Title: Menstrual Cycle and Hormonal Contraceptive Tracking in Gaelic Football: From the Lab to the Field

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Abstract

Purpose: To describe the implementation of menstrual cycle (MC) and hormonal contraceptive (HC) tracking among Gaelic Football players, including the characterisation of MC status and symptomatology. To examine the effect of MC and oral contraceptive pill (OCP) phases on daily wellness.

Methods: Fourteen highly trained players (age 24.2 ± 3.5 years), including non-HC (n=6), OCP (n=7), and intrauterine system (n=1) users, prospectively tracked their MC or HC alongside daily self-reported wellness measures for four months. A combination of calendar-based counting, urinary ovulation prediction testing, and a mid-luteal serum progesterone measurement was used to assess MC status.

Results: Only two non-HC players were eumenorrheic. Two players exhibited oligomenorrhea (cycle length 39 ± 4 days), and ovulation was not detected in one of them. Luteal phase deficiency was indicated in two players (serum progesterone range <1.0 – 7.5 $nmol \cdot L^{-1}$). All players, except one, reported at least one negative MC-related symptom or HC side effect. Linear mixed model (LMM) analyses revealed that wellness measures were not affected by OCP phase ($p > 0.05$). LMM analysis was not performed in non-HC users due to the small sample of eumenorrheic players (n=2).

Conclusions: Diverse reproductive profiles were observed, including HC use and subtle MC irregularities which would likely go undetected without prospective MC tracking using biochemical outcomes. This highlights the value of incorporating ovulation testing and blood sampling when establishing the MC status of athletes in applied research and practice, where feasible. Applied researchers should anticipate practical challenges, including the inconsistencies in ovulation testing timings and the timescale required to assess MC status among athletes.

Keywords: anovulation, athlete monitoring, sportswomen, female athlete, menstrual cycle symptoms

i. Introduction

Ladies Gaelic Football is one of the most popular team sports among girls and women in Ireland[1]. It is a high-intensity intermittent invasion field-based sport where two teams of fifteen players compete to score points over (one point) or beneath the crossbar (three points) in two 30-minute halves[1]. Like other invasion-based sports such as Australian football and soccer, its intermittent nature requires players to develop high levels of physical (e.g., aerobic fitness, strength, power, agility) and technical abilities[2]. To date, no research has investigated the menstrual cycle (MC) characteristics and perceived symptomatology among Ladies Gaelic Football players[3], despite its significance as an indicator of overall health and its potential influence on sport performance[4,5].

Indeed, cyclical fluctuations in endogenous oestrogen and progesterone occur during a eumenorrheic MC which can exert numerous physiological effects that may influence athletic performance[6]. However, due to limited high-quality evidence and poor methodological practices in establishing MC phases, there is currently no consensus on the effects of the MC on exercise performance[5]. To improve methodological quality, evidence-based guidelines for MC-based research in sport and exercise science have been outlined[7,8]. Specifically, it was recommended that a combination of methods should be used to identify MC status in female athletes who are not using hormonal contraceptives (HCs), including calendar-based counting, luteinising hormone surge testing, and a mid-luteal serum progesterone measurement[7–9]. Further, MC characteristics should be tracked for at least two consecutive months[7,10].

Given the rigorous nature of the guidelines[7,8], such as the requirement to collect a blood sample on short notice (i.e., seven days after ovulation), executing high-quality MC-based studies may be more practical in tightly controlled laboratory conditions than applied sporting settings. Notably, the constraints within field settings such as the time commitments of athletes amidst busy training and competition schedules may pose greater logistical complexities and variability, than under controlled conditions. Nonetheless, exploring the practicalities of using evidence-based methods to assess MC status in an applied setting may provide useful insights for researchers and practitioners.

These practical considerations may be relevant in the current context where MC tracking is gaining traction in athlete monitoring. Anecdotally, given its cost effectiveness and ease of use, MC length is commonly used as the sole indicator of MC status. For example, elite football players typically report menstrual bleeding and MC-related symptoms as part of monitoring questionnaires, without biochemical measurements[11]. However, solely relying on a regular MC cycle length does not distinguish between ovulatory, anovulatory, or luteal phase deficient (LPD) cycles[8,12]. Considering these limitations, implementing evidence-based guidelines for assessing MC status in practice may be valuable in accurately establishing MC status and facilitating timely management of any irregularities identified.

