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1 **Changes in self-reported physical fitness, performance, and side-effects**
2 **across the phases of the menstrual cycle among competitive endurance**
3 **athletes**

4
5
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8

9 **Original investigation**

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43 **Abstract**

44

45 **Purpose:** To investigate changes in self-reported physical fitness, performance, and side-
46 effects across the menstrual cycle (MC) phases among competitive endurance athletes, and to
47 describe their knowledge and communication with coaches about the MC.

48

49 **Methods:** The responses of 140 participants (>18 years), competing in biathlon or cross-
50 country skiing at the (inter)national level were analyzed. Data were collected via an online
51 questionnaire addressing participants' competitive level, training volume, MC history, physical
52 fitness and performance during the MC, MC-related side-effects, and knowledge and
53 communication with coaches about the MC and its effects on training and performance.

54

55 **Results:** 50% and 71% of participants perceived improved and reduced fitness respectively,
56 during specific MC-phases, whereas 42% and 49% perceived improved and reduced
57 performance, respectively. Most athletes reported their worst fitness (47%) and performance
58 (30%), and the highest number of side-effects during bleeding ($p<.01$; compared to all other
59 phases), the phase following bleeding were considered the best phase for perceived fitness
60 (24%, $p<.01$) and performance (18%, $p<.01$). Only 8% of participants reported to have
61 sufficient knowledge about the MC in relation to training, and 27% communicated about it
62 with their coach.

63

64 **Conclusions:** A high proportion of athletes perceived distinct changes in fitness, performance,
65 and side-effects across the MC-phases, with their worst perceived fitness and performance
66 during the bleeding phase. Because most athletes indicate a lack of knowledge about the MC's
67 effect on training and performance and few communicate with coaches on the topic, we
68 recommend that more time should be devoted to educating athletes and coaches.

69

70 **Keywords:** coaching, female athlete, hormonal contraceptives, sex hormones, training quality,
71 coach education

72 Introduction

73
74 Differences in physical development between women and men accelerate from the onset of
75 puberty, mainly due to changes in circulating levels of sex-specific hormones. In women aged
76 ~13 to ~50 years, ovarian hormones fluctuate with defined phases of varying hormonal profiles
77 during 21–35-day periods in an individual rhythm called the *menstrual cycle* (MC).^{1,2}
78 Hormonal fluctuations during the MC have been reported to particularly influence ventilation,
79 thermoregulation, and substrate metabolism^{3–6}, as well as causing negative side-effects such as
80 pain, heavy menstrual bleeding, anemia, and mood changes.^{7,8} In theory, such physiological
81 responses to hormonal fluctuations and their negative side-effects could influence the quality
82 of training and endurance performance throughout the MC. However, the previous research on
83 the influence of MC on objectively measured endurance performance are inconsistent.^{3,4,9–15}
84 This is possibly due to methodological differences (e.g., divergent definitions of MC phases),
85 the low number of available studies using quantified hormonal concentrations to verify MC
86 phases,¹⁶ and the low number of studies with adequate sample size conducted on this topic.¹⁷
87 Furthermore, a substantial proportion of elite athletes are known to be susceptible to menstrual
88 irregularities,^{18,19} which disrupt their hormone profiles and thereby make the interpretation of
89 research findings challenging.

90
91 The available research on the athlete's perceived effect of the MC reports that 51% of elite
92 marathon runners experienced an impact of their MC on training and performance.⁸ However,
93 details on when runners performed best or worst during the cycle were not provided. Moreover,
94 Martin et al.⁷ found that 77% of athletes not using hormonal contraceptives (HCs) reported
95 negative MC-related symptoms (e.g., abdominal pains or cramps), mostly during the first days
96 of bleeding. However, their sample included athletes from a range of sports, and they did not
97 investigate whether the athletes had planned or adjusted their training to accommodate these
98 negative side-effects. Consequently, specific information about the influence of the MC on
99 perceived physical fitness and performance and the negative side-effects from a large sample
100 of elite endurance athletes would provide important information.

101
102 An estimated 40–70% of female athletes use some type of HCs,^{7,18,20} with athletes perceiving
103 in general more positive than negative effects of HC use.⁷ Examples of positive effects are the
104 ability to predict or manipulate the bleeding period and the reduction of pain, while
105 negative effects such as weight gain and irregular periods have also been reported.⁷
106 Women using combined oral contraceptives (OCs) have exhibited higher cortisol levels,²¹
107 lower maximal aerobic capacity,²² and less adaptation to sprint-interval training²³ than non-
108 users, whereas endurance performance seems unaffected.^{14,24,25} It is currently unknown
109 whether the varying doses and routes of administration of sex hormones in different HC
110 preparations (e.g., OCs, implants, injections, transdermal patches, vaginal rings, and
111 intrauterine systems) and types of HCs (e.g., estrogen–progestin and progestin-only types) will
112 influence endurance performance.²⁶ However, negative side-effects have more often been
113 reported for progestin-only than estrogen–progestin HCs.⁷ In addition, considerable individual
114 variations in the type and severity of HC-related side-effects, as well as in reasons to start and
115 stop using HCs, have been reported.⁷ Indeed, more specific knowledge about the use of HCs
116 among competitive endurance athletes could help female athletes to optimize their training
117 adaptations during the MC. Therefore, the primary aim of the current study was to investigate
118 changes in self-reported physical fitness, performance, and side-effects during the different
119 phases of the MC in competitive endurance athletes, and the influence of age (i.e., senior vs.
120 junior athletes), performance level (i.e., international vs. national), and HC-use.

