








**Please cite the Published Version**

McNulty, Kelly L , Ansdell, Paul , Goodall, Stuart , Thomas, Kevin , Elliott-Sale, Kirsty J , Howatson, Glyn  and Hicks, Kirsty M  (2024) The symptoms experienced by naturally menstruating women and oral contraceptive pill users and their perceived effects on exercise performance and recovery time posttraining. *Women in Sport and Physical Activity Journal*, 32 (1). wspaj.2023-0016 ISSN 1063-6161

**DOI:** <https://doi.org/10.1123/wspaj.2023-0016>

**Publisher:** Human Kinetics

**Version:** Accepted Version

**Downloaded from:** <https://e-space.mmu.ac.uk/635816/>

**Usage rights:**  In Copyright

**Additional Information:** Accepted author manuscript version reprinted, by permission, from *Women in Sport and Physical Activity Journal*, 2024, 32 (1): wspaj.2023-0016, <https://doi.org/10.1123/wspaj.2023-0016>. © Human Kinetics, Inc.

**Enquiries:**

If you have questions about this document, contact [openresearch@mmu.ac.uk](mailto:openresearch@mmu.ac.uk). Please include the URL of the record in e-space. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from <https://www.mmu.ac.uk/library/using-the-library/policies-and-guidelines>)

1 **TITLE:** ‘The symptoms experienced by naturally menstruating women and oral contraceptive  
2 pill users and their perceived effects on exercise performance and recovery time post training’.

3

#### 4 **ABSTRACT**

5 This study examined the type, frequency, and severity of symptoms experienced by naturally  
6 menstruating women and combined, monophasic, oral contraceptive pill (mOCP) users and  
7 their perceived effects on exercise performance and recovery time post training. Forty-two  
8 recreationally active women; 21 naturally menstruating and 21 mOCP users participated in the  
9 study. Data were collected using two approaches: 1) an online 54-part retrospective survey;  
10 and 2) a daily questionnaire. ‘Total number of symptoms’, ‘symptom index [Si] score’,  
11 ‘average symptom severity’, and ‘Si × severity score’ were calculated from the retrospective  
12 dataset. Real-time symptom data (*i.e.*, ‘symptom frequency per *phase*’ and ‘*phase* symptom  
13 frequency × severity score’) were calculated across pre-defined cycle *phases* from the daily  
14 questionnaire. The retrospective survey showed that symptoms were commonly reported by  
15 recreationally active women, but there were no differences in symptomology between the  
16 groups ( $P > 0.113$ ). The daily questionnaire showed both groups experienced a greater  
17 frequency and severity of symptoms whilst bleeding ( $P \leq 0.001$ ), which was associated with  
18 perceived reductions in exercise performance (odds ratio [OR] = 1.04 - 1.07) and a perceived  
19 longer recovery time post-training (OR = 1.03 - 1.04). The results from this study show that  
20 cycle related symptoms were commonly reported by a group of recreationally active women,  
21 with no difference in symptomology between naturally menstruating women and mOCP users.  
22 The magnitude of symptoms was greater whilst bleeding, which was associated with a  
23 perceived reduction in exercise performance and a longer recovery time post-training.

24

#### 25 **1.0 INTRODUCTION**

26 There are complex interactions between endogenous and exogenous sex hormones and various  
27 aspects of health, well-being, exercise performance, and training (Constantini *et al.*, 2005,  
28 Elliott-Sale *et al.*, 2020, Lebrun *et al.*, 1994, McNulty *et al.*, 2020). It has been reported that  
29 between 36 to 93% of active women perceive that their menstrual cycle (MC) or hormonal  
30 contraceptive (HC) use influences their ability to perform or train (Armour *et al.*, 2020,

31 Bruinvels *et al.*, 2021, Findlay *et al.*, 2020, Heather *et al.*, 2021, Martin *et al.*, 2018, Read *et*  
32 *al.*, 2021, Solli *et al.*, 2020). At present, the specific mechanisms behind these performance and  
33 training effects are not well-understood, however one plausible reason is the impact of cycle  
34 related symptoms. Specifically, the cyclic fluctuations in endogenous sex hormones across the  
35 MC have been associated with a variety of physical and psychological symptoms (Ferries-  
36 Rowe *et al.*, 2020, Yonkers *et al.*, 2008), which are commonly reported within the general  
37 population and often impact negatively on the quality of life (Schoep *et al.*, 2019). In contrast,  
38 the oral contraceptive pill (OCP) is often prescribed to women to reduce negative MC related  
39 symptoms within general and athletic populations (Yonkers *et al.*, 2008, Wong *et al.*, 2009).  
40 From a sporting perspective, cycle related symptoms are prevalent in recreationally active and  
41 elite sportswomen and are perceived to impact an individual's ability to perform and train, as  
42 well as general health and well-being (Armour *et al.*, 2020, Brown *et al.*, 2020, Bruinvels *et*  
43 *al.*, 2021, Clarke *et al.*, 2021, Findlay *et al.*, 2020, Heather *et al.*, 2021, Martin *et al.*, 2018,  
44 Nolan *et al.*, 2022, Oxfeldt *et al.*, 2020, Parker *et al.*, 2020, Read *et al.*, 2021, Solli *et al.*, 2020).  
45 Despite these potential effects, little is known about the type, frequency, and severity of cycle  
46 related symptoms and how the symptoms experienced by naturally menstruating women and  
47 OCP users are perceived to influence exercise performance and training.

