Scientific Research Publishing

Advances in Physical Education, 2025, 15(4), 372-380
https://www.scirp.org/journal/ape
ISSN Online: 2164-0408
ISSN Print: 2164-0386

Variation in Performance in Different Specific Physical Tests during a Menstrual Cycle in Congolese Handball Players

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How to cite this paper: Alongo, Y. R. G., Moussouami, S. I., Itoua Oniangue Assoba, K., Ibata Ondze, C., Epele, R. P., & Ampa, R. (2025). Variation in Performance in Different Specific Physical Tests during a Menstrual Cycle in Congolese Handball Players. *Advances in Physical Education, 15,* 372-380.
https://doi.org/10.4236/ape.2025.154026

Received: June 9, 2025
Accepted: September 21, 2025
Published: September 24, 2025

Abstract

Background: Handball is an intense intermittent sport, played for 60 minutes (two halves), with physical exertion provoking heart rates above 85% of HRmax and VO_2max up to 61 ml/kg/min in men. **Objective:** This study aims to evaluate the variations in physiological responses and physical performances in female handball players during the different phases of the menstrual cycle. **Methodology:** The performances measured included the intermittent Yo-Yo test, repeated sprints and exercises with a weighted ball (jumps, shots, supports, supports and duels simulating the attack/defense opposition). The sample consisted of female handball players aged 19.71 ± 0.72 years. **Results:** The tests revealed significant differences ($p < 0.05$) according to the phases of the cycle. Performance in ball exercises and repeated sprints is better in the follicular phase. The cycle also influences performance in the Yo-Yo test, maximum heart rate, and muscle strength, with optimal results during the ovulatory phase. **Conclusion:** The menstrual cycle influences the physical performance of handball players, with better results observed in the follicular phase, especially around ovulation. These variations must be taken into account in training planning to optimize performance and limit fatigue.

Keywords

Variations, Performance, Menstrual Cycle, Sport, Congo

1. Introduction

Handball, a demanding team sport, relies on intense and intermittent efforts including sprints, changes of direction and physical duels. To meet these demands, targeted physical preparation is essential. Optimal performance depends on several physiological and hormonal factors, including gender, blood volume, heart rate, body temperature, muscle strength (shoulder blades and lower limbs) and VO_2max (de Jonge et al., 2001). Although training rules and methods are identical for both sexes, physiological responses may differ depending on these parameters. The menstrual cycle is a key factor to consider in the training process in women. It is divided into two main phases: follicular and luteal, each marked by hormonal fluctuations that can affect physiology, particularly via estrogen and progesterone receptors present in skeletal muscle. These hormones influence performance, particularly in sports such as handball (Pallavi et al., 2017). Recent studies show that women may be more prone to decreased performance and muscle pain in the early follicular phase. In this context, Pallavi et al. (2017) and Wideman et al. (2010) emphasized the importance of strict inclusion criteria (regular cycle, absence of contraceptives) to ensure data reliability. The protocol of this study, validated by an ethics committee according to the principles of Helsinki, includes anthropometric, physiological and biochemical measurements at each phase of the cycle: heart rate and core body temperature. This rigorous monitoring aims to better understand the hormonal impact on female performance. In this study, urine density is used to assess the water status of the participants, and the heat stress index is also calculated. Several field tests are conducted: the Yo-Yo IRT2 to estimate VO_2max, the weighted ball test to measure scapular limb strength, as well as a repeated sprint capacity test (Moussouami et al., 2022).

These assessments are performed on the 6th and 10th days of the follicular phase, at the end of this follicular phase precisely around the 14^{th} damarking an important event: ovulation, and finally on the 20th and 24th days of the luteal phase, in order to compare physiological responses according to the menstrual cycle. All measurements are repeated at the same time to ensure reliability. The results show that parameters such as VO_2max and body temperature vary according to the phases of the cycle, confirming the hormonal impact on performance. Contrary to some research, Moussouami et al. (2022) and Güler & Günay (2019) have shown that the menstrual cycle does not influence physical performances such as flexibility, speed, power, or aerobic and anaerobic capacities in female futsal players. Similarly, Romero-Moraleda et al. (2019) have observed that resistance-trained women show consistent performances in strength and power, regardless of the time of the cycle, when working at varying loads. However, available data remain limited and sometimes contradictory. Few studies have specifically examined the impact of different phases of the menstrual cycle, with particular emphasis on ovulation, on the physical performance of female handball players. This study aims to fill this gap by assessing the effects of the menstrual cycle on physiological responses and performance during repeated sprints in high-level female handball players.

