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

**Submission type:** Original Investigation

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1 **Abstract**

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

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

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

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

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31 **Keywords:** anovulation, athlete monitoring, sportswomen, female athlete, menstrual cycle  
32 symptoms

### 33 i. Introduction

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

43  
44 Indeed, cyclical fluctuations in endogenous oestrogen and progesterone occur during a  
45 eumenorrheic MC which can exert numerous physiological effects that may influence athletic  
46 performance<sup>6</sup>. However, due to limited high-quality evidence and poor methodological  
47 practices in establishing MC phases, there is currently no consensus on the effects of the MC  
48 on exercise performance<sup>5</sup>. To improve methodological quality, evidence-based guidelines for  
49 MC-based research in sport and exercise science have been outlined<sup>7,8</sup>. Specifically, it was  
50 recommended that a combination of methods should be used to identify MC status in female  
51 athletes who are not using hormonal contraceptives (HCs), including calendar-based  
52 counting, luteinising hormone surge testing, and a mid-luteal serum progesterone  
53 measurement<sup>7-9</sup>. Further, MC characteristics should be tracked for at least two consecutive  
54 months<sup>7,10</sup>.

55  
56 Given the rigorous nature of the guidelines<sup>7,8</sup>, such as the requirement to collect a blood  
57 sample on short notice (i.e., seven days after ovulation), executing high-quality MC-based  
58 studies may be more practical in tightly controlled laboratory conditions than applied sporting  
59 settings. Notably, the constraints within field settings such as the time commitments of  
60 athletes amidst busy training and competition schedules may pose greater logistical  
61 complexities and variability, than under controlled conditions. Nonetheless, exploring the  
62 practicalities of using evidence-based methods to assess MC status in an applied setting may  
63 provide useful insights for researchers and practitioners.

64  
65 These practical considerations may be relevant in the current context where MC tracking is  
66 gaining traction in athlete monitoring. Anecdotally, given its cost effectiveness and ease of  
67 use, MC length is commonly used as the sole indicator of MC status. For example, elite  
68 football players typically report menstrual bleeding and MC-related symptoms as part of  
69 monitoring questionnaires, without biochemical measurements<sup>11</sup>. However, solely relying on  
70 a regular MC cycle length does not distinguish between ovulatory, anovulatory, or luteal  
71 phase deficient (LPD) cycles<sup>8,12</sup>. Considering these limitations, implementing evidence-based  
72 guidelines for assessing MC status in practice may be valuable in accurately establishing MC  
73 status and facilitating timely management of any irregularities identified.

74  
75 It is also important to consider that approximately half of elite female athletes report using  
76 HCs and of these, oral contraceptive pills (OCPs) are the most widely reported<sup>13,14</sup>. While  
77 OCP users do not have fluctuations in endogenous sex hormones and exercise performance  
78 remains consistent across the OCP cycle<sup>15</sup>, adverse side effects of OCP use have been  
79 reported<sup>13,14</sup>. Therefore, examining the perceived symptomatology of both non-HC and HC  
80 users would allow for a more representative sample of the female athletic population.

81

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

## 92 **ii. Methods**

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

106 The study design represents a prospective observational study, where players reported their  
107 daily wellness and MC/HC information across four consecutive months between February  
108 2022 and May 2022. A questionnaire examining demographic information, MC history, and  
109 HC use was administered at baseline. Height and body mass were measured using a  
110 stadiometer and a digital scale (models Seca 813 and 213, Seca, Hamburg, Germany)  
111 respectively. Players were instructed to report their wellness on an athlete monitoring app  
112 (Actimet, Galway, Ireland) every morning upon waking. The app was in use by the team  
113 before the study commenced and no modifications were made to the questionnaire. Players  
114 reported their sleep duration, sleep quality, energy, mood, stress, and soreness (upper- and  
115 lower-body) on a 10-point scale (1 = Worst to 10 = Best). Considering limited  
116 customisability within the app, MC and HC data were collected on a separate online  
117 questionnaire (MC/HC tracker) (Table 1). In this study, a MC-related symptom refers to  
118 something that a naturally menstruating person feels or experiences that may be associated  
119 with the cyclical fluctuations in endogenous hormones across the MC<sup>18</sup>, while a contraceptive  
120 side effect refers to any unintended effect of a HC (i.e., hormone-containing medication)  
121 experienced by the user, beyond its desired effect<sup>19</sup>. Players were instructed to log any  
122 perceived MC-related symptoms (for non-HC users) and contraceptive side effects (for HC  
123 users) in the MC/HC tracker. If players were unsure whether a symptom/side effect was  
124 related to MC or HC use, they were instructed to report it regardless. This was completed  
125 across four consecutive months, allowing for trends in symptomatology to be identified and  
126 differentiated from random occurrences possibly unrelated to the MC or HC use. To enhance  
127 player compliance, the lead researcher sent daily reminders to the players through text  
128 messages<sup>20</sup>.