48 There are a range of suggested mechanisms by which the cyclical fluctuations in oestrogen and  
49 progesterone across the MC might affect exercise performance (McNulty *et al.*, 2020) and  
50 training (Thompson *et al.*, 2020), however the potential indirect effects of cyclical hormonal  
51 changes, such as the influence of cycle related symptoms, are often overlooked (Bruinvels *et*  
52 *al.*, 2022). In active women, common negative symptoms are likely antagonistic with optimal  
53 performance and training if not managed (Armour *et al.*, 2020, Brown *et al.*, 2020, Bruinvels  
54 *et al.*, 2021, Findlay *et al.*, 2020, Heather *et al.*, 2021, Martin *et al.*, 2018, Read *et al.*, 2021,  
55 Solli *et al.*, 2020). For instance, research by Armour *et al.* (2020), Brown *et al.* (2020), Findlay  
56 *et al.* (2020) and Martin *et al.* (2018) showed that MC related symptoms, both physical and  
57 psychological, are prevalent in sportswomen, and most women perceive that these symptoms  
58 compromise their exercise participation as well as performance and training, particularly  
59 during or just prior to menstruation. Recently, Bruinvels *et al.* (2021) used a novel approach  
60 (Menstrual Symptom index [MSi]) that purports to quantify the type, number, and frequency  
61 of cycle related symptoms. The authors demonstrated that symptoms are commonly reported  
62 by regularly exercising women, and that a greater prevalence and frequency of symptoms (*i.e.*,  
63 a higher MSi score) was correlated with an increased likelihood of negative outcomes, such as

64 missing training or competition. It is important to note, however that all previous studies have  
65 relied on retrospective self-reported data and therefore are potentially limited by memory  
66 recall. Additionally, to date all studies have presented a general overview of symptoms  
67 throughout the entity of the MC, as such key timepoints where specific symptoms might be  
68 experienced were not examined in real-time, only retrospectively. Moreover, the tool  
69 developed by Bruinvels *et al.* (2021) did not capture the severity of symptoms, which could  
70 theoretically influence outcomes in addition to the type and frequency of symptoms  
71 experienced. For example, an individual might only experience one symptom per MC however  
72 the severity of this symptom could be severe and therefore have a greater impact on the likes  
73 of performance and training. As a result, the full extent of symptoms experienced by naturally  
74 menstruating women, and their potential impact on exercise performance and training, have  
75 yet to be examined.

76 The naturally occurring MC is susceptible to external perturbations; around 50% of  
77 sportswomen use some form of HC, with the OCP the most prevalent type (Heather *et al.*,  
78 2021, Martin *et al.*, 2018). Whilst there are various types of OCPs each with different  
79 compositions, potencies, and androgenicity, most are combined, monophasic, OCPs (<sub>m</sub>OCPs)  
80 that contain ethinyl oestradiol and a type of progestin delivered in a fixed amount for 21 pill-  
81 taking days, followed by seven pill-free days (Elliott-Sale *et al.*, 2020). These exogenous  
82 oestrogens and progestins act to suppress the hypothalamic-pituitary-ovarian (HPO) axis,  
83 which results in low endogenous levels of sex hormones (Elliott-Sale *et al.*, 2020). Specifically,  
84 <sub>m</sub>OCP use results in four distinct hormonal environments: 1) a downregulated endogenous  
85 oestradiol profile during the 21 pill-taking days that rises during the seven pill-free days; 2) a  
86 chronically downregulated endogenous progesterone profile; 3) a daily surge of synthetic  
87 oestrogen and progestin during pill-taking days; and 4) seven exogenous hormone-free days  
88 (Rechichi *et al.*, 2009). In addition to its use as a birth control method, OCPs are commonly  
89 prescribed by medical professionals to ameliorate cycle related symptoms experienced across  
90 the naturally occurring MC (Yonkers *et al.*, 2008, Wong *et al.*, 2009). However, recent research  
91 highlights that some users still experience negative symptoms related to their OCP use, which  
92 might also affect performance and training (Clarke *et al.*, 2021, Heather *et al.*, 2021, Martin *et*  
93 *al.*, 2018, Nolan *et al.*, 2022, Parker *et al.*, 2020). Indeed, it has been reported that exogenous  
94 ethinyl oestradiol has a higher oestrogen receptor affinity and is several times more potent than  
95 endogenous oestradiol (Bennink *et al.*, 2005), which might play a role in the aetiology of cycle  
96 related symptoms during the pill-taking days. Additionally, it could be theorised that the

97 downregulation of endogenous sex hormones and sudden withdrawal of exogenous sex  
98 hormones might play a role in the aetiology of cycle related symptoms during the pill-free days  
99 (Sulak *et al.*, 2000). Despite this, few studies have investigated the experience of cycle related  
100 symptoms in OCP users and their potential impact on perceived exercise performance and  
101 training outcomes in active women.

102 Overall, given that sportswomen (irrespective of reproductive hormonal profile) might be  
103 affected by cycle related symptoms, and that these symptoms have the potential to influence  
104 aspects of exercise performance and training, it is important to gain a better understanding of  
105 symptoms in this population. Therefore, the purpose of this study was to: 1) retrospectively  
106 describe and compare the type, frequency, and severity of symptoms experienced by naturally  
107 menstruating women and  $m$ OCP users; 2) investigate in real-time the effect of MC and  $m$ OCP  
108 *phases* on the type, frequency, and severity of symptoms; and 3) determine whether the  
109 symptoms experienced by naturally menstruating women and  $m$ OCP users during pre-defined  
110 MC and  $m$ OCP *phases* are associated with perceived exercise performance and recovery time  
111 post-training.