2. Materials and Methods

2.1. Participants

A total of 69 elite female players from Brazzaville, juniors and seniors, with a normal menstrual cycle (between 26 and 28 days), participated in this research. The sample for this study, selected by reasoned choice, consisted of 23 players in the luteal phase and 23 in the follicular phase and 23 players in ovulation. These athletes were selected for their experience in national and international competitions. To be included in the sample for this research, each player had to meet the following inclusion criteria: be licensed during the 2023-2024 season. In addition to the general criteria, the athletes had to continue their training during the follicular (FP) and luteal (LP) phases, except on the days of the experiment. They were prohibited from consuming caffeine, alcohol, or any other drugs.

2.2. Anthropometric Tests and Measurements

Participants' height was measured using a ZT-150A height measuring rod (Perlong Medical, China), graduated to the nearest centimeter. Subjects stood barefoot, heels together, arms at their sides, and eyes horizontal. Measurements were taken from the floor to the vertex (top of the head), compressing the hair with a movable set square. Body mass: Body weight was determined using an electronic Personal Scale (model 2003A, accuracy: 0.1 kg; maximum capacity: 180 kg). Participants stood on the platform with their feet approximately 15 cm apart, arms relaxed, and eyes straight ahead. Weight was read directly from the screen in kilograms. Participants wore lightweight, culturally appropriate clothing and were barefoot during weight measurement. BMI (kg/m^2) was calculated using the Quetelet formula. Biometric measurements included: core body temperature, which was measured rectally using an MT 101R automatic thermometer (Hangzhou Sejoy, China). The device, disinfected with alcohol before each use, emitted an audible signal when switched on. A Biopac MP100 system with a SKT100C transducer (1.7 mm diameter) was also used for more accurate measurement. The repeated sprint test assessed the ability to repeat intense efforts. Over a distance of 35 meters, delimited by two sensors placed at the start and finish, participants performed sprints at maximum speed, interspersed with 10 seconds of recovery. The time of each race was timed to assess performance and anaerobic endurance. Furthermore, the anaerobic sprint (CSR)—6 × 35 m test consisted of performing six 35-meter sprints at maximum intensity, separated by 10 seconds of recovery. The times achieved in each sprint were recorded to calculate individual anaerobic power. The Yo-Yo Intermittent Recovery Test Level 2 (Yo-Yo IRT2) was used to assess aerobic capacity. It consists of a series of round-trip runs at increasing intensity, interspersed with brief rests. The total distance covered is used to estimate VO_2max. Body temperature was measured using a rectally inserted thermistor probe, protected by a plastic film lubricated with gel, to ensure comfort and accuracy. However, heart rate was measured using a Geonote heart rate monitor (Decathlon, France), worn during the various tests to monitor heart rate variations during exercise. Heart rate was measured for all subjects; the participant wore a belt equipped with heart rate sensors connected to a wristwatch. After activating the device and the heart-shaped icon indicating recording, the subject remained at rest for a few minutes. Heart rate was then recorded by the administrator once stabilized. Water status was assessed using a PEN-Urine clinical refractometer (Atago, Japan), based on urinary specific gravity (UD). UD < 1.020: normal hydration; 1.020 < UD < 1.030: moderate dehydration; UD > 1.030: severe dehydration.