130 (Insert Table 1 about here)

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

142  
143 Blood sampling was available at training venues where a phlebotomy space was set up and  
144 was performed by the lead researcher who was phlebotomy trained. This was to reduce the  
145 time and travel burden on the players, given the short notice of scheduled blood tests. Venous  
146 blood samples (5ml) were obtained from an antecubital vein and collected into gold-top  
147 vacutainer tubes (BD Vacutainer® SST II Advance, Cat no. 367954, Beckton Dickinson,  
148 USA). As much as possible, blood draws occurred before training, and thereafter players  
149 were instructed to sit for ten minutes. Serum tubes were stored between 4-8°C until same- or  
150 next-day collection by a pathology transport service (Eurofins Lablink, Biomnis Logistics  
151 Division) and transported to a medical laboratory (Eurofins Biomnis Ireland Limited, Dublin,  
152 Ireland), where blood samples were analysed for serum progesterone. Based on the standard  
153 definitions of eumenorrhea and MC disorders<sup>7</sup> (Table 2), non-HC users were either  
154 confirmed as eumenorrheic or suspected to have a MC disorder (not formally diagnosed by a  
155 medical professional within the study).

156  
157 (Insert Table 2 about here)

158  
159 Data analyses were conducted using Microsoft Excel and Jamovi, version 2.3.13. Descriptive  
160 statistics were expressed as mean ± standard deviation (SD) and percentage. Data of the  
161 intrauterine system user (n=1) was descriptively reported and excluded from further analysis.  
162 Linear mixed model (LMM) analyses were used to determine whether OCP phase (i.e., early  
163 pill-taking, late pill-taking, early pill-free and late pill-free) had any significant effect on self-  
164 reported wellness measures, with OCP phases as a fixed effect and players as a random  
165 effect. All wellness data from each player across three consecutive OCP cycles were inputted  
166 into the model. Model assumptions were assessed using residual plots and the Shapiro-Wilk  
167 test for normality of residuals (Supplementary file 1). Statistical significance ( $p < 0.05$ ) for  
168 fixed effects were calculated using Satterthwaite approximations<sup>21</sup>. Due to the small sample  
169 of eumenorrheic players (n=2), LMM analysis was not performed to examine the within-  
170 player differences in wellness measures by MC phases. Instead, the descriptive statistics  
171 (mean ± SD) of each wellness measure in eumenorrheic players by MC phases are presented  
172 (Supplementary file 2). As MC phases could not be established where ovulation was not  
173 detected or mid-luteal progesterone concentration was lower than the verification limit of 16  
174  $\text{nmol}\cdot\text{L}^{-1}$ , LMM analysis and the descriptive reporting of wellness measures by MC phases  
175 were not performed.

### 176 177 **iii. Results**

178 A final sample of 14 players completed the study, including both non-HC (n=6) and HC users  
179 (n=8). Among the HC users, seven players used the combined, monophasic OCP, while one  
180 player used a progestin-only intrauterine system. Player demographics are presented in Table  
181 3.