112

## 113 **2.0 METHODS**

### 114 **2.1 Participants**

115 In total, 42 women volunteered to take part. The sample included 21 naturally menstruating  
116 (mean  $\pm$  standard deviation [SD]: age,  $29 \pm 5$  years; stature,  $164.9 \pm 5.7$  cm; mass,  $63.7 \pm 9.1$   
117 kg) and 21  $m$ OCP users (age  $28 \pm 4$  years; stature  $165.2 \pm 7.1$  cm; mass  $60.9 \pm 11.6$  kg).  
118 Naturally menstruating participants self-reported having a regular MC between 21 and 35 days  
119 in length for at least one year prior to participation. Additionally, all naturally menstruating  
120 participants were not taking any form of HC for a minimum of three-months prior to the  
121 investigation, and self-reported being free from other medication (*i.e.*, hormonal replacement  
122 therapy), MC related irregularities (*e.g.*, amenorrhea), or conditions (*e.g.*, polycystic ovarian  
123 syndrome, endometriosis, pregnancy) known to affect the HPO axis. To employ a homogenous  
124 design, all participants in the  $m$ OCP group reported taking a  $m$ OCP containing ethinyl oestradiol  
125 and progestin (Supplementary File 1) for 21 days, followed by a seven-day pill free interval (or  
126 taken for 28 days, inclusive of a seven-day inactive/placebo pill interval) for a minimum of  
127 three-months prior to the study (Elliott-Sale *et al.*, 2013). All participants were deemed at least

128 recreationally active (McKay *et al.*, 2022). Participants also reported taking part in multiple  
129 sports/forms of activity (*i.e.*, ‘Running’, ‘Cycling’, ‘Swimming’, ‘Gym-based classes’, and  
130 ‘Weight training’). A small percentage (19%) of participants were classified as trained (McKay  
131 *et al.*, 2022). All participants were healthy, were not taking any form of medication, and were  
132 free from any injury in the past six months. Full ethical approval was granted, and the study  
133 was conducted in accordance with the Declaration of Helsinki. Written, informed consent was  
134 obtained from all participants prior to participation. This study uses the term ‘woman’ for  
135 people who self-report identifying with the sex they were assigned with at birth (Robinson *et*  
136 *al.*, 2022).

## 137 **2.2 Design**

138 Data were collected for this study using two approaches. Firstly, an initial 54-part online survey  
139 was created (Online Surveys, Jisc, UK) and distributed to all participants via email. The survey  
140 retrospectively assessed reproductive status, the type, frequency, and severity of symptoms  
141 typically experienced, and the perceived effects of the MC and <sub>m</sub>OCP use on aspects of exercise  
142 performance and training. Information gathered from the initial 54-part online survey was used  
143 to ensure all participants met the *a priori* inclusion and exclusion criteria, and to answer aim  
144 one, and partly answer aim three of the present study. Secondly, following a virtual pre-testing  
145 session to habituate participants to all procedures, participants tracked cycle related data (*i.e.*,  
146 day of MC or <sub>m</sub>OCP *cycle*, blood flow amount during period or withdrawal bleed, as well as  
147 ovulation tracking in naturally menstruating participants), and their symptoms daily to further  
148 quantify symptom type, frequency, and severity across pre-defined MC and <sub>m</sub>OCP *phases*. To  
149 do this, each participant received a unique link to an online form (Google Forms, Google, UK),  
150 consisting of 12 questions, which they completed daily, at a similar time of day ( $\pm$  two-hours),  
151 to minimise the effects of diurnal variation. Recording of daily cycle related data and symptom  
152 tracking began on day one of menses in naturally menstruating women, or day one of pill-  
153 withdrawal in <sub>m</sub>OCP users and continued for the duration of one full MC (*i.e.*, until the onset  
154 of the next menses) or <sub>m</sub>OCP *cycle* (*i.e.*, until day 21 of pill-consumption). A daily text reminder  
155 was sent at the same time each day to all participants to ensure compliance. Results from this  
156 daily cycle related data, and symptom tracking were used to answer aim two, and partly answer  
157 aim three in the present study.

## 158 **2.3 Methodology**

159 2.3.1 54-part online survey

160 Data gathered from the initial 54-part online survey included: 1) demographic data (*i.e.*, age  
161 and sex); 2) current MC and HC status (*i.e.*, MC length, period duration, type of HC used and  
162 duration of use); 3) type, frequency, and severity of cycle related symptoms; 4) training history;  
163 5) respective cycle monitoring and tracking; 6) perceived effects of the MC and mOCP use on  
164 aspects of performance and training; and 7) previous education on the MC and HC use  
165 (Supplementary File 2). All survey questions were either multiple choice check boxes, short/  
166 long text answers, a matrix, or a linear scale. Free text answers were also requested where  
167 ‘Other’ was applicable. The 54-part online survey was adapted specifically for this study based  
168 on previous research in this area (Bruinvels *et al.*, 2021). The survey was piloted with five  
169 researchers and five participants for language, comprehension, and compliance. To help  
170 content and face validity, as well as general clarity around questions, minor edits were made to  
171 the survey wording based on their feedback. To ensure a uniform understanding of the pre-  
172 defined MC and mOCP *phases* and to assist in the answering of questions an idealised four-  
173 phase lay definition (and diagram) was provided to participants within the survey. Although  
174 only three pre-defined *phases* were used within the study for those in the naturally menstruating  
175 group, a four-phase lay diagram was provided to help participant understanding  
176 (Supplementary File 3). The survey was designed to take approximately 20 minutes to  
177 complete.