It is also important to consider that approximately half of elite female athletes report using HCs and of these, oral contraceptive pills (OCPs) are the most widely reported[13,14]. While OCP users do not have fluctuations in endogenous sex hormones and exercise performance remains consistent across the OCP cycle[15], adverse side effects of OCP use have been reported[13,14]. Therefore, examining the perceived symptomatology of both non-HC and HC users would allow for a more representative sample of the female athletic population.

The focus on MC function as an essential component of female athlete care is a relatively new development, and the practicalities of translating rigorous research methods to assess MC status from the laboratory to sporting settings warrant further consideration[16]. Therefore, the primary aim of this study was to describe the implementation of MC and HC tracking among female Gaelic Football players, with a focus on assessing and characterising MC status and symptomatology using evidence-based methods. In doing so, the study also aimed to identify some practical considerations and challenges associated with applying these methods in real-world contexts. Finally, a secondary objective was to examine the effect of MC and OCP phases on wellness measures in eumenorrheic players and OCP users respectively.

ii. Methods

Seventeen highly trained (Tier 3[17]) female Gaelic Football players were recruited using convenience sampling from an intercounty team. The players were actively training with both their county team and their club teams at near maximal training volumes for their sport. This included at least three formal sessions per week for county training, excluding any additional club or college training sessions. All players were competing nationally at the highest level of competition in Ireland (National Football League Division 1). The inclusion criteria for the study were: 1) above 18 years old, 2) not pregnant, 3) non-peri/post-menopausal, 4) no HC use for at least three months before recruitment (for non-HC users). This study was conducted according to the Helsinki Declaration and approved by the Technological University of the Shannon research ethics committee. All players provided written informed consent following an information session.

The study design represents a prospective observational study, where players reported their daily wellness and MC/HC information across four consecutive months between February 2022 and May 2022. A questionnaire examining demographic information, MC history, and HC use was administered at baseline. Height and body mass were measured using a stadiometer and a digital scale (models Seca 813 and 213, Seca, Hamburg, Germany) respectively. Players were instructed to report their wellness on an athlete monitoring app (Actimet, Galway, Ireland) every morning upon waking. The app was in use by the team before the study commenced and no modifications were made to the questionnaire. Players reported their sleep duration, sleep quality, energy, mood, stress, and soreness (upper- and lower-body) on a 10-point scale (1 = Worst to 10 = Best). Considering limited customisability within the app, MC and HC data were collected on a separate online questionnaire (MC/HC tracker) (Table 1). In this study, a MC-related symptom refers to something that a naturally menstruating person feels or experiences that may be associated with the cyclical fluctuations in endogenous hormones across the MC[18], while a contraceptive side effect refers to any unintended effect of a HC (i.e., hormone-containing medication) experienced by the user, beyond its desired effect[19]. Players were instructed to log any perceived MC-related symptoms (for non-HC users) and contraceptive side effects (for HC users) in the MC/HC tracker. If players were unsure whether a symptom/side effect was related to MC or HC use, they were instructed to report it regardless. This was completed across four consecutive months, allowing for trends in symptomatology to be identified and differentiated from random occurrences possibly unrelated to the MC or HC use. To enhance player compliance, the lead researcher sent daily reminders to the players through text messages[20].

(Insert Table 1 about here)

To assess MC status in non-HC users, a combination of calendar-based counting, urinary ovulation prediction testing, and mid-luteal blood sampling for the determination of progesterone was adopted[7,8]. The MC/HC tracker was used to obtain MC length, calculated as the number of days from the onset of menses to the day before subsequent bleeding onset. Players were provided with urinary ovulation prediction test kits (Clearblue, Geneva, Switzerland) and were instructed to test for luteinising hormone surge every morning from day eight of the MC until a positive result returned. Upon a positive result, players alerted the lead researcher through text message and a blood sampling session was scheduled for seven to nine days after the positive result to measure serum progesterone concentration in the mid-luteal phase[9].