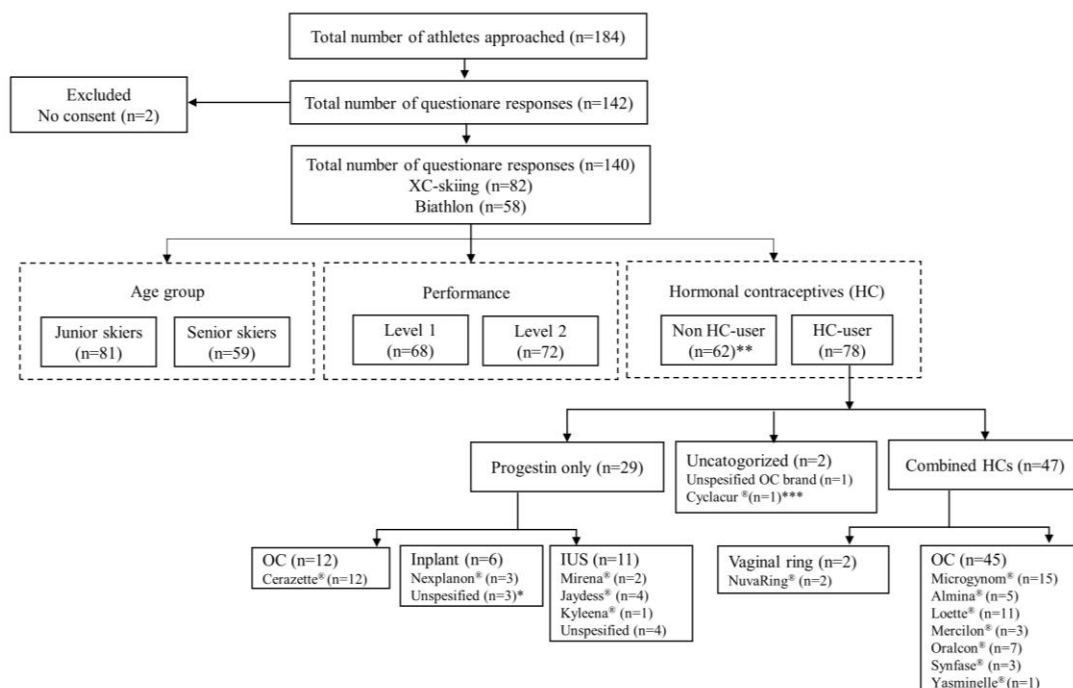
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122 Another unclear factor is how much endurance athletes know about the MC and its possible
 123 effects on their training and performance. Furthermore, a large proportion of female athletes
 124 are coached by men,^{27,28} who, according to a previous study, are less knowledgeable about, and
 125 less comfortable with talking about MC irregularities than female coaches.²⁹ However, this has
 126 only been examined in a sample of high-school coaches whose knowledge and communication
 127 behaviors might differ from coaches of elite athletes. Moreover, the main topic of their
 128 questionnaire was the female athlete triad, not the MC. Consequently, research on how much
 129 endurance athletes and their coaches know and communicate about the MC remains necessary.
 130 Therefore, the secondary aim of the current study was to describe athletes' knowledge and
 131 communication with their coaches about the MC.

132
 133 **Methods**

134
 135 **Participants**

136 As cross-country skiing and biathlon are demanding endurance sports in which approximately
 137 90% of training consists of aerobic endurance exercises,^{30,31} 184 elite female athletes from
 138 these sports were recruited between May and September 2018. All participants had to be >18
 139 years old and competing at the national or international level. Ultimately, 140 elite endurance
 140 athletes completed the questionnaire, and their data were included in the final analysis (Figure
 141 1). Of them, 59% (n=82) were cross-country skiers, and 41% (n=58) biathletes. The study was
 142 evaluated by the Regional Committee for Medical and Health Research Ethics (2018/50/REK-
 143 midt) and approved by the Norwegian Social Science Data Services. All participants were
 144 informed about the content and nature of the questions, and that they by agreeing to the terms
 145 and completing the questionnaire, had provided written informed consent for their information
 146 to be used in this study.



*Unspecified in combination with Microgynom® (n=1). **Unspecified copper based (n=1). ***Hormonal preparation without contraceptives (n=1).