182  
183 (Insert Table 3 about here)

184  
185 At baseline, all non-HC users (n=6) self-reported mean MC lengths of between 21-35 days  
186 and mean period lengths of 3-4 days (n=3), 5-6 days (n=2), and 7-8 days (n=1). One non-HC  
187 player self-reported a history of secondary amenorrhea for five months from December 2019  
188 to April 2020 (i.e., 20 months prior to study participation). Another non-HC player also self-  
189 reported a history of secondary amenorrhea, which was likely due to the player's cessation of  
190 OCP use in June 2021 (i.e., eight months prior to study participation). The mean duration of  
191 OCP use among users (n=7) was  $4.8 \pm 2.6$  years (Figure 1). The intrauterine system user  
192 (n=1) self-reported using it for 2.5 years.

193  
194 The MC information collected over four consecutive months (i.e., three consecutive MCs),  
195 including indication of ovulation and serum progesterone analysis, is presented in Table 4.  
196 The mean completion rate of ovulation testing was 87%. Among non-HC players with at least  
197 one positive ovulation test result, the mean completion rate for blood sampling was 73%.  
198 Only one complete MC was captured in Player 6 as the player's menses only began 34 days  
199 after study commencement and that cycle lasted 45 days. Subsequent MCs were not captured  
200 within the study duration. No positive ovulation test result was obtained for that cycle,  
201 suggesting possible anovulatory oligomenorrhea. The mean length of the pill-taking and pill-  
202 free phases in OCP users were  $21 \pm 1$  days and  $6 \pm 1$  days respectively.

203  
204 (Insert Table 4 about here)

205  
206 (Insert Figure 1 about here)

207  
208 Among all players, only one non-HC player did not log any negative MC-related symptoms.  
209 The remaining five non-HC and eight HC users reported at least one negative symptom/side  
210 effect throughout the study. The frequencies of individual perceived symptoms/side effects  
211 are presented in Figure 2. The overall mean symptom severity (i.e., interference on training  
212 and ability to perform) rated on a three-point scale (1 = No/mild interference to 3 = Extreme  
213 interference) was  $1.7 \pm 0.5$  (non-HC:  $1.5 \pm 0.4$ ; OCP users:  $2.0 \pm 0.5$ ; intrauterine system  
214 user:  $1.6 \pm 0.4$ ). Perceived negative symptoms/side effects were mainly reported during  
215 menstruation (MC days 1 to 4) in non-HC users and withdrawal bleeding (pill-free days 1 to  
216 5) in OCP users.

217  
218 (Insert Figure 2 about here)

219  
220 The mean compliance with daily wellness monitoring was 68% (non-HC users = 48%; OCP  
221 users = 74%) and declined over time from 82% in the first cycle to 37% in the third cycle.  
222 The LMM analyses revealed that wellness measures did not differ by OCP phase ( $p > 0.05$ )  
223 (Table 5).

224  
225 (Insert Table 5 about here)

#### 226 227 **iv. Discussion**

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

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

239  
240 The presence of LPD and/or anovulation with presumably ‘normal’ MCs, based on MC  
241 length, has previously been observed in physically active females<sup>12</sup>. However, the prevalence  
242 of these irregularities among competitive female athletes remains poorly understood, possibly  
243 due to methodological constraints in assessing endogenous hormones<sup>22</sup>. A key rationale for  
244 the inclusion of biochemical methods is that MC length alone does not provide insight into  
245 ovulatory and luteal function and therefore, would not represent an accurate depiction of MC  
246 status<sup>8,12</sup>. In this study, all non-HC players self-reported mean MC lengths of 21-35 days at  
247 baseline, but potential cases of subtle MC disorders were identified when biochemical  
248 outcomes were included. For example, three non-HC players with apparently regular MCs  
249 presented with possibly anovulatory (n=1) and LPD (n=2) cycles. A short luteal phase  
250 duration of five days was also observed in one player with potential LPD, corroborating the  
251 low serum progesterone results. These findings are similar to a recent study that reported  
252 evidence of anovulation and LPD in two out of eleven highly trained rugby players<sup>16</sup>. Despite  
253 the relatively small sample size in both studies, these findings highlight the potential burden  
254 of subtle MC irregularities among highly trained athletes. This emphasises the need for  
255 further investigations to elucidate their impact on health and reinforces the value of  
256 incorporating biochemical methods alongside MC length tracking.