178 2.3.2 Daily cycle related data and symptom tracking

179 Data gathered from the daily cycle and symptom tracking form included: 1) day of MC or  
180 mOCP *cycle*; 2) blood flow amount during period or withdrawal bleed; and 3) symptom type,  
181 presence, and severity with 18 possible symptoms listed based on previous work (Bruinvels *et*  
182 *al.*, 2021), with the addition of symptom severity questions enhancing the form and the novelty  
183 of the current study. Additionally, to identify MC *phases* participants in the naturally  
184 menstruating group were asked to track ovulation using urinary ovulation detection kits  
185 (Advanced Digital Ovulation Test, Clearblue, Switzerland) and basal body temperature (BBT)  
186 using a digital thermometer (One Step Digital Basal Thermometer, Home Health Ltd, UK).  
187 Specifically, beginning on a predetermined day (depending on each participant’s typical cycle  
188 length), using the start of menses as day one, participants in the naturally menstruating group  
189 used the ovulation detection kits once daily (at the same time each day with first urine void  
190 after their longest sleep), until a positive ovulation test was achieved. The urinary ovulation

191 detection kit tracked changes in oestrogen and luteinizing hormone (LH) concentration (greater  
192 than 40 mIU·mL<sup>-1</sup>) and provided participants with a static smiley face when the ‘LH surge’  
193 was detected. The urinary ovulation detection kit used had 99% accuracy in detecting the ‘LH  
194 surge’, as determined by the manufacturer. Participants were asked to record the status of the  
195 smiley face within the daily form. For BBT, participants were instructed to take this measure  
196 orally every morning before rising and record the value in °C, to two decimal places, within  
197 the daily form. Further information pertaining to cervical fluid was also collected but was not  
198 used to confirm ovulation and/or classify phases. All questions in the form were either multiple  
199 choice check boxes, short text answers, a matrix, or a linear scale. The form was designed to  
200 take approximately five minutes to complete.

### 201 2.3.3 Menstrual cycle and combined, monophasic, oral contraceptive pill phase classification

202 The MC and mOCP *cycle*, were separated into pre-defined *phases* (Supplementary File 4).  
203 Specifically, the MC was classified into three *phases* which were selected as those theoretically  
204 coinciding with low concentrations of oestrogen and progesterone (phase one, ‘early follicular  
205 phase’), rising/high oestrogen and low progesterone (phase two, ‘mid- to late  
206 follicular/ovulatory phase’), and high oestrogen and progesterone (phase three, ‘mid-luteal  
207 phase’). Menstrual cycle *phases* were calculated based on the first day of menstruation. Phase  
208 one was defined as the first five days of the cycle from the onset of self-reported menstruation.  
209 Phase two was defined as four days prior to a positive ovulation test and the day of the positive  
210 ovulation test (Stricker *et al.*, 2006). Phase three was classified as the time between five to nine  
211 days post a positive ovulation test and was also indicated by BBT (*i.e.*, a significant rise in  
212 BBT [approximately 0.25 to 0.50 of a degree] following ovulation, that remains relatively  
213 constant for 10 to 16 days; Thompson *et al.*, 2019). Participants that did not report a positive  
214 ovulation test or a biphasic rise in BBT were subsequently excluded from the analysis. As such,  
215 our confidence in the hormonal profiles captured during phase one and phase two of the MC  
216 in the present study is high, however phase three of the MC is estimated rather than confirmed,  
217 thus our confidence in the hormonal profile of phase three is limited. To ensure an equal  
218 number of days were used for each *phase* the mOCP *cycle* was classified into four *phases*: phase  
219 one (‘mOCP withdrawal’, days 1 to 7 of pill-free days), phase two (‘mOCP consumption, days  
220 1 to 7’), phase three (‘mOCP consumption, days 8 to 14’), and phase four (‘mOCP consumption,  
221 days 15 to 21). The *phases* of the mOCP *cycle* were defined using counting from either the first  
222 day of the mOCP free *phase* or the mOCP taking *phase*. It is important to acknowledge that



223 these profiles, reflecting  $m$ OCP consumption and withdrawal, are pseudo-phases as they are  
224 ‘artificial’ *phases* in comparison with the phases of the MC, but for the purposes of this study  
225 will be referred to as *phases*.

## 226 **2.4 Data analysis**

### 227 *2.4.1 54-part online survey*

228 The raw data from the 54-part online survey were exported from Online Surveys directly to  
229 Microsoft Excel software for Windows. The sum of the number of symptoms reported was  
230 calculated to create the ‘total number of symptoms’, with a maximum value of 18. The average  
231 frequency of the symptoms reported, was then calculated using a Likert scale, based on  
232 previous research (Bruinvels *et al.*, 2021). Specifically, the following numerical value was  
233 attached to the Likert, ‘often’ = 3 points, ‘sometimes’ = 2 points, ‘rarely’ = 1 point, and ‘never’  
234 = 0 points for each of the 18 symptoms reported. The ‘symptom index (Si) score’ was then  
235 calculated by totalling the frequency score (0-3) for each symptom (0-18) reported, with total  
236 scores ranging from 0 (minimum) to 54 (reporting every symptom, often). ‘Average symptom  
237 severity score’ was assessed using a Likert scale, with the following numerical values attached  
238 to the Likert, ‘absent’ = 1, ‘mild’ = 2, ‘moderate’ = 3 and ‘severe’ = 4. The ‘Si score’ was then  
239 multiplied by the ‘average symptom severity score’ to provide an overall ‘Si × severity score’.

