Journal of Women's Sports Medicine



# MENSTRUAL CYCLE PHASES AND ELITE FEMALE SOCCER DURING TRAINING: EXERCISE LOAD PERCEPTION AND EXTERNAL WORKLOAD MONITORING

Chiara Groff, MSc[1], Cristian Ieno, PhD[1,2], Ruggero Romagnoli, PhD[1,3], Marco Lista, PhD[3], Paolo Sgrò, MD[4], Francesca Pittaccio, MSc[1], Luigi Di Luigi, MD[3], Luigi Fattorini[2]

[1]*SS Lazio Spa, Via di Santa Cornelia, Formello, Roma, Italy*
[2]*University of Rome La Sapienza Department of Physiology and Pharmacology, Rome, Italy*
[3]*University of Rome Department of Movement, Human and Health Sciences, Rome, Italy*
[4]*University of Rome Department of Endocrinology, Movement, Human and Health Sciences, Rome, Italy*

**BACKGROUND:** Female soccer has grown exponentially in the last years, however studies on women soccer players are very few compared with male ones and several inconsistencies are reported in the literature for female players. Physiological hormonal fluctuations during the different moments of menstrual cycle (MC) could have important implications on soccer performance, therefore, the aim of the present study was to investigate the impact of menstrual cycle phases on external and internal loads in elite women' soccer players during an in-season training period, and to describe the internal-external training load relationship, in relation to different menstrual cycle moments.
**METHODS:** 16 elite players from Italian soccer first division were monitored for 12 weeks. The main internal parameter (rate of perceived exertion, RPE), external variables (total time, total distance, high speed running [HSR], numbers of accelerations/decelerations) and session-RPE were collected during training sessions and analyzed trough a repeated-measures ANOVA to identify differences in the MC weeks. Menstrual cycle was monitored through daily questionnaires and was divided into four phases: menstruation week, pre-ovulation, post-ovulation, and pre-cycle.
**RESULTS:** HSR and total distance were significantly lower during menstruation week than post-ovulation week (18318.70 ±1802.04 m vs 20358.41 ± 1639.27 m, respectively; $p = 0.022$). A significant correlation was found in pre-cycle week between RPE and total distance ($r = 0.545$; $p = 0.029$), and between session-RPE with total distance (r=0.514; p=0.042) and total time ($r = 0.502$; $p = 0.048$). When considering the whole menstrual cycle, weak and moderate correlations were found for RPE and session-RPE with total time, total distance and HSR.
**CONCLUSION:** Appropriate menstrual cycle monitoring is required for better interpretation of players' response in elite women's soccer training, given that during menstruation week, external load variables could be impaired. RPE and session-RPE values do not change statistically with changes in external variables, and their relationship showed unclear results, highlighting caution when interpreting them, and suggesting their use in combination with other parameters, especially during early follicular phase.

## INTRODUCTION

Women's soccer has grown exponentially in the last years. However, scientific studies on women soccer players are very few compared with male ones, and in 2021 only 15% of all the soccer literature focused on women's elite soccer players.[1]

The need of further research on women's soccer is essential given the growing interest on this area and has the aim to help coaches to improve players' performance, health, and well-being. Planning and managing effective training protocols and individual workloads, with the aim to optimize players' performance, reduce injury risk and avoid non-functional overreaching, requires continuous feedback with player's perception and physical status.[2] This feedback is necessary to adapt the periodized training protocols continuously to obtain better players' adaptive responses to training

DOI: 10.53646/7xj3ry38
Published online: August 25, 2024

and to increase performance during matches.[3,4] Training load monitoring ensures the success of the planned training program: when data from the monitoring training workload are not in line with the one expected by trainers, a proper intervention in the training workload should be done in order to reduce injury risks and improve players' performance.[5] For instance, a tapering training week before important matches led to increase external training load values during the game, nevertheless these findings need to be interpreted carefully given that other factors can affect match outcomes.[6]

Training load quantification uses the same monitoring methods both in men's and women's soccer, such as data from the Global Positioning System (GPS), or accelerometers, heart rate sensor and self-report questionnaires like the rate of perceived exertion (RPE). While heart rate and RPE are used to estimate the internal training load, the other instruments allow the monitoring of external training load by means total distance (totalDist), high speed running (HSR), number of sprints, number of accelerations (nAccel), number of decelerations (nDecel).[2] The literature presents few studies and different approaches in the definition of speed thresholds to evaluate external parameters in women's soccer. Some studies applied men thresholds while others set fixed or individualized thresholds based on the maximal aerobic speed (MAS) or maximal sprinting speed (MSS). Fixed thresholds could underestimate the real effort of a player, but no studies support a better external load quantification when individualized thresholds are set via MAS or MSS in women's soccer.[2] The lack of studies and the several approaches used in this field do not support a clear and uniform definition of these thresholds, therefore a mixed approach including both fixed and individualized thresholds could be appropriate. Another parameter widely used to assess the session training load in soccer is the session RPE (sRPE), obtained by multiplying RPE values with the duration of the activity.[2,7] Although the same monitoring methods are used in men and women's soccer, several inconsistencies are reported in the literature for female players. While the research on men supports the presence of a positive relationship between internal and external training load, the same results are not yet been found for elite women soccer players that show an unclear relationship.[2, 8–10] Some studies found a strong correlation between RPE and sRPE with some external parameters.[11,12] Meanwhile another reported a less clear relationship between internal training load and HSR, probably due to the player position and its influence on this relationship.[13]