257  
258 Overall, a high prevalence of potential MC irregularities, including clinical disturbances, was  
259 observed in this sample. As MC disturbances often result from multiple stressors, the unique  
260 demands of Gaelic Football may inherently challenge the maintenance of a regular MC.  
261 Specifically, despite its amateur status, intercounty players can train up to seven sessions a  
262 week<sup>2</sup>, while also managing full-time employment or studies. These competing demands may  
263 predispose players to factors such as low energy availability and excessive stress, potentially  
264 resulting in dysregulation of the reproductive axis<sup>23</sup>. Therefore, leveraging the MC as an  
265 indicator of overall health and homeostasis through MC tracking, along with player  
266 education, could be particularly beneficial for identifying irregularities and implementing  
267 appropriate strategies to restore MC function.

268  
269 The prospective approach in this study identified two oligomenorrhic players, highlighting  
270 the potential discrepancy between retrospectively and prospectively collected data. While  
271 both players retrospectively self-reported a mean MC length of 21-35 days, the actual MC  
272 length recorded prospectively ranged from 37-45 days. This reinforces the limitations and  
273 potential measurement errors of retrospective MC history questionnaires<sup>24</sup>. Prospective  
274 monitoring in this study also included logging of perceived MC/HC-related symptoms/side  
275 effects. Regardless of HC use, 93% of players in this study reported negative symptoms/side  
276 effects which they perceived to have mild to moderate interferences on their training and  
277 performance. This supports recent findings that negative MC-related symptoms are common  
278 in athletes and may impair their perceived ability to train and perform<sup>25</sup>. Nonetheless, it is  
279 worth considering that not all menstruating women may experience MC-related symptoms, as  
280 demonstrated by the non-HC player who did not report any symptoms. This suggests that



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

283  
284 Considering that MC-related symptoms may occur at any time in the MC such as pain around  
285 ovulation<sup>25,26</sup>, prospective symptom logging throughout the entire MC is a strength of this  
286 study. Despite this, most players only reported negative symptoms/side effects during  
287 menstruation or withdrawal bleeding, with abdominal cramps and moodiness being the most  
288 common perceived symptoms/side effects regardless of HC use. Similarly, abdominal  
289 cramps/pain and mood swings were the most prevalent symptoms reported by UK-based non-  
290 HC elite athletes<sup>13</sup>. While the symptoms experienced by non-HC users are driven by  
291 aetiologies such as low levels of endogenous hormones<sup>27</sup>, the manifestation of side effects in  
292 OCP users is less clear. Interestingly, the high prevalence of perceived side effects in OCP  
293 users seems paradoxical as OCPs are commonly used to alleviate symptoms of dysmenorrhea  
294 (i.e., painful menstruation)<sup>28</sup>. While mild side effects may be associated with OCP use, they  
295 should disappear with continued use or by switching to another OCP formulation<sup>29</sup>. The  
296 reasons why OCP users tolerated these perceived side effects are beyond the scope of this  
297 study, however, this finding highlights the importance of educating HC users about their  
298 options in managing contraceptive side effects, such as consulting a medical doctor to switch  
299 OCP formulation or methods.

300  
301 Emerging studies have highlighted how negative MC-related symptoms can impair athletes'  
302 perceived ability to train at certain points during the MC<sup>30,31</sup>. While much of the research has  
303 focused on non-HC users, some evidence suggests that HC users perceive a similar adverse  
304 impact of contraceptive side effects on readiness to train<sup>14</sup>. However, the results of this study  
305 indicated that subjective wellness outcomes were consistent across an OCP cycle, suggesting  
306 that despite a high prevalence of perceived side effects, they were perhaps not severe to an  
307 extent that impaired the players' perceived wellness. The small sample of eumenorrheic  
308 players and heterogeneity in MC status observed within a single team demonstrate that in  
309 practice, the consideration of players' menstrual health should take precedence over attempts  
310 at implementing a group-level MC phase-based training approach. Specifically, MC tracking  
311 in athletes should first and foremost be used as a tool to establish and maintain a healthy MC  
312 function in non-HC users at the individual level.