Blood sampling was available at training venues where a phlebotomy space was set up and was performed by the lead researcher who was phlebotomy trained. This was to reduce the time and travel burden on the players, given the short notice of scheduled blood tests. Venous blood samples (5ml) were obtained from an antecubital vein and collected into gold-top vacutainer tubes (BD Vacutainer® SST II Advance, Cat no. 367954, Beckton Dickinson, USA). As much as possible, blood draws occurred before training, and thereafter players were instructed to sit for ten minutes. Serum tubes were stored between 4-8°C until same- or next-day collection by a pathology transport service (Eurofins Lablink, Biomnis Logistics Division) and transported to a medical laboratory (Eurofins Biomnis Ireland Limited, Dublin, Ireland), where blood samples were analysed for serum progesterone. Based on the standard definitions of eumenorrhea and MC disorders[7] (Table 2), non-HC users were either confirmed as eumenorrheic or suspected to have a MC disorder (not formally diagnosed by a medical professional within the study).

(Insert Table 2 about here)

Data analyses were conducted using Microsoft Excel and Jamovi, version 2.3.13. Descriptive statistics were expressed as mean ± standard deviation (SD) and percentage. Data of the intrauterine system user (n=1) was descriptively reported and excluded from further analysis. Linear mixed model (LMM) analyses were used to determine whether OCP phase (i.e., early pill-taking, late pill-taking, early pill-free and late pill-free) had any significant effect on self-reported wellness measures, with OCP phases as a fixed effect and players as a random effect. All wellness data from each player across three consecutive OCP cycles were inputted into the model. Model assumptions were assessed using residual plots and the Shapiro-Wilk test for normality of residuals (Supplementary file 1). Statistical significance ($p < 0.05$) for fixed effects were calculated using Satterthwaite approximations[21]. Due to the small sample of eumenorrheic players (n=2), LMM analysis was not performed to examine the within-player differences in wellness measures by MC phases. Instead, the descriptive statistics (mean ± SD) of each wellness measure in eumenorrheic players by MC phases are presented (Supplementary file 2). As MC phases could not be established where ovulation was not detected or mid-luteal progesterone concentration was lower than the verification limit of 16 $nmol \cdot L^{-1}$, LMM analysis and the descriptive reporting of wellness measures by MC phases were not performed.

iii. Results

A final sample of 14 players completed the study, including both non-HC (n=6) and HC users (n=8). Among the HC users, seven players used the combined, monophasic OCP, while one player used a progestin-only intrauterine system. Player demographics are presented in Table 3.

(Insert Table 3 about here)

At baseline, all non-HC users (n=6) self-reported mean MC lengths of between 21-35 days and mean period lengths of 3-4 days (n=3), 5-6 days (n=2), and 7-8 days (n=1). One non-HC player self-reported a history of secondary amenorrhea for five months from December 2019 to April 2020 (i.e., 20 months prior to study participation). Another non-HC player also self-reported a history of secondary amenorrhea, which was likely due to the player's cessation of OCP use in June 2021 (i.e., eight months prior to study participation). The mean duration of OCP use among users (n=7) was 4.8 ± 2.6 years (Figure 1). The intrauterine system user (n=1) self-reported using it for 2.5 years.

The MC information collected over four consecutive months (i.e., three consecutive MCs), including indication of ovulation and serum progesterone analysis, is presented in Table 4. The mean completion rate of ovulation testing was 87%. Among non-HC players with at least one positive ovulation test result, the mean completion rate for blood sampling was 73%. Only one complete MC was captured in Player 6 as the player's menses only began 34 days after study commencement and that cycle lasted 45 days. Subsequent MCs were not captured within the study duration. No positive ovulation test result was obtained for that cycle, suggesting possible anovulatory oligomenorrhea. The mean length of the pill-taking and pill-free phases in OCP users were 21 ± 1 days and 6 ± 1 days respectively.