Such unclear outcomes probably depend on the physical differences between men and women soccer players. An interesting work of Pedersen and coll.[14] stated that a direct comparison between men and women's soccer is unfair, because of the external physical factors which are responsible of many of the differences between sexes. When comparing a game, female players cover shorter total distance than male counterpart, moreover they cannot sprint as fast as men, and spend longer time at lower speeds. Despite this, women get fatigued earlier and performance decrease more than male in the second half.[14] Another possible explanation that could explain these gender differences is due to physiological hormonal fluctuations during the different moments of menstrual cycle (MC). Estrogen and progesterone hormones influence many physiological aspects which could have an impact on players' performance.[15–17] The cardiovascular system is influenced by estrogen hormones which improve endothelium-dependent vasodilatation and can lead to a difference in cardiac excitability. Conversely, progesterone seemed to have opposite effects than estrogen, generating an increase cardiac excitability. Estrogen and progesterone are involved in central neural control of breathing and have an impact on respiration and ventilation. Also, thermoregulation is affected by progesterone which has a central thermogenic effect. Estrogen and progesterone are also influenced the substrate metabolism: the first is involved in the increase of glycogen uptake and storage in liver and muscles, while both, but progesterone to a lesser extent, shift the metabolism toward free fatty acids. Lastly, psychological aspects are influenced by these hormonal levels: estrogen may influence different aspects of cognition, alertness, and cognitive performance.[15] All these physiological aspects influenced by sexual hormones could have an impact on players' performance. For these reasons the impact of MC and its relationship with performance parameters should be taken in account when monitoring women's performance. In fact, a recent systematic review on MC phase effect on exercise performance, reported that performance might be trivially reduced during the early follicular phase.[16] The investigation of MC impact on soccer performance is still poor and unclear.[18] Some studies found no

DOI: 10.53646/7xj3ry38
Published online: August 25, 2024

significant differences on performance outcomes between each MC phase, while Julian and coll.[19-21] found higher values of HSR during matches, in the luteal phase compared to follicular phase, with large level of match variation. Furthermore, MC impact on performance was investigated mainly through the administration of specific tests for aerobic capacity, sprint ability and strength.[19,20,22]

MC phased-based training is a promising area to improve training adaptive responses, especially for elite athletes where every detail might be fundamental. It is based on the proposed metabolic effect of estrogens and progesterone, where the first seemed to have an anabolic effect on skeletal muscles and improve muscle glycogen storage and fat utilization, while the latter seemed to have anti-estrogen effect.[15,16,18] Following this statements, follicular phase should be a favorable moment for training adaptations than luteal phase, and the beneficial effect of estrogen should be greater during late follicular phase and during ovulatory phase, when progesterone is lower.[18] Moreover, estrogen might have a protection effect on exercise-induced muscle damage, which could be another interesting point to enhance strength adaptations.[16,18]

Only few studies have investigated the internal training load and MC relationship and showed no MC effect on them, while another study showed lower perceived exertion during menstrual bleeding.[23,24,17]

The aim of this study was therefore to investigate the impact of MC phases on the external and internal training load parameters of elite women soccer players. We hypothesized to find lower values for external and internal parameters during early follicular phase. In this regard, time duration of training, totalDist, HSR, nAccel, nDecel, RPE and sRPE were assessed and related to MC phases during a period 12-weeks long in the Italian women soccer first division.

## METHODS

16 elite women soccer players from the same team of Italian first division were recruited during a three months in-season period. Players with an average cycle length of 21-35 days were included in the study. Otherwise, players who had irregular MC, amenorrhea, used oral contraceptive, and goalkeepers were excluded from the study. Out of a total sample of 28 players, only 16 met the requirements and were included in the study, however the whole team followed the same weekly schedule routine of 5 sessions of training and 1 match. All participants were previously informed about the purpose of the study and the research methods used and gave their written consent to participate in the study in accordance with the Declaration of Helsinki. The study was approved by the institutional ethics review committee (CAR 119/2022).