313  
314 While robust methods to monitor MC status can provide valuable information, translating  
315 research methodology in an applied setting is not without practical challenges. As expected, a  
316 key obstacle was the time-sensitive nature of blood sampling, requiring participant and  
317 researcher availability within a narrow three-day window amidst tight player schedules.  
318 Reasons for missed blood sampling include player unavailability, failed blood draws, and  
319 missed ovulation tests. From a research perspective, guidelines recommend MC  
320 characteristics be tracked for at least two months before testing<sup>7</sup>. While this timescale might  
321 be feasible in a controlled environment, researchers working with athletes should account for  
322 the potential difficulties with blood sampling required within a specific and short timeframe  
323 that could result in an increased timescale to confirm MC status. For instance, biochemical  
324 outcomes over consecutive MCs may not be possible in a high-performance environment due  
325 to frequent travel for competition<sup>32</sup>. Practically, if sport teams integrate biochemical testing  
326 for assessing MC status, it may be prudent to select a monitoring timeframe with minimal  
327 variation in athletes' training and competition schedules, such as during the pre-season.

328  
329 As mid-luteal blood sampling relies on the indication of ovulation, missed ovulation tests  
330 would negate further blood sampling. Nonetheless, the players in this study were mostly

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

345

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

368

#### 369 v. Practical Applications

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

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

396

#### 397 **vi. Conclusion**

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

410

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416 **viii. References**

- 417 1. O'Connor S, Bruce C, Teahan C, McDermott E, Whyte E. Injuries in Collegiate Ladies  
418 Gaelic Footballers: A 2-Season Prospective Cohort Study. *Journal of Sport*  
419 *Rehabilitation*. 2020;30(2):261-266. doi:10.1123/jsr.2019-0468
- 420 2. Duggan JD, Keane K, Moody J, et al. Strength and Conditioning Recommendations for  
421 Female Athletes: The Gaelic Footballer. *Strength & Conditioning Journal*.  
422 2023;45(5):525. doi:10.1519/SSC.0000000000000761
- 423 3. Duggan JD, Collins K, Keane K. Factors influencing performance and injury risk in elite  
424 female Gaelic team sport players and future research directions: a narrative review. *BMC*  
425 *Sports Sci Med Rehabil*. 2022;14(1):164. doi:10.1186/s13102-022-00553-8
- 426 4. Diaz A, Laufer MR, Breech LL. Menstruation in Girls and Adolescents: Using the  
427 Menstrual Cycle as a Vital Sign. *Pediatrics*. 2006;118(5):2245-2250.  
428 doi:10.1542/peds.2006-2481
- 429 5. McNulty KL, Elliott-Sale KJ, Dolan E, et al. The Effects of Menstrual Cycle Phase on  
430 Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-  
431 Analysis. *Sports Med*. 2020;50(10):1813-1827. doi:10.1007/s40279-020-01319-3
- 432 6. Constantini NW, Dubnov G, Lebrun CM. The menstrual cycle and sport performance.  
433 *Clinics in Sports Medicine*. 2005;24(2):51-82. doi:10.1016/j.csm.2005.01.003
- 434 7. Elliott-Sale KJ, Minahan CL, de Jonge XAKJ, et al. Methodological Considerations for  
435 Studies in Sport and Exercise Science with Women as Participants: A Working Guide for  
436 Standards of Practice for Research on Women. *Sports Med*. 2021;51(5):843-861.  
437 doi:10.1007/s40279-021-01435-8
- 438 8. de Jonge XAKJ, Thompson B, Han A. Methodological Recommendations for Menstrual  
439 Cycle Research in Sports and Exercise. *Med Sci Sports Exerc*. 2019;51(12):2610-2617.  
440 doi:10.1249/MSS.0000000000002073
- 441 9. Schaumberg MA, Jenkins DG, de Jonge XAKJ, Emmerton LM, Skinner TL. Three-step  
442 method for menstrual and oral contraceptive cycle verification. *J Sci Med Sport*.  
443 2017;20(11):965-969. doi:10.1016/j.jsams.2016.08.013
- 444 10. Smith ES, McKay AKA, Ackerman KE, et al. Methodology Review: A Protocol to Audit  
445 the Representation of Female Athletes in Sports Science and Sports Medicine Research.  
446 *Int J Sport Nutr Exerc Metab*. 2022;32(2):114-127. doi:10.1123/ijsnem.2021-0257
- 447 11. McHaffie SJ, Langan-Evans C, Morehen JC, et al. Normalising the conversation: a  
448 qualitative analysis of player and stakeholder perceptions of menstrual health support  
449 within elite female soccer. *Science and Medicine in Football*. 2022;6(5):633-642.  
450 doi:10.1080/24733938.2022.2145349
- 451 12. De Souza MJ, Toombs RJ, Scheid JL, O'Donnell E, West SL, Williams NI. High  
452 prevalence of subtle and severe menstrual disturbances in exercising women:  
453 confirmation using daily hormone measures. *Human Reproduction*. 2010;25(2):491-503.  
454 doi:10.1093/humrep/dep411