(Insert Table 4 about here)

(Insert Figure 1 about here)

Among all players, only one non-HC player did not log any negative MC-related symptoms. The remaining five non-HC and eight HC users reported at least one negative symptom/side effect throughout the study. The frequencies of individual perceived symptoms/side effects are presented in Figure 2. The overall mean symptom severity (i.e., interference on training and ability to perform) rated on a three-point scale (1 = No/mild interference to 3 = Extreme interference) was 1.7 ± 0.5 (non-HC: 1.5 ± 0.4; OCP users: 2.0 ± 0.5; intrauterine system user: 1.6 ± 0.4). Perceived negative symptoms/side effects were mainly reported during menstruation (MC days 1 to 4) in non-HC users and withdrawal bleeding (pill-free days 1 to 5) in OCP users.

(Insert Figure 2 about here)

The mean compliance with daily wellness monitoring was 68% (non-HC users = 48%; OCP users = 74%) and declined over time from 82% in the first cycle to 37% in the third cycle. The LMM analyses revealed that wellness measures did not differ by OCP phase ($p > 0.05$) (Table 5).

(Insert Table 5 about here)

iv. Discussion

This study aimed to bridge the gap between the lab and the field by implementing evidence-based methodological guidelines for assessing MC status in real-world settings. In doing so, the study sought to provide novel insights into the MC characteristics and perceived symptomatology among female Gaelic Football players, addressing the current scarcity of

MC-related data in this population[3]. The key findings were: 1) some players exhibited indicators of subtle MC irregularities, 2) regardless of HC use, prospective symptom tracking revealed a high prevalence of perceived symptoms and side effects among players, particularly during menstruation/withdrawal bleeding, and 3) subjective wellness measures remained consistent throughout an OCP cycle. The study also identified several practical considerations and challenges that arose during its implementation, offering insights that may inform applied researchers and practitioners.

The presence of LPD and/or anovulation with presumably 'normal' MCs, based on MC length, has previously been observed in physically active females[12]. However, the prevalence of these irregularities among competitive female athletes remains poorly understood, possibly due to methodological constraints in assessing endogenous hormones[22]. A key rationale for the inclusion of biochemical methods is that MC length alone does not provide insight into ovulatory and luteal function and therefore, would not represent an accurate depiction of MC status[8,12]. In this study, all non-HC players self-reported mean MC lengths of 21-35 days at baseline, but potential cases of subtle MC disorders were identified when biochemical outcomes were included. For example, three non-HC players with apparently regular MCs presented with possibly anovulatory (n=1) and LPD (n=2) cycles. A short luteal phase duration of five days was also observed in one player with potential LPD, corroborating the low serum progesterone results. These findings are similar to a recent study that reported evidence of anovulation and LPD in two out of eleven highly trained rugby players[16]. Despite the relatively small sample size in both studies, these findings highlight the potential burden of subtle MC irregularities among highly trained athletes. This emphasises the need for further investigations to elucidate their impact on health and reinforces the value of incorporating biochemical methods alongside MC length tracking.

Overall, a high prevalence of potential MC irregularities, including clinical disturbances, was observed in this sample. As MC disturbances often result from multiple stressors, the unique demands of Gaelic Football may inherently challenge the maintenance of a regular MC. Specifically, despite its amateur status, intercounty players can train up to seven sessions a week[2], while also managing full-time employment or studies. These competing demands may predispose players to factors such as low energy availability and excessive stress, potentially resulting in dysregulation of the reproductive axis[23]. Therefore, leveraging the MC as an indicator of overall health and homeostasis through MC tracking, along with player education, could be particularly beneficial for identifying irregularities and implementing appropriate strategies to restore MC function.

The prospective approach in this study identified two oligomenorrheic players, highlighting the potential discrepancy between retrospectively and prospectively collected data. While both players retrospectively self-reported a mean MC length of 21-35 days, the actual MC length recorded prospectively ranged from 37-45 days. This reinforces the limitations and potential measurement errors of retrospective MC history questionnaires[24]. Prospective monitoring in this study also included logging of perceived MC/HC-related symptoms/side effects. Regardless of HC use, 93% of players in this study reported negative symptoms/side effects which they perceived to have mild to moderate interferences on their training and performance. This supports recent findings that negative MC-related symptoms are common in athletes and may impair their perceived ability to train and perform[25]. Nonetheless, it is worth considering that not all menstruating women may experience MC-related symptoms, as demonstrated by the non-HC player who did not report any symptoms. This suggests that

practitioners should recognise the individuality of MC-related symptoms and experiences when working with female athletes.