148
 149 Figure 1 – Sample characteristics and the prevalence of type, delivery method, and preparation
 150 of HCs used; HC, hormonal contraceptives; IUS, intrauterine system; OC, oral contraceptive.
 151

152 **Questionnaire**

153

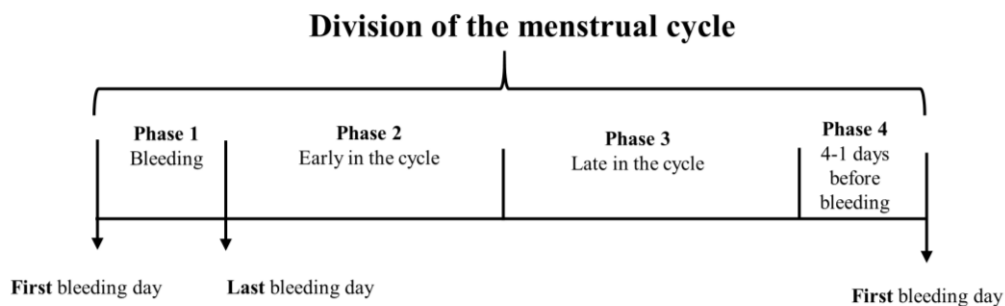
154 Data were collected via an online questionnaire (Questback, 2017) designed according to the
155 study’s aim and developed by an expert panel of former athletes, coaches, a physiologist, and
156 researchers with experience from similar projects and relevant medical expertise. To ensure that
157 participants understood the questions, a pilot study with eight participants was conducted
158 before data collection commenced.

159

160 Designed to take 15–20 min to complete, the questionnaire contained 54 questions: 25 closed-
161 ended questions, 11 questions asking for a numeric value, seven yes-or-no questions, three
162 multiple-choice questions, and 11 open-ended questions. Participants reported their
163 demographic information, aspects of training, competition level, menstrual history, physical
164 fitness (perceived training quality), and performance (results on tests or competitions) during
165 the MC, as well as MC-related negative side-effects. To ensure a uniform understanding of the
166 MC’s different phases, a simple four-phase definition of the MC was provided prior to
167 questions regarding the different phases (Figure 2). The questionnaire also contained questions
168 about the athletes’ perceptions of their own and their coaches’ knowledge of the MC in relation
169 to training and how they communicated about the topic. All athletes answered the questions
170 related to communication and knowledge about the MC (n=140), while all athletes who
171 reported to have had their menarche answered the questions regarding physical fitness,
172 performance and menstrual-related side effects across the different phases of the MC (n=139).
173 Current HC users (n=78, 56%) were instructed to complete an additional set of in-depth
174 questions about their experience with using HCs. Because the questionnaire was in Norwegian,
175 a translating process was performed to ensure validity when interpreting the questions in
176 English. First, the questionnaire was translated by one person that was fluent in English and
177 had a good understanding of Norwegian. Thereafter, this version was back-translated
178 independently by two persons who were fluent in Norwegian and had a good understanding of
179 English. Thereafter, all three translators compared the original questionnaire with the one
180 translated back and assessed if a word or several words reflected the same in both the original
181 and the English version of the questionnaire.³²

182

183



184

185 Figure 2 – Definition of the menstrual cycle in connection to questions related to phases of the
186 cycle.

187

188

189 **Statistics**

190

191 Questionnaire responses were summarized in numerical values to facilitate statistical analyses.
192 To categorize free-text questions, two researchers performed independent content, frequency,
193 and consistency analyses until consensus was reached. Direct verbatim quotations were used
194 to inform interpretation. Descriptive data for continuous variables were recorded as means (*SD*)
195 and for categorical variables as totals and percentages. For continuous variables, the Shapiro–
196 Wilk test and standard visual inspection were used to examine the assumption of normality.

197

198 A binary group categorization was performed to assess potential differences in subgroups by
199 age, including junior (i.e., 17–20 years old) versus senior athletes (i.e., 21–33 years old);
200 performance level, including Level 1 (i.e., at least one ranking of 1–30 in international
201 competitions or an overall ranking of 1–10 in the Norwegian National Cup) versus Level 2
202 (i.e., overall ranking of 11–50 in the Norwegian National Cup); and HC use status, including
203 current HC users versus current non-HC users. Pairwise differences in sample characteristics
204 between subgroups were assessed with independent samples *t*-tests and differences in
205 proportions assessed with Pearson’s chi-squared tests.

206

207 The total score of side-effects was calculated as the sum of reported symptoms during each
208 phase of the MC. Global differences in the number of side-effects across the phases were
209 assessed with linear mixed-effects models involving MC-phase as a fixed factor and participant
210 as a random factor. When significant *F*-values emerged, pairwise post hoc tests with Tukey’s
211 adjustment were used. Model fit was examined with normal Q–Q plots of studentized residuals.
212 Interactions of phase with age, performance level, and HC-use were examined to assess
213 differences between subgroups.

214

215 All statistical tests were two-sided, and *p* values <.05 were considered statistically significant.
216 Statistical analyses were conducted using the Statistical Package for the Social Sciences
217 version 24.0 (SPSS Inc., Chicago, IL, USA) and Microsoft Excel 2016 (Microsoft Corporation,
218 Redmond, WA, USA).

219

220 **Results**

221

222 The sample’s characteristics appear in Table 1 and summarized questionnaire responses in
223 Supplementary Tables 1–5. The average age of menarche for all athletes was 13.9±2.0 years;
224 15% were more than 16 years old at menarche, and one 19-year-old athlete reported primary
225 amenorrhea. Few athletes (4%) reported no bleeding periods during the previous year, 13%
226 reported fewer than five periods, 17% reported 5–9, and 56% reported 10–15. Moreover, 30%
227 experienced loss of menstrual bleeding in connection with high volumes of training and 23%
228 in connection with large amounts of high-intensity training.