Menstrual cycle data were collected via the MyCalendar mobile application (Period-Tracker, USA) and a personal menstrual diary. These tools allowed identification of cycle length, the start of each phase, as well as symptoms experienced before and during menstruation. Each participant completed a complete cycle from a randomly assigned phase. VO_2max (Yo-Yo Test IRT2) was assessed using the 20 m intermittent shuttle run test, interspersed with 10 seconds of active recovery over 5 m. The level achieved allows calculation of VO_2max according to the formula: VO_2max (mL/min/kg) = distance (m) × 0.0136 + 45.3 (Bangsbo et al., 2008). The medicine ball throw test (eccentric) was used to assess the strength/thrust of the scapular limbs. Using a 2 kg ball, the subject throws in flexion-extension of the arms, standing, without bending the legs or arching the back. Three trials are carried out, with 60 s of recovery; the best throw is retained for analysis.

2.3. Statistical Analysis

The data in this study were processed using Statistica software (Stat. Soft. Inc., version 12.0). The normality of the distribution of variables was verified by the Kolmogorov-Smirnov test and the homogeneity of variances by the Levée test. Three-way ANOVA or key factors (three phases/cycle periods) were used to test for interactions between measurement times and groups. The Wilcoxon signed-rank test was used to test the effect of measurement time for each period. Comparisons between the two cycle periods were made using the Man Whitney U test. The significance level of the statistical tests was set at $p < 0.05$.

3. Results

Table 1. Comparison of anthropometric and physiological characteristics related to cardiovascular values and body temperatures by different follicular, luteinic and ovulating phases in mean form ± standard deviation.

Variables	PF (n = 23) x ± σ	PO (n = 23) x ± σ	PL (n = 23) x ± σ	*p*
Age (years)	19.36 ± 0.84	19.71 ± 0.72	19.71 ± 0.72	NS
Height (cm)	160.61 ± 5.41	168.09 ± 3.73*	165.09 ± 3.73	<0.05
Body mass (kg)	59.88 ± 8.09	60.00 ± 5.76*	57.01 ± 5.76	<0.05
BMI (kg/m²)	21.61 ± 3.00	21.00 ± 2.17	21.03 ± 2.77	NS
HR (bpm)	83 ± 40	83 ± 2 5*	87 ± 50	<0.05
Tc (˚C)	37.26 ± 0.50	37.90 ± 0.48*	37.80 ± 0.48	<0.05

Legends: PF: follicular phase; PL: luteal phase; PO: ovulatory period; MC: body mass; BMI: hint of mass bodily; FC: frequency cardiac at rest; Tc: temperature central, significant at $p < 0.05$.

Table 2. Comparison of physiological parameters and performances during the different phases of the menstrual cycle in the handball players studied in the form of mean and standard deviation.

Variables	PF (n = 23) x ± σ	PO (n = 23) x ± σ	PL (n = 23) x ± σ	*p*
HR (bpm)	79.3 ± 3.4	78.7 ± 4.6	85.7 ± 4.6*	<0.05
Theoretical FCmax (bpm)	202 ± 1	208 ± 1*	202 ± 1	<0.05
FCemax (bpm)	161 ± 3	160 ± 5	174 ± 5*	<0.05
Tc (˚C)	38.81 ± 0.28	38.81 ± 0.5	38.85 ± 0.5*	<0.05
Urine Specific Gravity (UD)	1.01 ± 0.008	1.01 ± 0.002	1.01 ± 0.10*	<0.05
% PP (%)	1.30 ± 0.45	1.29 ± 0.62	1.73 ± 0.62*	<0.05
I PCT	6.48 ± 0.56	6.50 ± 1.01*	6.44 ± 1.01	<0.05
VO_2max (mL/min/kg)	49.28 ± 1.07	51.40 ± 0.75*	47.40 ± 0.76	<0.05
PBL	7.28 ± 0.35	7.41 ± 0.21*	6.73 ± 1.01	<0.05
CSR	6.81 ± 0.38	6.79 ± 0.32*	7.01 ± 0.32	<0.05
Pmoy	240.87 ± 58.30	242.47 ± 25.81*	209.47 ± 25.81	<0.05
Pmax	308.02 ± 68.63	369.34 ± 16.09*	269.34 ± 16.09	<0.05
IF	40.88 ± 7.23	40.89 ± 12.57*	40.44 ± 12.57	<0.05

Captions: FCe: exercise heart rate; FCmax theoretical: maximum heart rate; Tc: body temperature; % PP: percentage of weight loss; IPCT: heat stress index; VO_2max: maximum oxygen consumption; PBL: ball-weighted performance; CSR: repeated sprint capacity; Pmoy: average power; Pmax: maximum power; PL: luteinic phase, PF: follicular phase, PO: ovulation period; significance set at $p < 0.05$.