Considering that MC-related symptoms may occur at any time in the MC such as pain around ovulation[25,26], prospective symptom logging throughout the entire MC is a strength of this study. Despite this, most players only reported negative symptoms/side effects during menstruation or withdrawal bleeding, with abdominal cramps and moodiness being the most common perceived symptoms/side effects regardless of HC use. Similarly, abdominal cramps/pain and mood swings were the most prevalent symptoms reported by UK-based non-HC elite athletes[13]. While the symptoms experienced by non-HC users are driven by aetiologies such as low levels of endogenous hormones[27], the manifestation of side effects in OCP users is less clear. Interestingly, the high prevalence of perceived side effects in OCP users seems paradoxical as OCPs are commonly used to alleviate symptoms of dysmenorrhea (i.e., painful menstruation)[28]. While mild side effects may be associated with OCP use, they should disappear with continued use or by switching to another OCP formulation[29]. The reasons why OCP users tolerated these perceived side effects are beyond the scope of this study, however, this finding highlights the importance of educating HC users about their options in managing contraceptive side effects, such as consulting a medical doctor to switch OCP formulation or methods.

Emerging studies have highlighted how negative MC-related symptoms can impair athletes' perceived ability to train at certain points during the MC[30,31]. While much of the research has focused on non-HC users, some evidence suggests that HC users perceive a similar adverse impact of contraceptive side effects on readiness to train[14]. However, the results of this study indicated that subjective wellness outcomes were consistent across an OCP cycle, suggesting that despite a high prevalence of perceived side effects, they were perhaps not severe to an extent that impaired the players' perceived wellness. The small sample of eumenorrheic players and heterogeneity in MC status observed within a single team demonstrate that in practice, the consideration of players' menstrual health should take precedence over attempts at implementing a group-level MC phase-based training approach. Specifically, MC tracking in athletes should first and foremost be used as a tool to establish and maintain a healthy MC function in non-HC users at the individual level.

While robust methods to monitor MC status can provide valuable information, translating research methodology in an applied setting is not without practical challenges. As expected, a key obstacle was the time-sensitive nature of blood sampling, requiring participant and researcher availability within a narrow three-day window amidst tight player schedules. Reasons for missed blood sampling include player unavailability, failed blood draws, and missed ovulation tests. From a research perspective, guidelines recommend MC characteristics be tracked for at least two months before testing[7]. While this timescale might be feasible in a controlled environment, researchers working with athletes should account for the potential difficulties with blood sampling required within a specific and short timeframe that could result in an increased timescale to confirm MC status. For instance, biochemical outcomes over consecutive MCs may not be possible in a high-performance environment due to frequent travel for competition[32]. Practically, if sport teams integrate biochemical testing for assessing MC status, it may be prudent to select a monitoring timeframe with minimal variation in athletes' training and competition schedules, such as during the pre-season.

As mid-luteal blood sampling relies on the indication of ovulation, missed ovulation tests would negate further blood sampling. Nonetheless, the players in this study were mostly

compliant (87%) with ovulation testing demonstrating that ovulation testing was acceptable to the players, likely attributed to the ease of home-based testing that posed minimal disturbance to their daily schedules. Among ovulatory non-HC users, the mean number of ovulation prediction test sticks used per cycle was 9 ± 5 sticks (range 4-18), with the large range likely due to the interindividual variation in MC length, as ovulation tends to occur later in those with longer cycles[33]. As such, the number of ovulation test attempts before ceasing testing and concluding that the player is possibly anovulatory warrants consideration. Observations from this study seem to suggest that the number of test sticks used per cycle on average does not exceed ten. Therefore, rather than increasing the number of tests which may be perceived as burdensome to athletes, ovulation testing could potentially begin later than day eight for players with longer cycles. However, this requires further investigation. In addition, while players in this study were requested to test at the same time each morning[8,34], they performed the tests at varied timings during the day (between 06:00 and 23:30), reinforcing the difficulties in standardising variables within an applied setting.