- 455 13. Martin D, Sale C, Cooper SB, Elliott-Sale KJ. Period Prevalence and Perceived Side  
456 Effects of Hormonal Contraceptive Use and the Menstrual Cycle in Elite Athletes.  
457 *International Journal of Sports Physiology and Performance*. 2018;13(7):926-932.  
458 doi:10.1123/ijsp.2017-0330
- 459 14. Oxfeldt M, Dalgaard LB, Jørgensen AA, Hansen M. Hormonal Contraceptive Use,  
460 Menstrual Dysfunctions, and Self-Reported Side Effects in Elite Athletes in Denmark. *Int*  
461 *J Sports Physiol Perform*. 2020;15(10):1377-1384. doi:10.1123/ijsp.2019-0636
- 462 15. Elliott-Sale KJ, McNulty KL, Ansdell P, et al. The Effects of Oral Contraceptives on  
463 Exercise Performance in Women: A Systematic Review and Meta-analysis. *Sports*  
464 *Medicine*. 2020;50(10):1785-1812. doi:10.1007/s40279-020-01317-5
- 465 16. McKay AKA, Minahan C, Harris R, et al. Female Athlete Research Camp: A Unique  
466 Model for Conducting Research in High Performance Female Athletes. *Medicine &*  
467 *Science in Sports & Exercise*. Published online October 17,  
468 2023;10.1249/MSS.0000000000003354. doi:10.1249/MSS.0000000000003354
- 469 17. McKay AKA, Stellingwerff T, Smith ES, et al. Defining Training and Performance  
470 Caliber: A Participant Classification Framework. *International Journal of Sports*  
471 *Physiology and Performance*. 2022;17(2):317-331. doi:10.1123/ijsp.2021-0451
- 472 18. Clayton AH. Symptoms Related to the Menstrual Cycle: Diagnosis, Prevalence, and  
473 Treatment. *Journal of Psychiatric Practice*®. 2008;14(1):13.  
474 doi:10.1097/01.pra.0000308491.54885.f8
- 475 19. National Cancer Institute. National Cancer Institute Dictionaries. Published May 15,  
476 2015. Accessed April 9, 2024. <https://www.cancer.gov/publications/dictionaries>
- 477 20. Saw AE, Main LC, Gastin PB. Monitoring Athletes Through Self-Report: Factors  
478 Influencing Implementation. *J Sports Sci Med*. 2015;14(1):137-146.
- 479 21. Satterthwaite FE. An Approximate Distribution of Estimates of Variance Components.  
480 *Biometrics Bulletin*. 1946;2(6):110-114. doi:10.2307/3002019
- 481 22. Taim BC, Ó Catháin C, Renard M, Elliott-Sale KJ, Madigan S, Ní Chéilleachair N. The  
482 Prevalence of Menstrual Cycle Disorders and Menstrual Cycle-Related Symptoms in  
483 Female Athletes: A Systematic Literature Review. *Sports Med*. 2023;53(10):1963-1984.  
484 doi:10.1007/s40279-023-01871-8
- 485 23. Mikkonen RS, Ihalainen JK, Davis-Wilson HC, Hackney AC. The Hypothalamic–  
486 Pituitary–Ovarian Axis, Menstrual and Oral Contraceptive Cycles: Regulation and  
487 Function in the Context of Exercise and Sport. In: Hackney AC, ed. *Sex Hormones,*  
488 *Exercise and Women: Scientific and Clinical Aspects*. Springer International Publishing;  
489 2023:1-24. doi:10.1007/978-3-031-21881-1\_1
- 490 24. Small CM, Manatunga AK, Marcus M. Validity of Self-Reported Menstrual Cycle  
491 Length. *Annals of Epidemiology*. 2007;17(3):163-170.  
492 doi:10.1016/j.annepidem.2006.05.005
- 493 25. Bruinvels G, Goldsmith E, Blagrove R, et al. Prevalence and frequency of menstrual  
494 cycle symptoms are associated with availability to train and compete: a study of 6812