To assess players' metabolic profile, a pre-season maximal incremental test was performed on a treadmill (RunMed, Technogym, Italy) with a slope of 1%. Gas exchange data were collected continuously using an automated breath-by-breath system (K5, Cosmed, Italy). The measuring instrument was calibrated before each test. Test protocol was composed of a rest phase 5 min long, a warm-up phase 3 min long, which consisted of running pace of 8 $km \cdot h^{-1}$, and an incremental phase, where speed increased by 1 $km \cdot h^{-1}$ every minute until exhaustion. Aerobic and anaerobic threshold were detected by two independent observers (CI and LF) and were used to define players' functional physiological profile and to plan the initial workloads of the season. Also, RPE was collected each minute through the revised Borg scale CR10 by Foster et al.[25] The team average maximal aerobic speed (MAS) from incremental test, was used to set the HSR threshold.

The training sessions schedule followed the same order every week which focused on strength, aerobic power, repeated sprint ability (RSA), explosive strength, and pre-game session, respectively on Day 1 (Tuesday), 2 (Wednesday), 3 (Thursday), 4 (Friday) and 5 (Saturday) of the weeks. The sessions investigated for the present study were Day 2, 3 and 4, where external training load was monitored during the entire training through a personal GPS device (GPexe, Pro2, Udine, Italy).[26] Day 1 and 5 were excluded from the GPS monitoring because Day 1 was performed into the gym, and Day 5 was a shorter tactical session that did not lead to a real physical effort. All the variables reported in this study were the sum of data of Day 2, 3 and 4. For this reason, if a player missed one of the 3 selected sessions, the data of that week were removed from the study and the player was excluded if no other complete MC data were collected.

Each session included a warmup, technical and tactical exercises that were included in the monitoring process. Training sessions were performed at 9.30 in the morning and lasted about

DOI: 10.53646/7xj3ry38
Published online: August 25, 2024

90 and 120 minutes. Each session time was recorded as a variable named "totalTime".

The planned aerobic session consisted of 3 running blocks of 4 minutes each, at intermittent pace and different distances within a specific time. Secondly, players performed 6 minutes of high intensity games of 6 vs 6 players in a small size pitch, for 3 times. RSA session included 4 series of 6 all out sprints on different distances and with different angles of change of directions. Between each sprint 15 seconds of rest were performed and 2 minutes of active rest with the ball was completed between series. After this specific exercise, small side games of 3vs3, 4vs4 and 5vs5 were performed on different pitch sizes, with a specific tactical focus. To conclude, two matches lasted 10 to 15 minutes of 10 vs 10 were performed on a 75m size pitch. The explosive strength session included 30 minutes of specific exercises on the field such as plyometric jump, exercises with low weight or free bodyweight, sprints with and without loads, and a longer tactical part on a 75m pitch.

Before all sessions, participants completed a Google Form questionnaire on their personal mobile phone. In the questionnaire players specify the presence/absence of the MC, the day when it started and the eventually presence and level of menstrual symptoms. Menstrual symptoms were selected through a checklist and, if necessary, written in a textbox by the players (Appendix 1). With the same procedure, players reported RPE through the CR10 Borg scale within 30 minutes from the end of the training, through another questionnaire via mobile phone. [25] RPE data were used to obtain the sRPE to assess the training load of each session. All questionnaires' data were collected into an Excel sheet in anonymous form using an identification number for each player.

From GPS the following variables were extracted: totalDist, HSR, nAccel (>2 $m/s^2$) and nDecel (<-2 $m/s^2$).[2,18] Given the unclear definition of speed thresholds in literature, the HSR threshold was set at 15 $km \cdot h^{-1}$, which was the average MAS of the team, and which was selected based on the purpose of this study, the level of the players, and following data from literature and from a FIFA Women's World Cup report.[27]

MC phases individuation has been made through a "counting days" procedure, following the recommendation of Schmalenberger and coll.[28] MC track has been made since the start of the season, in order to detect players with irregular MC prior to the start of the collecting data and to exclude them from the present study. Only when a player reported two contiguous MC, the first of them were included in the analysis. Most of the players reported the data of one MC, while a few of them reported the mean values of two or three MCs, given that the data collection period was 3 months. The counting days procedure started with the first day of bleeding and ends with the first day of bleeding of the next MC. Once a specific MC was selected, the counting procedure started from the first day of bleeding and lasted 7 days, period that was defined as the menstrual week (menstWeek). The other weeks were calculated with a backward-count method from the second MC. Pre-cycle week (preCycle) was considered as the 7 days preceding the second MC; the post-ovulation week (postOV) included the days between day -14, and -7 from the second MC. This backward counting method is a solid way to discover the ovulation day that is on the day -14 from the second MC, but no ovulation test was performed using the gold standard method (LH-testing or body basal temperature). The pre-ovulation week (preOV) was calculated as the -7 days prior to the ovulation day. The period of 7 days was chosen to include Day 2, 3 and 4 into each selected MC week, regardless the day of the week where the counting procedure started.

