive and elastic explosive strength work during the training of their teams in reference to the phases of the menstrual cycle, since it has been shown

that in the Luteal Phase and especially in the Ovulatory Phase the percentages of elasticity index are higher than those obtained during the Follicular Phase.

Physical performance necessitates injury prevention for enhanced performance throughout the season. If there are few injuries, the chances of performing at a higher level are increased.

In this way of prevention, the elastic index provides information about the condition of the athletes, which can be correlated with their menstrual cycle.

AUTHOR CONTRIBUTIONS

Ángel Muñoz: conducted the study intervention and was responsible for writing the article. Carlos Sanchis: analysed the data and contributed to the results section. Ángel Francisco García: contributed to the design of the study and reviewed the manuscript. Cristina Monleón: directed the study, contributed to the design the study and approved the final draft.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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