### 240 *2.4.2 Daily cycle and symptom tracking*

241 The raw data from the daily cycle related data and symptom tracking form were exported from  
242 Google Forms directly to Microsoft Excel software for Windows. To quantify the type,  
243 frequency, and severity of symptoms across the MC and  $m$ OCP *cycle*, cycles were first  
244 separated into pre-defined *phases* (see heading ‘2.3.3’). The number of symptoms experienced  
245 in each phase were summed to create the ‘symptom frequency per *phase*’. The mode severity  
246 (*i.e.*, ‘absent’ = 1, ‘mild’ = 2, ‘moderate’ = 3 and ‘severe’ = 4) of each of the symptoms  
247 experienced per *phase* was then calculated to create the ‘symptom severity per *phase*’. Finally,  
248 the ‘symptom frequency per *phase*’ was then multiplied by the ‘symptom severity per *phase*’  
249 to give an overall ‘*phase* symptom frequency × severity score’.

## 250 **2.5 Statistical analysis**

251 The statistical software package IBM SPSS Statistics (Version 24, SPSS Inc., USA) for  
252 Windows was used to conduct the statistical analysis. Data are presented as mean  $\pm$  SD (for  
253 normally distributed, continuous data), medians (*Mdn*)  $\pm$  interquartile range (*IQR*; for non-  
254 normally distributed, or ordinal data), and number and percentages (for categorical data).  
255 Normal distribution of data was confirmed using the Shapiro-Wilk test. If a normality breach  
256 was detected, a nonparametric Mann-Whitney U test was used. For data collected from the  
257 initial 54-part online survey an independent t-test was used to assess between group  
258 comparisons in the ‘total number of symptoms’ and the ‘Si score’. As data were ordinal, a  
259 nonparametric Mann-Whitney U test was used to assess for any between group comparison in  
260 ‘average symptom severity’. Additionally, as data were not normally distributed, a  
261 nonparametric Mann-Whitney U test was used to assess for any between group comparison in  
262 the overall ‘Si  $\times$  severity score’. For data collected through daily tracking, one-way repeated  
263 measures ANOVAs were used to assess for differences in ‘symptom frequency per *phase*’, and  
264 the ‘*phase* symptom frequency  $\times$  severity score’ across MC and <sub>m</sub>OCP ‘phases’  
265 (independently). Sphericity was assessed using Mauchly’s test of sphericity. Where sphericity  
266 was violated, a Greenhouse-Geisser correction was used. If a significant main effect was  
267 observed, a *post hoc* Bonferroni-corrected pairwise comparison was used. As data were ordinal,  
268 a nonparametric Friedman test was used to assess differences in ‘symptom severity per *phase*’  
269 across MC and <sub>m</sub>OCP *phases* (independently). A binomial logistic regression was used to  
270 predict changes in perceived exercise performance and recovery time post-training in specific  
271 MC and <sub>m</sub>OCP *phases* (from the 54-part online survey), based on the ‘*phase* symptom  
272 frequency  $\times$  severity score’ (from the daily cycle and symptom tracking form). The odds ratio  
273 for each variable and the accompanying 95% confidence intervals (CIs) were calculated. The  
274  $\alpha$  for all statistical tests was set at  $P \leq 0.05$ .

275

## 276 **3.0 RESULTS**

### 277 **3.1 Participant characteristics**

278 Self-reported, descriptive, MC and <sub>m</sub>OCP characteristics data are displayed in Supplementary  
279 File 5.

### 280 **3.2 The type, frequency, and severity of cycle related symptoms from the initial 54-part** 281 **online survey**

282 The reported type and frequency of each symptom, for each group, are shown in Figure 1.  
283 There was no difference in the ‘total number of symptoms’ reported (naturally menstruating:  
284  $12 \pm 4$  symptoms;  $mOCP$ :  $11 \pm 4$  symptoms;  $P = 0.353$ ), the ‘Si score’ (naturally menstruating:  
285  $26 \pm 10$ ;  $mOCP$ :  $22 \pm 10$ ;  $P = 0.200$ ), ‘average symptom severity’ (naturally menstruating: 3  
286 ‘moderate’ [*Mdn*];  $mOCP$ : 2 ‘mild’ [*Mdn*];  $P = 0.145$ ), and the overall ‘Si  $\times$  severity score’  
287 (naturally menstruating:  $68$  [*Mdn*]  $\pm$   $90$  [*IQR*];  $mOCP$ :  $50$  [*Mdn*]  $\pm$   $56$  [*IQR*];  $P = 0.113$ ) between  
288 naturally menstruating women and  $mOCP$  users.