229

230

231 **Table 1 Age and training data (Mean±SD) for the 140 elite female cross-country skiers and biathletes included in this study.**

	Total (n=140)	Age group		<i>P-value</i>	Performance			Current HC-user		
		Junior (n=81)	Senior (n=59)		Level 1 (n=68)	Level 2 (n=72)	<i>P-value</i>	No (n=61)	Yes (n=78)	<i>P-value</i>
Age (years)	21.6±3.1	19.4±0.9	24.4±2.8	.000	22.4±3.5	20.8±2.5	.009	20.5 ± 2.3	22.4 ± 3.4	.000
Training volume (h/year)	575±148	523±109	620±163	.000	640±130	513±138	.000	570±130	579±162	.633
Weekly volume GP (h/wk)	13.6±3.9	12.7±3.5	14.5±4.1	.000	15.4±3.4	12.0±3.5	.000	13.4±3.7	13.9±4.0	.373
Weekly sessions GP (h/wk)	9.9±2.6	9.5±2.8	10.3±2.4	.013	10.4±2.0	9.0±2.7	.000	9.8±2.4	10.1±2.8	.481
Weekly HIT GP (h/wk)	2.4±0.8	2.3±0.8	2.4±0.8	.035	2.5±0.7	2.2±0.9	.014	2.2±0.8	2.4±0.9	.045
Weekly volume CP (h/wk)	10.1±3.0	9.6±2.4	10.7±3.3	.013	11.4±2.5	9.1±2.9	.000	10.0±3.0	10.4±2.9	.264
Weekly sessions CP (h/wk)	8.5±2.6	8.3±2.7	8.9±2.4	.014	9.5±2.5	7.8±2.4	.000	8.5±2.7	8.7±2.4	.247
Weekly HIT CP (h/wk)	2.6±0.8	2.6±0.8	2.7±0.8	.169	2.8±0.6	2.5±0.9	.008	2.6±0.7	2.7±0.9	.304

232 HC; hormonal contraceptives, Level 1; at least one ranking between 1-30 in world cup races and/or an overall ranking between 1-10 in the Norwegian National Cup, Level 2;
 233 at least and/or an overall ranking between 11-50 in the Norwegian National Cup, HIT; high-intensity training, GP; general preparation phase, CP; Competition phase.

234 **Physical fitness, performance, and MC-related side-effects during the MC**

235

236 Figure 3 illustrates the athletes' self-reported physical fitness and performance during the MC.
 237 Fifty and 71% of the athletes reported improved or reduced physical fitness during specific
 238 phases of the MC, respectively, whereas 42% and 49% reported improved or reduced
 239 performance, respectively. Global comparisons revealed that physical fitness and performance
 240 differed significantly by phase (both $p < .001$) and that the greatest proportion of athletes
 241 experience their worst fitness (47%) and performance (30%) during Phase 1 ($p < .01$ compared
 242 to all other groups). By contrast, the best physical fitness was reported most frequently during
 243 Phases 2 and 3 (24% and 14%, respectively; both $p < .01$ compared to Phases 1 or 4), as was
 244 best performance (18% and 18%, respectively; both $p < .01$ compared to Phases 1 or 4).
 245 Subgroup analyses revealed no significant differences between age groups, performance levels,
 246 or use of HCs (all $p > .05$). A large proportion of athletes indicated not to perceive improvement
 247 (50%) or reduction (29%) in physical fitness, or improvement (58%) or reduction (51%) in
 248 performance across the different phases of the MC (Figure 3).

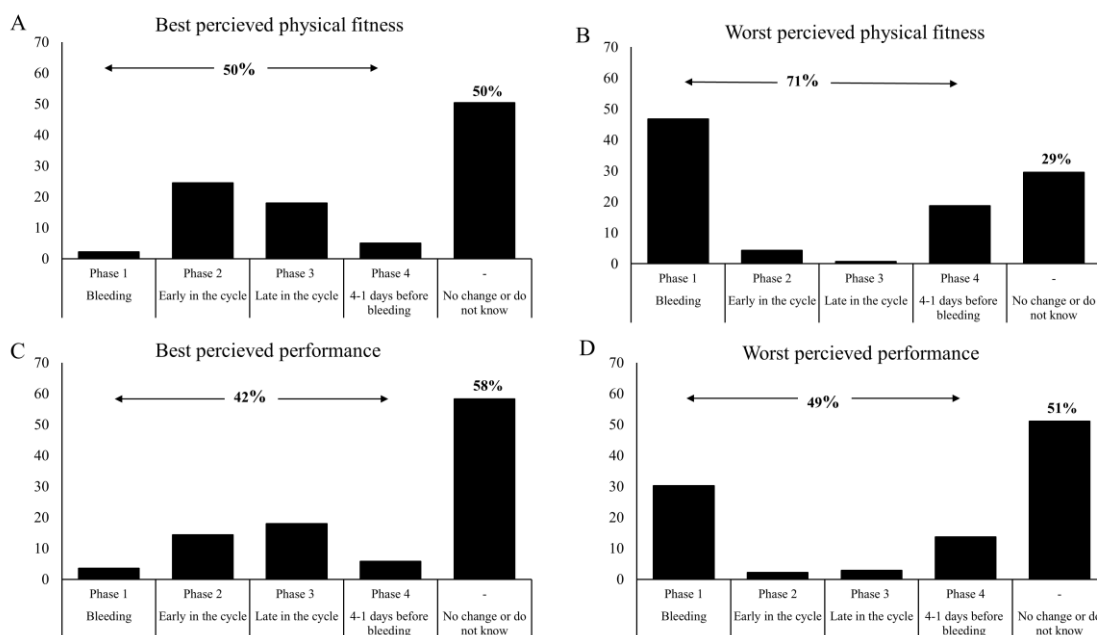
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250 The most frequently reported side-effects were stomach pain (83%) and bloating (63%, Figure
 251 4), while 8% of the athletes had not experienced any MC-related side-effects in the last year.
 252 The number of side-effects differed significantly by phase ($p < .001$), with the highest number
 253 being reported in Phase 1 (3.6 ± 2.4), followed by Phases 4 (2.1 ± 2.1), 2 (0.5 ± 1.3), and 3
 254 (0.3 ± 0.7 , $p < .05$ for all pairwise comparisons). Subgroup analyses revealed no significant
 255 interactions by age group, performance level, or use of HCs (all $p > .05$).