There are several limitations of this study. Firstly, the small sample of players from a single team limits the extent to which the results can be generalised. Nonetheless, the learnings of this study remain valuable in informing the methodological considerations of MC tracking in applied practice and research. Next, mid-luteal serum progesterone measurements were not obtained for three consecutive MCs and therefore, MC irregularities identified were not reviewed in a second/third cycle. Further, MC disorders were not diagnosed by a medical professional within the study. However, it is likely that the LPD cycles were accurately identified as the serum progesterone concentrations recorded in the players with suspected LPD were obtained within the recommended testing window[9]. As the symptom log did not specifically record positive symptoms/side effects associated with the MC or HC use, the findings regarding symptomatology are limited in fully encompassing the complexities of both positive and adverse physical and emotional changes across the MC. Additionally, the symptom severity scale used in this study was not validated, and the use of a 3-point scale may have been limited in capturing nuanced information. Future research should focus on developing and validating a symptom tracking tool for athletes, assessing the type, frequency, and severity of symptoms. Lastly, missing data has been acknowledged as a near certainty in longitudinal athlete monitoring[35] and was observed in this study, where player compliance with daily wellness monitoring declined over the course of the study. As such, LMM was chosen as the statistical method considering its robustness in accounting for missing and unbalanced data[36]. Nonetheless, the poorer compliance among players towards the end of the study may suggest that perceived symptoms/side effects were likely to have been underreported in the third cycle.

v. Practical Applications

- Integrating MC tracking capabilities in athlete monitoring systems, including perceived symptom and symptom severity (i.e., interference on training) logging over the entire MC may improve female athlete monitoring practices. Open-ended symptom logs may enable athletes to record specific details about their symptoms (e.g., duration, timing of symptom).
- Sport teams with adequate resources and medical expertise could implement ovulation testing and mid-luteal blood sampling for assessing MC status into routine medical screenings, such as yearly pre-season laboratory screening, with follow-up as needed (subject to athlete consent). There should be appropriate medical oversight to support athletes with any MC irregularities identified (e.g., exclude underlying causes, restore eumenorrhea).

- Applied researchers should account for the potential difficulties with time-sensitive blood sampling over consecutive MCs and consider an extended timescale to confirm MC status in research (e.g., four-month window to obtain biochemical outcomes for two MCs). It may be therefore prudent for researchers/practitioners to select a monitoring timeframe with minimal variation in athletes' schedules.
- In training environments where evidence-based methods are not feasible, researchers/practitioners may consider alternative non-invasive methods to assess MC status alongside MC length, such as salivary hormone analysis and basal body temperature charting. However, the limitations of these methods should also be acknowledged[8].
- Athletes experiencing perceived negative MC-related symptoms should explore individualised symptom management strategies to minimise any negative impact on performance. Similarly, HC users with perceived adverse side effects should be educated and aware of their option to consult a medical professional to discuss management strategies.

vi. Conclusion

Diverse reproductive profiles were observed within a team of highly trained female Gaelic Football players, including HC use and possible MC disorders in non-HC users which would be undetected without prospective MC tracking using biochemical outcomes. This study supports the use of prospective MC tracking that includes periodic testing for ovulation and mid-luteal serum progesterone measurement (where feasible) such that anovulatory and LPD cycles can be identified, thereby facilitating early detection and management of conditions such as low energy availability or other gynaecological/endocrinological conditions. MC tracking should first and foremost be used as a tool to establish menstrual health in female athletes. Careful consideration of several practical issues involved in translating evidence-based MC tracking methods in both applied research and practice should take place at the outset. These include the variable timings of ovulation testing and an increased timescale to assess MC status among athletes in a high-performance environment.

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531

ix. Figure captions

Figure 1 The prevalence of hormonal contraceptive users and non-users, including the menstrual cycle status of non-users and oral contraceptive pill brands and formulations. HC = hormonal contraceptive, IUS = intrauterine system, LPD = luteal phase deficiency, MC = menstrual cycle, OCP = oral contraceptive pill, n = number of players. *Note*: Menstrual cycle disorders were not formally diagnosed by a medical professional within the study

Figure 2 The frequency of perceived negative symptoms/side effects reported by players based on their profiles. HC = hormonal contraceptive, IUS = intrauterine system, OCP = oral contraceptive pill

x. Tables

Table 1 Questionnaire items for menstrual cycle and hormonal contraceptive tracking