All the reported data were expressed as mean, ± standard deviation (SD). Data were processed using the statistical software package IBM SPSS Statistics (Version 25.0. Armonk, NY: IBM Corp). Before analysis, the Shapiro-Wilk test was used to check the normality of data distribution. A repeated-measures ANOVA was performed to identify differences in the MC weeks for all the variables. The relationship between RPE and sRPE with external training load parameters were calculated using the Pearson's correlation coefficients ($r$). The strength of correlations was set as trivial (< 0.10), weak (0.10-0.29), moderate (0.30-0.49), strong (0.50 - 0.69), very strong (0.70 - 0.89) and nearly perfect (> 0.90).[29] The statistical significance was set at $p < 0.05$ for all tests.

## RESULTS

Analyses performed on our sample (age: 24.56 ±3.42 years; weight: 60.16 ±6.34 kg; height: 167.31 ±6.99 cm; $VO_{2max}$: 48.56 ±4.98 $mL \cdot kg^{-1} \cdot min^{-1}$), showed the following results which are presented on Table 1. The totalTime variable had no significant differences between the weeks of the MC ($F(3,45)=1.321$, $\eta_p^2=0.081$, $p = 0.279$). A significant difference was found in totalDist ($F(3,45)=3.677$,

DOI: 10.53646/7xj3ry38
Published online: August 25, 2024

$\eta_p^2$=0.197, *p* = 0.019) where the values of menstWeek (18318.70 ±1802.04 m) were lower than those of postOV (20358.41 ± 1639.27 m) (*p* = 0.022). The same significant difference was found in HSR (F(3,45)=3.760, $\eta_p^2$=0.200, *p* = 0.017) with lower values in menstWeek (5126.68 ± 996.67 m) than postOV (6084.28 ± 1030.35 m) (*p* = 0.002). All the other variables nAccel (F(3,45)=0.928, $\eta_p^2$=0.058, *p* = 0.435), nDecel (F(3,45)=0.972, $\eta_p^2$=0.061, *p* = 0.414), RPE (F(3,45)=1.882, $\eta_p^2$=0.111, *p* = 0.146) and sRPE (F(3,45)=1.512, $\eta_p^2$=0.092, *p* = 0.224), did not present differences between the MC phases.

Correlation of RPE and sRPE with external values was performed in two different ways. First, the relationship was evaluated without differentiate between MC weeks, and reported a weak positive association for RPE and totalDist (*r* = 0.258; *p* = 0.039), while sRPE showed a moderate positive association with totalDist (*r* = 0.389; *p* = 0.001), a weak positive association with HSR (*r* = 0.260; *p* = 0.038) and totalTime (*r* = 0.284; *p* = 0.023) as shown in Table 2. Trivial and non-significant correlations were found for RPE and sRPE with nAccel and nDecel variables. The second method evaluated the internal-external relationship for each MC week, and different results emerged and are reported in Table 3. Only the preCycle showed a strong significant positive correlation between RPE and totalDist (*r* = 0.545; *p* = 0.029), and between sRPE with totalDist (*r* = 0.514; *p* = 0.042) and totalTime (*r* = 0.502; *p* = 0.048).

It is worth noting that while there were no other significant differences, a trend emerged for all the external training load parameters: except for nAccel, totalTime and RPE, the other variables reached a peak in postOV, with lower values in preOV and preCycle than postOV, but greater than menstWeek. However, no statistical significance was reached.

**Table 1**. Sum of the weekly values (Day1, 2 and 3) expressed as mean ± SD of all the observed variables in the different weeks of MC.

| *Variable* | *menstWeek* | *preOV* | *postOV* | *preCycle* | *p* |
|---|---|---|---|---|---|
| ***totalTime (min)*** | 308.36 ±27.84 | 303.06 ±28.39 | 316.13 ±17.29 | 303.06 ±19.60 | 0.279 |
| ***totalDist (m)*** | 18318.70 ±1802.04* | 19531.32 ±2153.13 | 20358.41 ±1639.27* | 19196.58 ±2180.04 | 0.019 |
| ***HSR (m)*** | 5126.68 ±996.67** | 5661.66 ±1058.91 | 6084.28 ±1030.35** | 5435.13 ±1072.44 | 0.017 |
| ***nAccel (n)*** | 249.06 ±62.39 | 260.19 ±51.88 | 259.50 ±44.45 | 270.06 ±34.86 | 0.435 |
| ***nDecel (n)*** | 233.75 ±83.31 | 235.94 ±61.34 | 254.44 ±59.61 | 249.63 ±46.81 | 0.414 |
| ***RPE (au)*** | 12.28 ±3.20 | 13.59 ±2.25 | 13.69 ±3.57 | 14.16 ±3.53 | 0.146 |
| ***sRPE (RPE min)*** | 1270.25 ±369.15 | 1375.13 ±213.02 | 1455.56 ±396.91 | 1452.06 ±393.63 | 0.224 |

** Significant difference between menstWeek and postOV p=0.022*
***Significant difference between menstWeek and postOV p=0.002*