256

257 Fifty-two and 22% of the athletes altered their training at least once or more than 3 times,
 258 respectively, due to MC-related side-effects during the previous year. Only 7% of athletes
 259 planned their training according to their MC ($p < .001$). The most frequent reasons for altering
 260 training were stomach pain (40%) and lower-back pain (20%) (detailed information presented
 261 in Table 2).

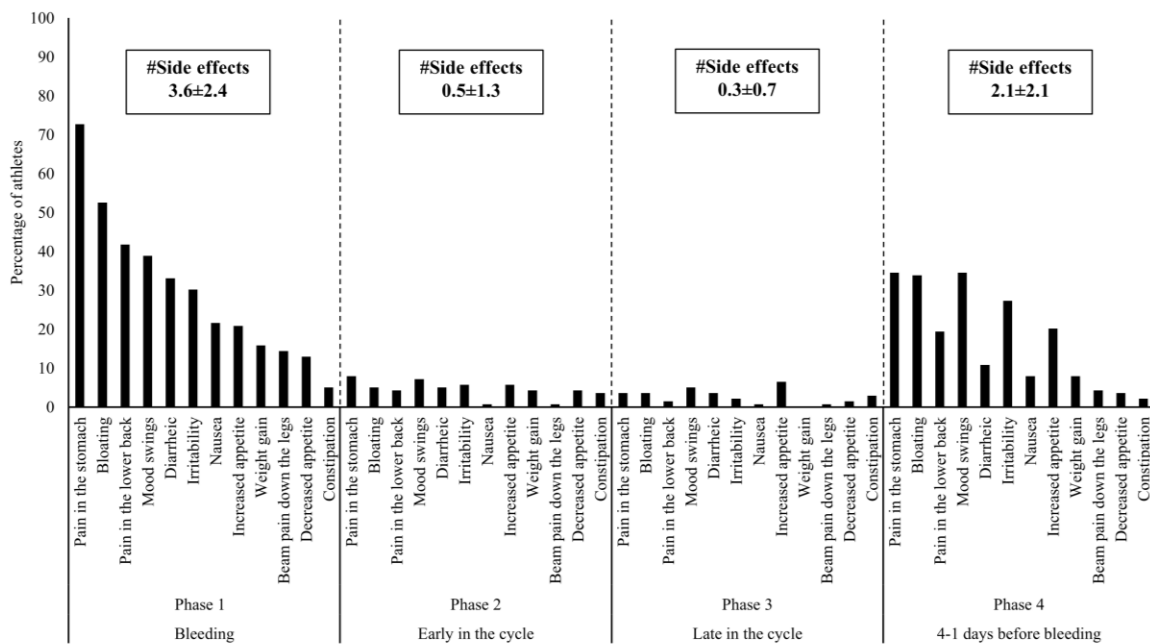
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263

264 Figure 3 A–D – The athletes' self-reported best (A) and worst (B) physical fitness, and the
 265 athletes' self-reported best (C) and worst (D) performance across the phases of the menstrual
 266 cycle.

267



268

269 Figure 4 – The athletes’ self-reported side-effects across the phases of the menstrual cycle.
270

271 **Use of HCs**

272

273 As shown in Figure 1, 56% of the athletes were using HCs at the time of data collection. HC-
274 users were significantly older than non-users (22.4 vs. 20.5 years; $p < .01$), and 61% used
275 estrogen–progestin HCs, 38% used progestin-only HCs, and 1% used an unspecified type of
276 OC (Figure 1). OCs were the most widely used HCs, followed by intrauterine systems (15%),
277 implants (9%), and vaginal rings (3%).