Players *not* using hormonal contraceptives	Players using hormonal contraceptives
	Are you currently bleeding (e.g., withdrawal bleed)?
Are you currently menstruating?	
	Is today a pill-taking or a pill-free day?[a]
Are you experiencing any symptoms that may be related to your menstrual cycle?	Are you experiencing any side effects that may be related to your use of hormonal contraceptives?
List the symptoms/side effects[b] and on a scale of 1 to 3, rate how much the symptom/side effect interferes with your training and ability to perform (1 = No/mild interference to 3 = Extreme interference)	

Note: [a]Only applicable to oral contraceptive pill users, [b]'Symptom' refers to something that a naturally menstruating person feels or experiences that may associated with the cyclical fluctuations in endogenous hormones across the MC[18]; 'Side effect' refers to any unintended effect of a hormonal contraceptive (i.e., hormone-containing medication) experienced by the user, beyond its desired effect[19]

547 **Table 2** Definitions of eumenorrhea and menstrual cycle-related disorders

Menstrual cycle status	Definition[7]
Eumenorrhea	Menstrual cycle length ≥ 21 days and ≤ 35 days + Ovulation detected by urinary luteinising hormone surge testing + Greater than 16 nmol·L^{-1} of progesterone (determined by a single luteal phase serum progesterone measurement) + No hormonal contraceptive use three months prior to study commencement
Secondary Amenorrhea	The absence of at least three consecutive periods in non-pregnant females with past menstruation
Oligomenorrhea	Menstrual cycle length greater than 35 days
Anovulation	Menstruate but do not ovulate (unable to detect ovulation by urinary luteinising hormone surge testing or confirmed by serum hormone analysis)
Luteal phase deficiency	Menstrual cycles with less than 16 nmol·L^{-1} of progesterone (determined by a single luteal phase serum progesterone measurement)

548

549 **Table 3** Player demographic information

Characteristics	All (n=14)	Non-hormonal contraceptive user (n=6)	Oral contraceptive pill[b] user (n=7)	Intrauterine system user (n=1)
Age[a] (y)	24.2 ± 3.5	25.2 ± 4.0	23.7 ± 3.5	22
Height (m)	1.65 ± 0.4	1.65 ± 3.6	1.64 ± 0.5	1.65
Body mass (kg)	63.6 ± 5.7	63.9 ± 6.7	63.3 ± 5.8	64.6
Age of menarche[a] (y)	13.6 ± 1.2	12.8 ± 1.3	14.0 ± 0.8	15

550 Abbreviations: n = number of players. *Note*: [a]Self-reported information, [b]Combined, monophasic oral contraceptive pill, Data expressed as mean
551 ± standard deviation (SD).

Table 4 Menstrual cycle information of non-hormonal contraceptive users over three consecutive menstrual cycles

Player	Overall	Cycle 1			Cycle 2			Cycle 3		
	Mean cycle length (days)[c]	**Day of ovulation**	**PROG (nmol·L^{-1})**	**Day of blood sample[a]**	**Day of ovulation**	**PROG (nmol·L^{-1})**	**Day of blood sample[a]**	**Day of ovulation**	**PROG (nmol·L^{-1})**	**Day of blood sample[a]**
1	24 ± 4	11	<1.0[b]	8	14	Unknown	Unknown	x	x	x
2	28 ± 3	12	7.5[b]	9	13	x	x	13	x	x
3	29 ± 2	11	33.5	8	x	x	x	11	31.1	8
4	37 ± 2	25	25.9	9	25	x	x	21	x	x
5	29 ± 5	17	18.7	7	22	11.4[b]	8	15	17.6	10
6	45[d]	Not detected					–			
All[c]	**32 ± 6**	**15 ± 6**	**17.3 ± 13.2**	**8 ± 1**	**19 ± 6**	**11.4**	**8**	**15 ± 4**	**24.4 ± 9.5**	**9 ± 1**