### 289 **3.3 The type, frequency, and severity of symptoms across menstrual cycle and combined,** 290 **monophasic, oral contraceptive pill phases from daily tracking data**

291 Two naturally menstruating women were excluded from this analysis because one exhibited a  
292 short luteal phase defect (defined by not having a luteal phase long enough to meet mid-luteal  
293 analysis classification in the present study), and one was identified as anovulatory (defined by  
294 a lack of a positive ovulation test and no biphasic response in BBT). The different types of  
295 symptoms experienced across MC and  $mOCP$  phases, for each group, are shown in Figure 2.

296 There was a difference in ‘symptom frequency per phase’ across MC phases ( $P = 0.001$ ; Figure  
297 3, Panel A), whereby naturally menstruating women experienced a greater frequency of  
298 symptoms during phase one ( $28 \pm 18$  symptoms) of the MC compared to phases two ( $13 \pm 13$   
299 symptoms;  $P = 0.006$  [95% CI 4 to 27]), and three ( $16 \pm 12$  symptoms;  $P = 0.010$  [95% CI 3  
300 to 22]), whereas there was no difference between phases two and three ( $P = 0.611$ ). There was  
301 no difference in ‘symptom severity per phase’ across MC phases (phase one: *Mdn* = 2 [‘mild’],  
302 phase two: *Mdn* = 2 [‘mild’], and phase three: *Mdn* = 2 [‘mild’];  $P = 0.084$ ). The ‘phase  
303 symptom frequency  $\times$  severity score’ differed across MC phases ( $P < 0.001$ ; Figure 3, Panel  
304 B), whereby the ‘phase symptom frequency  $\times$  severity score’ was greater during phase one ( $62$   
305  $\pm 43$  Au) of the MC compared to phases two ( $26 \pm 25$  Au;  $P = 0.005$  [95% CI 10 to 62]) and  
306 three ( $37 \pm 27$  Au;  $P = 0.026$  [95% CI 3 to 48]), but there was no difference between the phases  
307 two and three ( $P = 0.287$ ).

308 There was a difference in ‘symptom frequency per phase’ across  $mOCP$  phases ( $P < 0.001$ ;  
309 Figure 4, Panel A), whereby pill users experienced a greater frequency of symptoms during  
310 phase one ( $35 \pm 24$  symptoms) compared with all other  $mOCP$  phases (phase two:  $18 \pm 20$   
311 symptoms,  $P = 0.001$  [95% CI 6 to 28]; phase three:  $13 \pm 17$  symptoms,  $P < 0.001$  [95% CI 9  
312 to 34]; phase four:  $19 \pm 21$  symptoms  $P < 0.003$  [95% CI 5 to 27], respectively), but there was  
313 no difference between any of the  $mOCP$  consumption phases ( $P = 0.079$ ,  $P = 1.000$ , and  $P =$

0.376, respectively). There was no difference in ‘symptom severity per *phase*’ across *mOCP phases* (phase one: *Mdn* = 2 [‘mild’]; phase two: *Mdn* = 2 [‘mild’]; phase three: *Mdn* = 2 [‘mild’]; and phase four: *Mdn* = 2 [‘mild’];  $P = 0.702$ ). The ‘*phase* symptom frequency  $\times$  severity score’ differed across *mOCP phases* ( $P < 0.001$ ; Figure 4, Panel B), whereby the ‘*phase* symptom frequency  $\times$  severity score’ was greater during phase one ( $73 \pm 55$  Au) of the *mOCP cycle* compared with all other *mOCP phases* (phase two:  $36 \pm 39$  Au,  $P = 0.002$  [95% CI 11 to 61]; phase three:  $30 \pm 46$  Au,  $P = 0.005$  [95% CI 11 to 75]; phase four:  $42 \pm 51$  Au,  $P = 0.022$  [95% CI 4 to 59], respectively), however there was no difference between any of the *mOCP consumption phases* ( $P = 0.981$ ,  $P = 1.000$ , and  $P = 0.477$ , respectively).

### **3.4 Perceived effect of menstrual cycle and combined, monophasic, oral contraceptive pill *phase* on aspects of exercise performance and training**

The perceived effect of MC and *mOCP phases* on aspects of exercise performance and training in naturally menstruating women and *mOCP* users as determined from the initial 54-part online survey is shown in Table 1. Specifically, 67% of naturally menstruating women reported a perceived improvement in their exercise performance during phase two of the MC, whilst 38% reported a perceived decrease in exercise performance during phase one of the MC. Most naturally menstruating women reported that their perceived recovery time following a training session took longer during phase one (48%), whereas the majority perceived their recovery time following a training session to be quicker in phase two (67%). Fifty-seven percent of *mOCP* users reported a perceived improvement in their exercise performance during pill-taking days, whilst 57% reported a perceived decrement in exercise performance during pill-free days. Most *mOCP* users reported no differences in perceived recovery time following a training session across *mOCP phases* (57% and 71%, respectively).

### **3.5 Association between perceived exercise performance and recovery time post-training and the experience of cycle related symptoms**

The effect of ‘*phase* symptom frequency  $\times$  severity score’ on the probability of perceived reduced/improved exercise performance or longer/quicker recovery time post-training across MC *phases* in naturally menstruating women and across *mOCP phases* in pill users is shown in Table 2 (as determined from both the initial 54-part online survey and daily tracking data). The odds ratios for the ‘*phase* symptom frequency  $\times$  severity score’ provide an estimate of the change in odds for the corresponding response variable per unit increase in ‘*phase* symptom frequency  $\times$  severity score’. A higher ‘*phase* symptom frequency  $\times$  severity score’ was

346 associated with a perceived reduction in exercise performance and a longer recovery time post-  
347 training during phase one of the MC in naturally menstruating women, and during pill-free  
348 days in <sub>m</sub>OCP users. Specifically, it is estimated that the odds of perceiving performance as  
349 reduced in phase one of the MC/ pill-free days are multiplied by 1.07 and 1.04 per unit increase  
350 in '*phase symptom frequency × severity score*', respectively. Likewise, it is estimated that the  
351 odds of perceiving recovery time to take longer post-training during phase one of the MC/ pill-  
352 free days are multiplied by 1.04 and 1.03 per unit increase in '*phase symptom frequency ×*  
353 *severity score*', respectively.