278

279 In response to follow-up questions, nearly all HC users (98%) used HCs throughout the entire
280 year, and 33% used HCs to manipulate their timing of the MC. 17% of HC-users stated that
281 HCs had positively affected their performance or physical fitness, 5% reported negative
282 experiences, and 26% reported previously discontinuing their use of another type of HC that
283 had compromised their performance (detailed information presented in Table 2).
284

285 **Knowledge and communication about the MC**

286

287 Overall, 8% of the athletes reported having sufficient knowledge about the MC in relation to
288 athletic training and performance. Most athletes had communicated about training and the MC
289 with other athletes (79%), friends (66%), and family members (56%), while only 27% had
290 communicated with their coaches about the topic. Notably, 81% of the athletes’ coaches were
291 men, and 19% were women; however, 44% of athletes with female coaches reported discussing
292 the MC with their coaches, only 22% of ones with male coaches reported doing so. Among
293 athletes who had not talked to their coaches about the MC and training, 63% did not want to
294 do so, and 27% found broaching the subject difficult (reasons presented in Table 2).
295

Table 2 Overview of the analysis of open-end follow up questions about menstrual cycle-related adjustments of training, knowledge and communication about the menstrual cycle and the experiences of hormonal contraceptives

<p>How have you changed your training according to MC-related side effects?¹⁾ Reduced the intensity (n=22) Cancelled/postponed session or taken a rest day (n=21) Reduced the duration (n=17) Postponed high-intensity sessions (n=10) Interrupted sessions (n=4) Changed exercise mode (n=4)</p>	<p><i>"I did not train due to a bad physical shape or feeling miserable. I sometimes performed an easier type of session, and often missed a good training session."</i></p> <p><i>"I just get very tired and have poor physical shape on the first day of the bleeding phase. If it is an interval session or test, I try to postpone it because it always goes bad on these days."</i></p>
<p>What would you like to learn in relation to the MC and training?²⁾ General information about how the MC can affect training (n=41) If it's possible to periodize training sessions after the MC to get more effect of the training (n=33) If the MC affects performance (n=30) If the MC can affect training adaptations (n=19) If/how HCs affect training and performance (n=9) If it is dangerous if the menstrual bleeding phase disappears (n=6) If there are menstrual phases during which you are more vulnerable for injuries (n=2) If there is something you can do to reduce pain (n=2)</p>	<p><i>"If and to what extent the MC can affect exercise. For example, if I can benefit from exercising in a specific way, like more emphasis on high-intensity or strength sessions in a particular phase of the cycle. The same applies recovery after sessions; how does the MC affects this, and to what extent would the use of oral contraceptives affect training and recovery."</i></p> <p><i>"I have lost my period completely, so it would be nice to know if this is normal and whether it will be possible to have children in the future."</i></p>
<p>Why do you find it difficult to talk to your coach about the MC?³⁾ Private, taboo, uncomfortable or embarrassing (n=11) My coach is a man (n=10) Don't know (n=7) Don't know the coach well enough (n=4) The coach lacks knowledge on this topic (n=3)</p>	<p><i>"Feels like it's a taboo. I am afraid that the coach won't take it seriously and thinks I'm using it as an excuse."</i></p> <p><i>"I think I have more competence and knowledge about this topic than he."</i></p> <p><i>"Because he is a man."</i></p>
<p>What knowledge about the MC and training do you think your coach lacks?⁴⁾ General information about how the MC can affect training (n=22) Don't know since we have not talked about this (n=16) If the MC can affect training adaptations or performance (n=13) That it leads to pain (n=3) How it affects the risk for injuries (n=1)</p>	<p><i>"The difference between female and male athletes. I think there may be differences due to the MC that he is not aware of."</i></p> <p><i>"General lack of knowledge about the menstrual cycle"</i></p>
<p>How has the use of HCs affected your performance at training or competitions?⁵⁾ Less pain (n=9) More tired (n=4) Don't need to worry about the bleedings (n=2) Gain of weight (n=2) Less bleeding (n=1) Mood swings (n=1)</p>	<p><i>"Decreases pain and shortens the bleeding phase."</i></p> <p><i>"Positive: can skip my period in the competition season."</i></p> <p><i>"Gained 3 kg! When I quit using the pill, I lost weight and could run much easier uphill."</i></p>
<p>Can you describe why you stopped using this type of HC?⁶⁾ Weight gain (n=7) Irregular MC(n=6) Increased pain (n=5) Mood swings (n=5) Lack of performance progress (n=2) Unsure if it could affect my training adaptations (n=1) Thrombosis (n=1) Stressful to remember to take the pill (n=1)</p>	<p><i>"Gained weight. It negatively affected my performance."</i></p> <p><i>"Mostly because I felt out of balance, both physically and mentally."</i></p> <p><i>"Experienced discomfort during the bleeding period. Got irregular bleeding, weight gain and mood swings."</i></p>

MC; menstrual cycle, HC; hormonal contraceptives. The questions in the table were follow-up questions asked to all athletes answering ¹⁾that they had changed their training because of MC-related side effects ²⁾"No" at the question: "Do you think you have enough knowledge about how the MC can affect training and performance?", ³⁾"Yes" at the question: "Do you find it difficult to talk to your coach about the MC in relation to training and performance?" ⁴⁾"No" at the question: "Do you think your coach has enough knowledge about the MC in relation to training and performance?" ⁵⁾"Yes" at the question: Have you experienced that the HC affects your performance on training or competition? ⁶⁾"Yes" at the question: "Have you ever stopped using a HC, because you experienced it affected your physical fitness or performance?"