DOI: 10.53646/7xj3ry38
PUBLISHED ONLINE: AUGUST 25, 2024

**Table 2**. Pearson's correlation coefficient (r) for RPE and sRPE with external training load variables

| *Variable* | *RPE* | | *sRPE* | |
|---|---|---|---|---|
| | *r* | *p* | *r* | *p* |
| ***totalTime (min)*** | 0.042 | 0.743 | **0.284*** | **0.023** |
| ***totalDist (m)*** | **0.258*** | **0.039** | **0.389*** | **0.001** |
| ***HSR (m)*** | 0.124 | 0.331 | **0.260*** | **0.038** |
| ***nAaccel (n)*** | 0.093 | 0.467 | 0.077 | 0.545 |
| ***nDecel (n)*** | 0.010 | 0.939 | -0.053 | 0.675 |

* *Significant correlation ($p$<0.05)*

**Table 3**. Pearson's correlation coefficient (r) between RPE and sRPE with external training load variables in the different MC weeks

| | *menstWeek* | | *preOV* | | *postOV* | | *preCycle* | |
|---|---|---|---|---|---|---|---|---|
| ***Variable*** | *r* | *p* | *r* | *p* | *r* | *p* | *r* | *p* |
| | **RPE** | | | | | | | |
| ***totalTime (min)*** | 0.096 | 0.723 | -0.392 | 0.133 | 0.079 | 0.770 | 0.264 | 0.323 |
| ***totalDist (m)*** | 0.180 | 0.504 | -0.286 | 0.282 | 0.303 | 0.253 | **0.545*** | **0.029** |
| ***HSR (m)*** | -0.093 | 0.733 | -0.186 | 0.489 | 0.267 | 0.318 | 0.247 | 0.355 |
| ***nAccel (n)*** | -0.081 | 0.767 | 0.155 | 0.566 | 0.270 | 0.312 | -0.045 | 0.869 |
| ***nDecel (n)*** | -0.216 | 0.422 | 0.170 | 0.529 | 0.112 | 0.679 | 0.001 | 0.997 |
| | **sRPE** | | | | | | | |
| ***totalTime (min)*** | 0.374 | 0.154 | 0.206 | 0.444 | 0.283 | 0.289 | **0.502*** | **0.048** |
| ***totalDist (m)*** | 0.374 | 0.154 | 0.112 | 0.679 | 0.375 | 0.153 | **0.514*** | **0.042** |
| ***HSR (m)*** | -0.005 | 0.985 | 0.288 | 0.280 | 0.385 | 0.141 | 0.258 | 0.334 |
| ***nAccel (n)*** | -0.214 | 0.426 | 0.475 | 0.063 | 0.186 | 0.491 | -0.005 | 0.986 |
| ***nDecel (n)*** | -0.362 | 0.168 | 0.391 | 0.134 | -0.001 | 0.997 | -0.079 | 0.770 |

* *Significant correlation ($p < 0.05$)*

## DISCUSSION

To the best of our knowledge, there were no studies which has focused on the training monitoring of external and internal training load parameters in relation to MC phases in elite women's soccer during a professional season. These parameters are currently monitored to tune the training workload to enhance the physical and psychological player's status before the match. The aim of the present study was therefore to investigate the effect of MC phases on the main internal and external parameters during the training of elite women soccer players.

Data collection was conducted during specific sessions of training days and not during games, to avoid the potential impact of external and non-controllable match-factors that could have an impact on players' performance. Games are affected by several factors (level of the opponent, surface's type, type of the match, psychological and motivational aspects) which are difficult to manage. Therefore, this study focused only on training days, to standardize the monitoring process and to focus on the performance in relation to MC phases.

As expected, results showed no significant difference in the weekly totalTime between the MC phases, suggesting that the total amount of minutes for every training week investigated was maintained the same during the monitored period. Therefore, external and internal training load

DOI: 10.53646/7xj3ry38
PUBLISHED ONLINE: AUGUST 25, 2024

variables were not affected by the totalTime which was constant for all the weeks, but their variations may be attributed to other factors, such MC.

As reported above, present totalDist values showed significantly lower values during menstWeek compared to postOV and this result differs from that reported by Julian and coll., that did not find a significant difference between follicular phase and luteal phase during games. [21] A possible explanation can be found in the different approach of MC phases individuation: the authors considered the entire follicular phase and luteal phase, while the present study focused on more specific weeks of observation. To support this hypothesis the present data were also analyzed in a grouped way to compare with literature (menstWeek + preOV considered as follicular phase; postOV + preCycle considered as luteal phase), but no significant differences emerged. The statistical difference reported when considering specific weeks of the MC and the non-statistical result when observing the whole follicular phase and luteal phase, suggest the importance to differentiate MC's phases into more specific segments, given that follicular phase and luteal phase have a bigger window of observation with different hormonal levels that may not be detected. Another explanation of this discrepancy with Julian and coll. outcomes, is that the present study focused on more days of observation, which could better describe the possible chronic impact of MC on training players' response, while the authors analyzed only one specific day, which describes acute responses.[21]