354

#### 355 **4.0 DISCUSSION**

356 The purpose of this study was to examine the type, frequency, and severity of symptoms  
357 experienced by naturally menstruating women and <sub>m</sub>OCP users, and their perceived effect on  
358 exercise performance and recovery time post training. Two approaches were used to answer  
359 these aims, firstly an initial retrospective 54-part online survey, and secondly a cycle and  
360 symptom form completed daily across one MC or <sub>m</sub>OCP *cycle*. Data from the initial  
361 retrospective survey showed that cycle related symptoms were commonly reported by a group  
362 of recreationally active women, and there appears to be no differences in symptomology  
363 between naturally menstruating women and <sub>m</sub>OCP users. As such, these results emphasise the  
364 need for active women, and those working with them, to consider regular and consistent  
365 monitoring of cycle related symptoms, to the same degree, irrespective of <sub>m</sub>OCP use.  
366 Moreover, data from daily symptom tracking showed that the type of symptoms reported, as  
367 well as symptom frequency and severity, changed across MC and <sub>m</sub>OCP *phases*, whereby  
368 participants experienced a greater magnitude of symptoms whilst bleeding (*i.e.*, during phase  
369 one of the MC in naturally menstruating women, and during the pill-free days in <sub>m</sub>OCP users)  
370 compared to all other timepoints. Finally, experiencing a greater magnitude of symptoms  
371 (higher '*phase symptom frequency × severity score*'), was associated with a greater likelihood  
372 of perceived negative outcomes, including a perceived reduction in exercise performance and  
373 a perceived longer recovery time post-training, whilst all participants were bleeding. Together,  
374 these results highlight the importance of daily symptom mapping, as retrospective recall does  
375 not account for the potential effect of different phases on the magnitude of cycle related  
376 symptoms, which when elevated might translate to negative implications on perceived  
377 performance and recovery outcomes. Further research is required to establish whether these

378 perceived negative effects result in an actual reduction in performance and/or recovery in  
379 sportswomen.

380 Data from the present study showed that cycle related symptoms are prevalent in  $mOCP$  users,  
381 and that symptomology appears to be similar among naturally menstruating women and  $mOCP$   
382 users, even though OCPs are often prescribed to women with the intention of alleviating  
383 symptoms associated with the MC (Yonkers *et al.*, 2008, Wong *et al.*, 2009). Indeed, this study  
384 shows that the most reported symptoms in  $mOCP$  users are ‘Mood changes/ irritability/anxiety’,  
385 which agrees with previous findings by Heather *et al.* (2021) who reported that the majority  
386 (56%) of OCP users reported side effects of use, with the most common being mood  
387 disturbances. Interestingly, results from the current study show no difference in the frequency  
388 and severity of cycle related symptoms between the naturally menstruating women and  $mOCP$   
389 users. This is despite 46% of pill users in the present study reporting the use of  $mOCP$ s to  
390 manage the symptoms experienced during the naturally occurring MC. Although, it is  
391 important to note that previous experience of symptoms prior to  $mOCP$  use is unknown so this  
392 finding must be interpreted in context. In agreement with these findings, Clarke *et al.* (2021)  
393 showed similarities in the symptoms experienced between HC users and naturally menstruating  
394 women, although this study extends these findings using a novel symptom monitoring tool.  
395 However, regardless of the prevalence of cycle related symptoms, they might not be seen as a  
396 deterrent from OCP use, with previous work highlighting that the reported benefits of HC use,  
397 such as its use as a birth control measure, outweigh the experience of negative symptoms  
398 (Martin *et al.*, 2018, Parker *et al.*, 2020). Thus, it is important that sportswomen do not solely  
399 make their decision to use or not use OCPs based on the cycle related symptom data reported  
400 herein and all relevant factors should be considered before individuals make this decision.  
401 Overall, these results indicate that with or without the intention of  $mOCP$  use to reduce cycle  
402 related symptoms, there appears to be no difference in symptomology between MC and  $mOCP$   
403 users. Therefore, practitioners are recommended to monitor the magnitude of cycle related  
404 symptoms, and use this data to develop symptom management strategies, in all sportswomen,  
405 irrespective of reproductive hormonal profile.