4. Discussion

The results in Table 1 show that the core temperature was significantly lower during the follicular phase (FP) (37.81˚C ± 0.5˚C), and during the ovulatory period it was equal to that of the luteal phase (LP). This thermal variation is consistent with the literature, which associates the luteal phase with a thermal elevation due to the thermogenic effect of progesterone (Sunderland & Nevill, 2003). On the cardiovascular level, the handball players in LP presented a higher heart rate during exercise (174 ± 5 bpm) and more less in the ovulatory period (160 ± 5 bpm) than in the follicular phase (161 ± 3 bpm), indicating a greater cardiovascular demand for an equivalent effort. This may explain the lower endurance capacity observed in the follicular phase, particularly in the ovulatory period, possibly linked to a slower recovery or an increased perception of fatigue. These results are close and corroborate the results (Moussouami et al., 2022; Sunderland & Nevill, 2003).

In contrast, no significant difference was found in raw sprint performance, suggesting that the impact of the menstrual cycle may be more evident on endurance than on explosiveness.

These results confirm the interest in adapting training loads according to the phases of the menstrual cycle to optimize performance and preserve the health of female athletes.

The objective of this study was to assess variations in physical performance in female handball players at different phases of the menstrual cycle and during ovulation.

The results in Table 2 show significant variations across the phases, particularly during the ovulatory period where the players' VO_2max values are higher in the follicular phase (49.28 ± 1.07 ml/min/kg) compared to the luteal phase (47.40 ± 0.76 ml/min/kg), with the highest values observed during ovulation (51.40 ± 0.75 ml/min/kg). This indicates better aerobic capacity during the ovulatory period.

This indicates a better aerobic capacity in the ovulating period. Repeated sprints and medicine ball throwing, the best performances were observed in the follicular phase, more precisely in the ovulating period, suggesting greater strength and explosiveness at this time of the cycle. Lactatemia ([La]): After sprints, lactic concentration was higher in the follicular phase (7.28 ± 0.35 mmol/l), particularly in the ovulatory period (7.41 ± 0.21 mmol/l) than in the luteal phase (6.73 ± 1.01 mmol/l), as was plasma osmolarity, indicating greater tolerance of intense effort in the ovulatory phase, which is an important event in the follicular phase. Maximum heart rate (HRmax) was significantly higher in the luteal phase, which may indicate a greater cardiovascular load at equal effort.

The results from Table 1 and Table 2 suggest that the follicular phase, particularly during ovulation, is a crucial period of the ovulatory process, enhancing the physical performance of handball players, especially in aerobic, anaerobic, and strength efforts. This supports the idea of individually considering the menstrual cycle when planning training programs.