- 495 exercising women recruited using the Strava exercise app. *British Journal of Sports*  
496 *Medicine*. 2021;55(8):438-443. doi:10.1136/bjsports-2020-102792
- 497 26. Bruinvels G, Hackney AC, Pedlar CR. Menstrual Cycle: The Importance of Both the  
498 Phases and the Transitions Between Phases on Training and Performance. *Sports Med*.  
499 2022;52(7):1457-1460. doi:10.1007/s40279-022-01691-2
- 500 27. King AE, Critchley HOD. Oestrogen and progesterone regulation of inflammatory  
501 processes in the human endometrium. *J Steroid Biochem Mol Biol*. 2010;120(2-3):116-  
502 126. doi:10.1016/j.jsbmb.2010.01.003
- 503 28. Wong CL, Farquhar C, Roberts H, Proctor M. Oral contraceptive pill for primary  
504 dysmenorrhoea. *Cochrane Database of Systematic Reviews*. 2009;(4).  
505 doi:10.1002/14651858.CD002120.pub3
- 506 29. Cooper DB, Patel P, Mahdy H. Oral Contraceptive Pills. In: *StatPearls*. StatPearls  
507 Publishing; 2022. Accessed December 16, 2022.  
508 <http://www.ncbi.nlm.nih.gov/books/NBK430882/>
- 509 30. McNamara A, Harris R, Minahan C. ‘That time of the month’ ... for the biggest event of  
510 your career! Perception of menstrual cycle on performance of Australian athletes training  
511 for the 2020 Olympic and Paralympic Games. *BMJ Open Sport & Exercise Medicine*.  
512 2022;8(2):e001300. doi:10.1136/bmjsem-2021-001300
- 513 31. Solli GS, Sandbakk SB, Noordhof DA, Ihalainen JK, Sandbakk Ø. Changes in self-  
514 reported physical fitness, performance, and side effects across the phases of the menstrual  
515 cycle among competitive endurance athletes. *International Journal of Sports Physiology*  
516 *and Performance*. 2020;15(9):1324-1333. doi:10.1123/IJSPP.2019-0616
- 517 32. Schwellnus M, Soligard T, Alonso JM, et al. How much is too much? (Part 2)  
518 International Olympic Committee consensus statement on load in sport and risk of illness.  
519 *Br J Sports Med*. 2016;50(17):1043-1052. doi:10.1136/bjsports-2016-096572
- 520 33. Bull JR, Rowland SP, Scherwitzl EB, Scherwitzl R, Danielsson KG, Harper J. Real-world  
521 menstrual cycle characteristics of more than 600,000 menstrual cycles. *npj Digit Med*.  
522 2019;2(1):1-8. doi:10.1038/s41746-019-0152-7
- 523 34. Eichner SF, Timpe EM. Urinary-Based Ovulation and Pregnancy: Point-of-Care Testing.  
524 *Ann Pharmacother*. 2004;38(2):325-331. doi:10.1345/aph.1D210
- 525 35. Windt J, Ardern CL, Gabbett TJ, et al. Getting the most out of intensive longitudinal data:  
526 A methodological review of workload-injury studies. *BMJ Open*. 2018;8(10):1-17.  
527 doi:10.1136/bmjopen-2018-022626
- 528 36. Gibbons RD, Hedeker D, DuToit S. Advances in Analysis of Longitudinal Data. *Annual*  
529 *Review of Clinical Psychology*. 2010;6(1):79-107.  
530 doi:10.1146/annurev.clinpsy.032408.153550
- 531