HSR values were statistically lower during menstWeek compared to postOV. This finding is in part consistent with those of Julian and coll., where they found higher values in luteal phase compared to follicular phase during matches, despite a large variation across games which can be due to several influencing factors: the opponent's level, the home/away match, the type of surface, the time of the day in which the match is performed.[21] Conversely, practice can be considered a more standardized condition, at the same time every session, the same surface, and a more stable weekly workload, controlled by coaches. Moreover, during training the psychological and motivational aspects should not affect players, while during a match they could have an enormous impact.[30] Another important factor that emphasized the difference between practice and match and that could give more relevance to training observation, is the difference in external training load values that occurs in relation to player's position during games. Contrarily, during training, similar values were found for different roles.[31]

TotalDist and HSR are parameters which can provide relevant information on aerobic and anaerobic performance respectively, and their lower values registered during menstWeek suggest that aerobic and anaerobic endurance performance during training could be impaired in early follicular phase in elite women's soccer.[32] These findings are in line with a recent systematic review that reported a trivial reduction of performance in early follicular phase.[16] These impairments could be due to the low levels of estrogen and progesterone which have no effect on the metabolic pathway, as happens, on the contrary, when these hormones levels are higher. Therefore, during menstruation week the efficiency of the glycogen spare and fat utilization is no longer present and can led to lower performance.

No significant differences were found between MC's weeks for nAccel and nDecel variables. As these variables describe the neuromuscular effort, it seemed that MC phases have no impact on this aspect.[32] These results were not expected given that a study stated that these variables seemed to be important for a complete training load monitoring in women's soccer.[12] Probably the shorter period of investigation of that study was not enough to individuate the real monitoring capacity of these variables. However, further research to understand at which extend nAccel and nDecel can be important indicators for elite women's soccer monitoring is needed.

From a hormonal perspective, the highest external training load values were expected in preOV when the level of progesterone (hormone associated with catabolic response and known for its anti-estrogen effects), was still low and when the peak of estrogen (which is known for the anabolic effect on skeletal muscle), occurred.[16] However, the higher significant external training load values were reported during postOV, after the estrogen peak and when progesterone started to increase. This could be explained by the possible time lag between the change in hormonal levels and their effect on performance, given that it was found a 4-day delay on knee laxity changes.[15] Another possible explanation is the sparing progesterone effect on glycogen utilization and shift on fat free acids which could contribute to enhance performance in postOV phase.[15]

DOI: 10.53646/7xj3ry38
Published online: August 25, 2024

Given the statistical differences reported for two main external training load parameters, an unexpected non-significant change occurred for RPE and sRPE values that were similar during all the MC weeks. These results showed that in menstWeek, despite less external training load, the perceived effort was similar to the other observed weeks and not lower as expected. A probable justification could be given by the effect that MC's symptoms could have on players and that may lead to alter perceived effort, increasing its values. This hypothesis is supported by a study where higher values of perceived exertion were registered during menstWeek, and put the attention on RPE and sRPE parameters, highlighting that, in elite women's soccer practice, they should be interpreted with caution especially when players are in the first week of MC.[17]

The correlations of RPE and sRPE with external training load showed weak and unclear results. Specifically, when considering the whole MC without differentiate between specific phases, the relationship for RPE and sRPE reported respectively a weak and moderate correlation with totalDist, and a weak correlation for sRPE with HSR and totalTime. However, when considering the MC phases as proposed in this study, the only strong and significant correlations were found during the preCycle for RPE with totalDist, and for sRPE with totalDist and totalTime values. No significant relationships were found with nAccel and nDecel parameters, despite a study described these two variables as good indicators for a better training load monitoring in elite women soccer.[12] This discrepancy could be due to the shorter monitoring period of the study in which only two weeks of work were monitored. The lack of significant correlation for these variables showed the need of further investigation, also due to the preOV values that reported a moderate relationship for nAccel with sRPE with a tendency toward significance ($p$ = 0.063).

This unclear relationship between RPE and external training load parameters had already been discussed in the literature for women's soccer, and current results suggest using RPE values with caution and always in combination with other parameters (both internal and external), especially when monitoring elite women soccer players during practice and in early follicular phase.[2]

Some limitations must be recognized. The counting method to individuate MC phase has already been used in the literature, but it cannot confirm whether ovulation occurs or not, given that anovulatory MC are common in players.[28] In addition, there are no hormonal data which confirm the estrogen/progesterone influence on external and internal training load parameters. Moreover, our methodology greatly reduces contextual and non-controllable factors which can affect performance but cannot totally exclude them from having a minimum and possible influence on it. To conclude, the limited period of study observation and the small sample size, allowed to collect few MC for each participant, and a prolonged period with greater number of participants would permit a wide data collection.