Physical performance in handball, particularly in endurance, is influenced not only by training but also by physiological factors such as the menstrual cycle. This study confirms previous work, notably that of (Bandyopadhyay & Dalui, 2012), which shows that aerobic capacity is modified according to the phases of the cycle. A central hypothesis is based on the fluctuation of ovarian hormones, in particular the rise of progesterone in the luteal phase, which leads to an increase in body temperature (0.3˚C to 0.5˚C). This mild hyperthermia could alter thermoregulation, induce early fatigue and decrease aerobic performance, particularly in hot and humid conditions. However, the data remain partially contradictory, with some studies finding no significant differences. This indicates that other factors (environment, individual adaptation, type of effort) may interact with the menstrual cycle. Despite this, the general trend suggests that the follicular phase remains more favorable for long-term efforts. Post-exercise lactate concentrations vary depending on the phase of the menstrual cycle, particularly at 3 and 5 minutes of recovery. In this study, a reduction in luteal phase lactate was observed, which may be explained by a reduced demand for aerobic glycolysis, as suggested by (Oosthuyse & Bosch, 2010). However, no difference is noted at rest or at peak effort, which confirms the observations of (Vaiksaar et al., 2011) in female rowers. This suggests that it is not the initial lactate production that varies, but rather the post-exercise clearance, potentially influenced by hormones. The diversity of protocols, disciplines (handball, football) and intensities makes a strict comparison between studies difficult. These differences justify the need for sport-specific research, because physiological responses to the menstrual cycle are not universal but modulated by the nature of the effort. Sprint performance and muscle strength do not vary significantly between the follicular and luteal phases of the menstrual cycle are high in the late follicular phase otherwise in the ovulating period. These results are consistent with those of (Julian et al., 2017). In female footballers, as well as other studies using classic muscle strength tests. However, this study was innovated by using the medicine ball throw test to assess pelvic limb strength, without finding a notable effect of the cycle. On the other hand, some research shows that the follicular phase, with higher levels of free testosterone, may promote an increase in muscle strength and volume. This suggests that the influence of the menstrual cycle on muscle strength remains controversial and may depend on the type of test, the muscle assessed, and the population studied, depending on the sport practiced. A better understanding requires more targeted studies on different muscles and types of effort in relation to the technical gesture.

The hormonal impact of the menstrual cycle on performance and fluctuations in estradiol and progesterone potentially influence athletic physiology and performance, but without direct hormonal measurements, these effects remain difficult to confirm precisely. The methodological limitations of the study include the small sample size and the lack of hormone assays to validate cycle phases. Monitoring was based solely on the menstrual calendar, without information on blood loss or hormone levels. This study shows the importance of ovulation, which occurs around day 14 of the cycle, corresponding to a peak in estrogen and LH, promoting better energy availability and a possible improvement in muscle capacity or recovery. This is a potentially favorable period for performance, but this varies between individuals. The data are still heterogeneous. Hence the importance of future research integrating hormone assays and larger samples to better understand the link between the menstrual cycle and athletic performance. Indeed, the period of high physiological performance is during ovulation, the estrogen level is at its peak. This promotes better recovery, an increase in muscle strength and greater tolerance to effort. These effects are beneficial for intense activities such as sprints or handball duels. Thus, the influence on the training strategy is to understand this moment which allows to optimize the workloads in the high efficiency phase, and to modulate the training in the luteal phase where fatigue can be more present. This is why the reduction of the risk of injury during the post-ovulatory period, when progesterone increases, is associated with greater ligament laxity. Furthermore, adaptations to exercises can prevent ligament injuries (e.g. knee sprain). This work allows to promote an individualized approach to female sports performance, still too little considered in training planning.

5. Perspectives

Further studies should consider:

1) to monitor the evolution of physical parameters throughout the menstrual cycle and to assess the actual duration of the menstrual cycle with serum hormone

measurements; 2) to analyze the differences between the variation of these physical parameters in players with a regular cycle and those with an irregular cycle.

6. Conclusion

In summary, ovulation is a strategic phase to be known and integrated into the performance management of elite athletes with menstrual problems to their general practitioner and their sports entourage. This study evaluated the variation of different phases and an important moment of the menstrual cycle on physiological responses, performances in the intermittent Yo-Yo test, repeated sprints and medicine ball in elite handball players. The results obtained suggest that the follicular phase during the ovulation period induces an increase in performances in the IET Yo-Yo test, muscular strength as well as the capacity to perform repeated sprints. The evaluation of performances in different physical tests in handball will help handball players and coaches to understand the specific adaptations of the menstrual cycle phase to exercise and sports performance.

Authors' Contributions

All authors contributed to this article and agree with the content and approved the final manuscript.

Acknowledgements

The authors would like to thank all the handball players for their participation in the study, as well as all the team leaders who believed in it. They also thank their laboratory colleagues for their valuable contribution.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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