532 **ix. Figure captions**

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

537

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

540

541 x. Tables

542

543 **Table 1** Questionnaire items for menstrual cycle and hormonal contraceptive tracking

<b>Players <i>not</i> using hormonal contraceptives</b>	<b>Players using hormonal contraceptives</b>
Are you currently menstruating?	Are you currently bleeding (e.g., withdrawal bleed)?
Are you experiencing any symptoms that may be related to your menstrual cycle?	Is today a pill-taking or a pill-free day? <sup>a</sup>
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 <sup>b</sup> 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)	

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



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

<b>Menstrual cycle status</b>	<b>Definition<sup>7</sup></b>
Eumenorrhea	Menstrual cycle length $\geq 21$ days and $\leq 35$ days + Ovulation detected by urinary luteinising hormone surge testing + Greater than $16 \text{ nmol}\cdot\text{L}^{-1}$ 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 $16 \text{ nmol}\cdot\text{L}^{-1}$ of progesterone (determined by a single luteal phase serum progesterone measurement)

548

549 **Table 3** Player demographic information

<b>Characteristics</b>	<b>All (n=14)</b>	<b>Non-hormonal contraceptive user (n=6)</b>	<b>Oral contraceptive pill<sup>b</sup> user (n=7)</b>	<b>Intrauterine system user (n=1)</b>
Age <sup>a</sup> (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 <sup>a</sup> (y)	13.6 ± 1.2	12.8 ± 1.3	14.0 ± 0.8	15

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

552 **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) <sup>c</sup>	Day of ovulation	PROG (nmol·L <sup>-1</sup> )	Day of blood sample <sup>a</sup>	Day of ovulation	PROG (nmol·L <sup>-1</sup> )	Day of blood sample <sup>a</sup>	Day of ovulation	PROG (nmol·L <sup>-1</sup> )	Day of blood sample <sup>a</sup>
1	24 ± 4	11	<1.0 <sup>b</sup>	8	14	Unknown	Unknown	x	x	x
2	28 ± 3	12	7.5 <sup>b</sup>	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 <sup>b</sup>	8	15	17.6	10
6	45 <sup>d</sup>	Not detected					–			
<b>All<sup>c</sup></b>	<b>32 ± 6</b>	<b>15 ± 6</b>	<b>17.3 ± 13.2</b>	<b>8 ± 1</b>	<b>19 ± 6</b>	<b>11.4</b>	<b>8</b>	<b>15 ± 4</b>	<b>24.4 ± 9.5</b>	<b>9 ± 1</b>

553 Abbreviations: PROG = serum progesterone concentration, Unknown = unable to collect blood sample as player's next menses started before the  
554 scheduled blood sampling window, x = missed ovulation testing or missed blood sampling due to player unavailability (n=2), failed blood draw  
555 (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  
556 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  
557 ovulation. *Note:* <sup>a</sup>Represented as the number of days after a positive ovulation test result, <sup>b</sup>Serum progesterone concentration lower than the  
558 verification limit of at least 16 nmol·L<sup>-1</sup>, <sup>c</sup>Data expressed as mean ± standard deviation (SD), <sup>d</sup>Only one complete menstrual cycle was captured

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

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

	Late pill-free <sup>a</sup>	0.37	0.31	-0.24 – 0.99	1.19	0.239					
<b>Upper body soreness</b>											
	Intercept	8.17	0.41	7.36 – 8.99	19.75	< .001					
	Late pill-taking <sup>a</sup>	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 <sup>a</sup>	-0.20	0.34	-0.88 – 0.47	-0.60	0.553					
	Late pill-free <sup>a</sup>	0.31	0.38	-0.43 – 1.04	0.83	0.412					

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