303 **Discussion**

304

305 We investigated changes in self-reported physical fitness, performance, and negative side-
306 effects during the different phases of the MC among competitive endurance athletes, as well as
307 the athletes' knowledge and communication with their coaches about this topic. The main
308 findings of the current study were: 1) 50% and 71% of the athletes perceived improved or
309 reduced physical fitness, respectively, during specific phases of the MC, whereas 42% and 49%
310 reported improved and reduced performance, respectively; 2) a large proportion of athletes
311 perceived no changes in physical fitness or performance across the MC; and 3) no differences
312 in fitness, performance or negative side-effects by age, performance level, or HC-use emerged.
313 Moreover, 4) only 8% of the athletes indicated having sufficient knowledge about the MC's
314 effects on athletic training and performance, and 5) only 27% reported to communicate with
315 their coaches about the topic.

316

317 **Physical fitness, performance, and side-effects during the different phases of the MC**

318

319 The result that approximately 50% of the athletes reported distinct changes in physical fitness
320 and performance during the MC-phases is comparable to what Bruinvels et al.⁸ observed
321 among marathon runners. Of the athletes who reported that the MC had affected their fitness
322 or performance, significantly more reported reduced physical fitness or performance in Phase
323 1 (i.e., bleeding) than during the other three phases. Reduced physical fitness or performance
324 during the MC has been associated with premenstrual symptoms or dysmenorrhea (i.e.,
325 menstrual cramps caused by uterine contractions).² Likewise, our athletes reported that
326 negative side-effects of the MC most often occurred during Phase 1, followed by Phase 4 (i.e.,
327 1–4 days before bleeding). The most common symptoms were stomach pain, bloating, and
328 mood swings. Such findings align those of Martin et al.⁷, who reported the highest prevalence
329 of side-effects during days 1 and 2 of Phase 1. Other researchers have observed higher training
330 monotony and strain during the early stages of the MC than during the ovulatory phase, which
331 they attributed to the increased prevalence of MC-related symptoms in the first half of the MC
332 (i.e., follicular phase) compared to the second half (i.e., luteal phase).³³ Most likely due to the
333 high incidence of side-effects in Phases 1 and 4, athletes in our sample reported the best
334 physical fitness and performance during Phases 2 and 3. However, experimental research on
335 endurance performance during the phases of the MC has produced mixed results; some
336 researchers have observed better performance during the follicular phase^{11,15} or increased
337 performance during the luteal phase,^{9,12} although most have reported no fluctuation in
338 performance during the MC.^{3,4,10,13,14} Such inconsistent findings may stem from
339 methodological differences,¹⁶ particularly in different definitions of the MC's phases.
340 However, the substantial number of athletes in our study who reported distinct changes in
341 performance during the MC highlights the need for additional research on the topic.

342

343 Despite the high incidence of symptoms of stomach pain (83%), only 22% of the athletes
344 reported to repeatedly (i.e., >3 times/year) alter their training due to MC-related side-effects.
345 By comparison, Martin et al.⁷ found that only 4% of athletes in different sports reported needing
346 to refrain from exercise at certain points of their MC.⁷ In our study, the most frequent types of
347 MC-related training adjustments were reduced intensity or duration, cancelled sessions and
348 postponed high-intensity training sessions. To reduce the severity of negative side-effects, 52%
349 of the athletes reported having used painkillers, which suggests that many athletes experience
350 some degree of pain during the MC that can affect their physical fitness, performance, and
351 training quality. However, it remains uncertain whether athletes take those medications to
352 become able to perform planned training sessions and whether doing so affects subsequent

353 training adaptations. In response, monitoring the MC could likely provide information to guide
354 the development of training schedules and optimize performance.

355

356 **Period prevalence and HC use**

357

358 The mean age at menarche (13.9 ± 2.0) was roughly the same as that previously reported by
359 endurance athletes (13.8 ± 1.5),¹⁸ slightly higher than that of athletes from various sports
360 (13.6 ± 1.4)⁷, and higher than that observed in non-athlete controls (13.0 ± 1.3).¹⁸ Whereas 15%
361 of the athletes in our study reported primary amenorrhea (i.e., menarche at 16 years of age or
362 older), only 11% of endurance athletes reported the same in an earlier study.¹⁸ Although it
363 remains unclear whether delayed menarche derives from genetic factors, high volumes of
364 training, or a focus on leanness,¹⁸ most non-HC users (56%) reported a prevalence of MCs
365 within the normal range of 10–15 cycles per year. Notably, 35% of non-HC users reported
366 fewer than nine periods in the previous year, which could indicate menstrual dysfunction.³⁴
367 Elite female athletes, particularly endurance athletes, are known to be susceptible to menstrual
368 irregularities, often due to relative energy deficiencies associated with high volumes of
369 training.³⁵ In line with that trend, 30% of the athletes in our study indicated the loss of periods
370 in connection with high volumes of training and 23% with large amounts of high-intensity
371 training. Although we did not assess energy intake or energy expenditure, high volumes of
372 training and high amounts of high-intensity endurance training are associated with high energy
373 expenditure and can prompt relative energy deficiencies. Elite endurance athletes and their
374 coaches should therefore be aware of the risk of MC irregularities induced by high volumes of
375 training and high amounts of high-intensity training. The prevention of MC irregularities
376 should also be pursued, because primary and secondary amenorrhea can result in adverse health
377 conditions, including reduced bone health.³⁵