## CONCLUSION

The results showed lower values of totalDist and HSR during menstWeek, with no differences for RPE and sRPE values, showing that changes in exercise load perception do not always follow external training load changes and may be influenced by MC, especially in early follicular phase. Therefore, RPE and sRPE should be interpreted with caution when used alone, particularly during menstWeek, because they could be affected by MC's symptoms and, in turn, change external training load performance. The menstWeek could negatively affect aerobic and anaerobic endurance performance during training, therefore, when monitoring players with menstruation, different values could be expected, and the weekly training workload could be adapted and individualized.

**Conflict of Interest Statement**
The authors declare no conflicts of interest with the contents of this study.

**Corresponding Author**
Chirara Groff, MSc
SS Lazio Spa
Via di Santa Cornelia 1000
Formello, Roma, Italy 00060
Email: chiaragrofftn@gmail.com

DOI: 10.53646/7xj3ry38
Published online: August 25, 2024

## REFERENCES


1. Kirkendall DT, Krustrup P. Studying professional and recreational female footballers: A bibliometric exercise. Scand J Med Sci Sports. 2022;32(S1):12-26. doi:10.1111/sms.14019
2. Costa JA, Rago V, Brito P, et al. Training in women soccer players: A systematic review on training load monitoring. Front Psychol. 2022;13. doi:10.3389/fpsyg.2022.943857
3. Mujika I, Halson S, Burke LM, Balagué G, Farrow D. An integrated, multifactorial approach to periodization for optimal performance in individual and team sports. Int J Sports Physiol Perform. 2018;13(5):538-561. doi:10.1123/ijspp.2018-0093
4. Djaoui L, Haddad M, Chamari K, Dellal A. Monitoring training load and fatigue in soccer players with physiological markers. Physiol Behav. 2017;181:86-94. doi:10.1016/j.physbeh.2017.09.004
5. Ravé G, Granacher U, Boullosa D, Hackney AC, Zouhal H. How to Use Global Positioning Systems (GPS) Data to Monitor Training Load in the "Real World" of Elite Soccer. Front Physiol. 2020;11. doi:10.3389/fphys.2020.00944
6. Fessi MS, Zarrouk N, Di Salvo V, Filetti C, Barker AR, Moalla W. Effects of tapering on physical match activities in professional soccer players. J Sports Sci. 2016;34(24):2189-2194. doi:10.1080/02640414.2016.1171891
7. Impellizzeri FM, Rampinini E, Coutts AJ, Sassi A, Marcora SM. Use of RPE-based training load in soccer. Med Sci Sports Exerc. 2004;36(6):1042-1047. doi:10.1249/01.MSS.0000128199.23901.2F
8. Marynowicz J, Lango M, Horna D, Kikut K, Andrzejewski M. Predicting ratings of perceived exertion in youth soccer using decision tree models. Biol Sport. 2022;39(2):245-252. doi:10.5114/BIOLSPORT.2022.103723
9. Marynowicz J, Kikut K, Lango M, Horna D, Andrzejewski M. Relationship Between the Session-RPE and External Measures of Training Load in Youth Soccer Training.; 2020. www.nsca.com
10. McLaren SJ, Macpherson TW, Coutts AJ, Hurst C, Spears IR, Weston M. The Relationships Between Internal and External Measures of Training Load and Intensity in Team Sports: A Meta-Analysis. Sports Medicine. 2018;48(3):641-658. doi:10.1007/s40279-017-0830-z
11. Askow AT, Lobato AL, Arndts DJ, et al. Session rating of perceived exertion (Srpe) load and training impulse are strongly correlated to gps-derived measures of external load in ncaa division i women's soccer athletes. J Funct Morphol Kinesiol. 2021;6(4). doi:10.3390/jfmk6040090
12. Douchet T, Humbertclaude A, Cometti C, Paizis C, Babault N. Quantifying accelerations and decelerations in elite women soccer players during regular in-season training as an index of training load. Sports. 2021;9(8). doi:10.3390/sports9080109
13. Ishida A, Kyle Travis S, Draper G, White JB, Stone MH. Player Position Affects Relationship Between Internal and External Training Loads During Division I Collegiate Female Soccer Season. J Strength Cond Res. 2022;36(2):513-517. doi:10.1519/JSC.0000000000004188
14. Pedersen AV, Aksdal IM, Stalsberg R. Scaling demands of soccer according to anthropometric and physiological sex differences: A fairer comparison of men's and women's soccer. Front Psychol. 2019;10(APR). doi:10.3389/fpsyg.2019.00762
15. Constantini NW, Dubnov G, Lebrun CM. The menstrual cycle and sport performance. Clin Sports Med. 2005;24(2). doi:10.1016/j.csm.2005.01.003
16. McNulty KL, Elliott-Sale KJ, Dolan E, et al. The Effects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-Analysis. Sports Medicine. 2020;50(10):1813-1827. doi:10.1007/s40279-020-01319-3
17. Gamberale F, Wahlberg I, Gamberale F, Wahlberg L. Female Work Capacity during the Menstrual Cycle Physiological and Psychological Reactions. Vol 1.; 1975.
18. Randell RK, Clifford T, Drust B, et al. Physiological Characteristics of Female Soccer Players and Health and Performance Considerations: A Narrative Review. Sports Medicine. 2021;51(7):1377-1399. doi:10.1007/s40279-021-01458-1
19. Tounsi M, Jaafaraafar H, Aloui A, Souissi N. Soccer-related performance in eumenorrheic Tunisian high-level soccer players: Effects of menstrual cycle phase and moment of day. Journal of Sports Medicine and Physical Fitness. 2018;58(4):497-502. doi:10.23736/S0022-4707.17.06958-4
20. Julian R, Hecksteden A, Fullagar HHK, Meyer T. The effects of menstrual cycle phase on physical performance in female soccer players. PLoS One. 2017;12(3). doi:10.1371/journal.pone.0173951
21. Julian R, Skorski S, Hecksteden A, et al. Menstrual cycle phase and elite female soccer match-play: influence on various physical performance outputs. Science and Medicine in Football. 2021;5(2):97-104. doi:10.1080/24733938.2020.1802057
22. Dos Santos A Ndrade M, Mascarin NC, Foster R, De Jármy Di Bella ZI, Vancini RL, Barbosa De Lira CA. Is muscular strength balance influenced by menstrual cycle in female soccer players? Journal of Sports Medicine and Physical Fitness. 2017;57(6):859-864. doi:10.23736/S0022-4707.16.06290-3
23. Cristina-Souza G, Santos-Mariano AC, Souza-Rodrigues CC, et al. Menstrual cycle alters training strain, monotony, and technical training length in young. J Sports Sci. 2019;37(16):1824-1830. doi:10.1080/02640414.2019.1597826
24. Arenas-Pareja M de los Á, López-Sierra P, Ibáñez SJ, García-Rubio J. Influence of Menstrual Cycle on