Abbreviations: PROG = serum progesterone concentration, Unknown = unable to collect blood sample as player's next menses started before the scheduled blood sampling window, x = missed ovulation testing or missed blood sampling due to player unavailability (n=2), failed blood draw (e.g., difficult veins, dehydration) (n=2), failure to comply with ovulation tests (n=2), – = unable to obtain data during the study duration due to the player's long cycle length (i.e., menstrual cycle began 34 days after study commencement and lasted for 45 days) and inability to establish ovulation. *Note*: [a]Represented as the number of days after a positive ovulation test result, [b]Serum progesterone concentration lower than the verification limit of at least 16 nmol·L^{-1}, [c]Data expressed as mean ± standard deviation (SD), [d]Only one complete menstrual cycle was captured

559 **Table 5** Linear mixed model results for wellness measures in the different oral contraceptive pill phases

	Fixed Effects (Oral Contraceptive Pill Phase)					Player | Intercept		Residual		ICC[b]
	Estimate	SE	95% CI	t	*p*	Variance	SD	Variance	SD	
Sleep hours										
Intercept	7.97	0.19	7.59 – 8.335	41.14	< .001	0.23	0.48	0.28	0.53	0.46
Late pill-taking[a]	0.02	0.17	-0.31 – 0.36	0.12	0.903					
Early pill-free[a]	0.11	0.17	-0.23 – 0.44	0.63	0.534					
Late pill-free[a]	0.30	0.19	-0.06 – 0.67	1.62	0.111					
Sleep quality										
Intercept	7.92	0.33	7.28 – 8.56	24.30	< .001	0.70	0.84	0.42	0.65	0.62
Late pill-taking[a]	0.02	0.21	-0.39 – 0.43	0.10	0.921					
Early pill-free[a]	0.04	0.21	-0.38 – 0.45	0.18	0.86					
Late pill-free[a]	-0.11	0.23	-0.56 – 0.35	-0.46	0.647					
Energy										
Intercept	7.37	0.47	6.41 – 8.30	15.61	< .001	1.5	1.23	0.51	0.71	0.75
Late pill-taking[a]	0.22	0.23	-0.24 – 0.67	0.93	0.355					
Early pill-free[a]	0.02	0.23	-0.43 – 0.48	0.11	0.916					
Late pill-free[a]	0.12	0.26	-0.38 – 0.62	0.48	0.632					
Mood										
Intercept	7.83	0.36	7.13 – 8.54	21.77	< .001	0.84	0.92	0.75	0.56	0.60
Late pill-taking[a]	0.35	0.24	-0.13 – 0.82	1.43	0.158					
Early pill-free[a]	0.17	0.24	-0.31 – 0.65	0.71	0.48					
Late pill-free[a]	0.07	0.27	-0.46 – 0.59	0.25	0.802					
Stress										
Intercept	7.58	0.49	6.63 – 8.53	15.64	< .001	1.50	1.22	1.34	1.16	0.53
Late pill-taking[a]	0.53	0.38	-0.21 – 1.26	1.40	0.166					
Early pill-free[a]	0.11	0.38	-0.63 – 0.85	0.29	0.773					
Late pill-free[a]	-0.34	0.41	-1.15 – 0.46	-0.84	0.407					
Lower body soreness										
Intercept	7.20	0.55	6.13 – 8.27	13.22	< .001	2.00	1.41	0.77	0.88	0.72
Late pill-taking[a]	0.42	0.29	-0.14 – 0.98	1.46	0.15					
Early pill-free[a]	0.15	0.29	-0.41 – 0.71	0.53	0.597					

Late pill-free[a]	0.37	0.31	-0.24 – 0.99	1.19	0.239					
Upper body soreness										
Intercept	8.17	0.41	7.36 – 8.99	19.75	< .001					
Late pill-taking[a]	0.25	0.34	-0.45 – 0.92	0.74	0.462	1.08	1.04	1.11	1.05	0.49
Early pill-free[a]	-0.20	0.34	-0.88 – 0.47	-0.60	0.553					
Late pill-free[a]	0.31	0.38	-0.43 – 1.04	0.83	0.412					

Abbreviations: SE = standard error, 95% CI = 95% confidence interval, SD = standard deviation, ICC = intraclass correlation coefficient. Note: [a]reference level = Early pill-taking, [b]Quantifies the proportion of variance explained by the random effect; calculated by dividing the random effect variance by the total variance (i.e., sum of random effect variance and the residual variance)