378

379 The prevalence of HC use in our study (56%) exceeded that reported for the female population
380 in Nordic countries (35–45%)³⁶ but fell within the 40–70% prevalence reported by elite
381 athletes.^{7,18,20} Martin et al.⁷ observed that a higher proportion of athletes used estrogen–
382 progestin HCs (61%) than progestin-only HCs (38%). This was also the case in our study, and
383 may be explained by the lower proportion of negative side-effects reported with the use of
384 estrogen–progestin versus progestin-only HCs.⁷ Martin et al.⁷ additionally reported that HC
385 users were more likely to indicate positive than negative side-effects, which we also observed
386 in our study. However, 26% of HC users reported previously discontinuing their use of other
387 contraceptives because they had compromised their performance. Other researchers have
388 highlighted a large individual response to HCs,⁷ possibly due to limited knowledge and
389 communication about this topic.

390

391 **Knowledge and communication about the MC**

392

393 Only 8% of the athletes indicated having sufficient knowledge about how the MC affects
394 athletic training and performance. Most coaches in women's sports are men,^{27,28} none of whom
395 has personal experience with the MC, which may reduce the transfer of knowledge and
396 communication about the MC and its possible effect on training and performance. In our study,
397 27% of the athletes reported that they had communicated about the MC with their coach during
398 the previous year, with the percentage being higher when the coach was a woman (44%) instead
399 of a man (22%). In line with those findings, a previous study reported that male coaches
400 believed it was less important to ask athletes about menstrual irregularities, had less knowledge
401 about the health risk associated with menstrual irregularities, and were less comfortable with
402 communicating about menstrual irregularity than female coaches.²⁹ Furthermore, our data also

403 revealed that most of the athletes (63%) did not want to talk to their coaches about their MCs,
404 which indicates that the topic continues to be regarded as taboo. Since menstrual dysfunctions
405 are an important marker for relative energy deficit, a syndrome affecting many aspects of
406 physiological functioning, health, and athletic performance,³⁵ it is important that athletes feel
407 comfortable to discuss this topic with their coach. Furthermore, because of the high inter-
408 individual variability in performance and side effects experienced by athletes during the MC,
409 coach-athlete communication is important to safeguard the athlete's health as well as optimize
410 training adaptations and performance. In response, increased attention should be paid to
411 educating female athletes and their support teams about the MC and athletic training.

412 413 **Limitations**

414
415 Several limitations of the current study should be highlighted: 1) The data of athletes using
416 different HCs were combined into one group, while the hormonal concentrations and perceived
417 side-effects might differ between types of HC; 2) The statistical power was too low to make
418 comparisons between the different types of HC 3) Recall bias is a limitation of retrospective
419 questionnaires; 4) Headaches or heavy menstrual bleeding, both of which are frequently
420 reported side-effects of the MC,^{7,8} were not included as side-effects in the questionnaire; 5)
421 The four-phase definition of the MC (Figure 2) has not been used in previous research, which
422 makes comparisons to literature difficult, and; 6) The relationships between the changes in
423 perceived physical fitness, performance and side-effects, and the concentration of hormones
424 cannot be established. Therefore, we can not provide any recommendations regarding training
425 and performance optimization during the specific phases of the MC.

426 427 **Practical applications**

- 428
429 • *Systematic monitoring of the MC:* Coaches should motivate their athletes to track their MC
430 and MC-related symptoms and actively use this information in the evaluation of training
431 quality, training adaptations and performance.
- 432 • *Conscious use of HC:* Coaches should make the athletes aware that HCs could affect their
433 training response, both positively and negatively, and ensure that the athletes communicate
434 about this with the medical doctor, so the preparations prescribed are optimal for their
435 individual situation. Athletes should also systematically monitor their training response
436 when starting with a (new) HC.
- 437 • *More communication:* Because of the high inter-individual variability in performance and
438 side effects experienced by athletes during the MC, coach-athlete communication is
439 important to safeguard the athlete's health as well as to optimize training adaptations and
440 performance. The same applies for the use of HC.
- 441 • *Increased knowledge about the MC and HC:* Coaches should consult experts to ensure that
442 they have enough knowledge to have an evidence-based dialogue about this topic with their
443 athletes.
- 444 • *Education of athletes:* Increased attention should be paid to educating female athletes and
445 their support teams about the MC, HC and athletic training.

446
447

448 **Conclusions**

449

450 A high proportion of athletes experienced distinct changes in fitness, performance, and side-
451 effects across the MC-phases, with their worst perceived physical fitness, performance and
452 most reported MC-related side-effects during bleeding. However, no differences by age,
453 performance level, or HC use emerged, indicating these findings to be generalizable for the
454 endurance athlete population. Because most athletes indicated a lack of knowledge about the
455 MC's effect on athletic training and performance and few to communicate with their coaches
456 about the topic, we recommend that more time should be devoted to educating athletes and
457 coaches.

458

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460

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464

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