DOI: 10.53646/7xj3ry38
Published online: August 25, 2024

Internal and External Load in Professional Women Basketball Players. Healthcare. 2023;11(6):822. doi:10.3390/healthcare11060822
25. Foster C, Florhaug JA, Franklin J, et al. A New Approach to Monitoring Exercise Training. J Strength Cond Res. 2001;15(1):109-115. doi:10.1519/00124278-200102000-00019
26. Komino P, Le Mat Y, Zadro I, Osgnach C, Morin JB. Sprint Acceleration Force-Velocity Profile with GPS and 1080 Sprint.
27. PHYSICAL ANALYSIS OF THE FIFA WOMEN'S WORLD CUP FRANCE 2019™.
28. Schmalenberger KM, Tauseef HA, Barone JC, et al. How to study the menstrual cycle: Practical tools and recommendations. Psychoneuroendocrinology. 2021;123. doi:10.1016/j.psyneuen.2020.104895
29. Hopkins WG. Measures of Reliability in Sports Medicine and Science. Vol 30.; 2000.
30. Slimani M, Baker JS, Cheour F, Taylor L, Bragazzi NL. Steroid hormones and psychological responses to soccer matches: Insights from a systematic review and meta-analysis. PLoS One. 2017;12(10). doi:10.1371/journal.pone.0186100
31. Romero-Moraleda B, Nedergaard NJ, Morencos E, Casamichana D, Ramirez-Campillo R, Vanrenterghem J. External and internal loads during the competitive season in professional female soccer players according to their playing position: differences between training and competition. Research in Sports Medicine. 2021;29(5):449-461. doi:10.1080/15438627.2021.1895781
32. Pino-Ortega J, Rojas-Valverde D, Gómez-Carmona CD, Rico-González M. Training design, performance analysis and talent identification—a systematic review about the most relevant variables through the principal component analysis in soccer, basketball and rugby. Int J Environ Res Public Health. 2021;18(5):1-18. doi:10.3390/ijerph18052642

DOI: 10.53646/7xj3ry38
PUBLISHED ONLINE: AUGUST 25, 2024

**APPENDIX 1.** Questionnaire

1. Do you have period now?
    - o Yes
    - o No

2. If you have your period right now: when did it start? (report the date)
_ _ / _ _ / _ _ _ _

3. Indicate the symptom level on a scale of 1 to 10 (1 = absent 10 = maximum)

❑Lower back pain
❑Pelvic pain
❑Headache
❑Stress
❑Mood swings
❑Change in appetite
❑Sleep alteration
❑Abdominal cramps
❑Flushes
❑Swelling
❑Other: ________

4. If you have no period right now: do you have premenstrual syndrome symptoms now? If so, which ones?

❑Lower back pain
❑Pelvic pain
❑Headache
❑Stress
❑Mood swings
❑Change in appetite
❑Sleep alteration
❑Abdominal cramps
❑Flushes
❑Swelling
❑Other: ________

DOI: 10.53646/7xj3ry38
PUBLISHED ONLINE: AUGUST 25, 2024