406 Few studies in active women have quantified the symptoms experienced across pre-defined  
407 MC and  $mOCP$  phases in real-time, and instead have focused on collecting retrospective  
408 symptom data across the entity of the MC and HC *cycle*. However, considering the different  
409 potential factors driving symptoms key timepoints for symptoms are likely to vary across

410 phases. Indeed, the present study shows that during phase one of the MC the frequency and  
411 severity of symptoms experienced was greater when compared to all other MC *phases*, in  
412 naturally menstruating women. Whilst the aetiology of MC symptoms is likely complex and  
413 multifactorial, the changes in symptoms across MC phases might be attributable to fluctuations  
414 in endogenous sex hormones (oestrogen and progesterone) across the MC. For example, the  
415 magnitude of symptoms experienced in this study was greater when oestrogen and  
416 progesterone were at their lowest in naturally menstruating women. Additionally, an  
417 overproduction of prostaglandins occurring at this timepoint (*i.e.*, during menstruation) has  
418 been commonly cited to result in primary dysmenorrhea (Guo *et al.*, 2013). Likewise, together,  
419 the changes in the release of inflammatory markers (Puder *et al.*, 2006) and reactive oxygen  
420 species (Gaskins *et al.*, 2012) across the MC might have caused the ‘period pain’ and other  
421 physical symptoms experienced at this time in the present study. Moreover, it is thought that  
422 variations in neurobiology across the MC, such as alterations in serotonergic and gamma-  
423 aminobutyric acid systems (Ansdell *et al.*, 2019), as well as dopaminergic signalling (Del Río  
424 *et al.*, 2018) could affect the prevalence and severity of psychological symptoms experienced  
425 by naturally menstruating women across MC phases. Results from the current study also  
426 revealed that, like their naturally menstruating counterparts, *m*OCP users also experienced  
427 changes in symptom magnitude across *m*OCP *phases*, with a greater frequency and severity of  
428 symptoms reported during the pill-free days when typically, a withdrawal bleed occurs, which  
429 agrees with previous literature (Sulak *et al.*, 2000). Therefore, it is plausible that the action of  
430 bleeding (*i.e.*, the mechanisms that result in the withdrawal bleed and the perceptual effects of  
431 bleeding) during the pill-free days might play a role in the aetiology of *m*OCP symptoms during  
432 the pill-free days regardless of circulating hormone concentrations. In contrast, given that  
433 exogenous ethinyl oestradiol has a higher oestrogen receptor affinity and is several times more  
434 potent than endogenous oestradiol (Bennink *et al.*, 2005), its sudden withdrawal during the pill-  
435 free days might remove any potential positive effects on symptomology, and thus contribute to  
436 the symptoms experienced during this time. Although, it is important to gain a better  
437 understanding of the aetiology of cycle related symptoms in both naturally menstruating and  
438 *m*OCP users from future research.

439 Understanding the frequency and severity of symptoms is important as recent research has  
440 shown that an increased number of both physical and psychological cycle related symptoms is  
441 associated with changes in various aspects of exercise performance and training. Specifically,  
442 Bruinvels *et al.* (2021) reported that experiencing a greater number of MC symptoms was

443 correlated with changing/missing training, missing a competition, as well as needing to use  
444 pain medication. Although agreeing with the work by Bruinvels *et al.* (2021), the current study  
445 extends these findings to consider the phase effect of cycle related symptoms on exercise  
446 performance and recovery time post training. Indeed, the current study highlights that having  
447 a higher ‘*phase symptom frequency × severity score*’ was associated with negative outcomes,  
448 such as a perceived reduction in exercise performance and a longer recovery time post-training,  
449 whilst participants were bleeding. While previous work investigating the effect of the MC and  
450 OCP use on performance and training has focussed on qualitative outcomes, few studies have  
451 examined the influence of symptoms on these outcomes. Indeed, a recent systematic review  
452 and meta-analysis investigating the effect of MC phase on exercise performance (McNulty *et*  
453 *al.*, 2020) showed that performance might, on average, be reduced by a trivial amount during  
454 the early follicular phase of the MC, compared with all other MC phases, in some individuals.  
455 Whilst a mechanistic explanation was beyond the scope of the paper, it was indicated that  
456 performance changes could be attributable to the fluctuations in endogenous sex hormones  
457 across the MC, but the potential influence of symptoms on these objective markers of  
458 performance was not considered. However, as established from the current results, the  
459 perceived reduction in performance during phase one of the MC, in some individuals, could be  
460 attributable to the greater magnitude of symptoms experienced at this timepoint, within those  
461 individuals. Unfortunately, within the current study it was not possible to compare time aligned  
462 phase symptomology between naturally menstruating women and <sub>m</sub>OCP users, thus it is  
463 unknown if the previous trivial difference in exercise performance reported between naturally  
464 menstruating and OCP users (Elliott-Sale *et al.*, 2020) might also be explained by group  
465 differences in symptomology during phase one, when both groups were bleeding. As such,  
466 there is a need to adopt a multifaceted approach to investigating the effect of MC and <sub>m</sub>OCP  
467 phase on performance and training, which considers not only the reproductive hormonal milieu,  
468 but also the symptoms experienced by the individual, irrespective of whether they are naturally  
469 menstruating or taking the <sub>m</sub>OCP. Future work should adopt our real-time, daily, data collection  
470 processes to investigate the potential relationship between cycle related symptoms and  
471 objective exercise performance and training outcomes and should build upon these data with  
472 mechanistic work to fully understand the underlying processes driving this potential  
473 relationship. Moreover, from a practical position, it is important for practitioners to track cycle  
474 related symptom data daily, rather than retrospectively, to identify key timepoints where an  
475 individual might experience a greater magnitude of symptoms which could potentially impact  
476 their perception of performance and/or recovery.



#### 477 4.1 Limitations and future directions

478 It is important to acknowledge that the current study has several limitations. Indeed, data was  
479 collected from a small group (n = 42) of recreationally active women, therefore the average  
480 response presented in this study might not be specific and meaningful to all women. As such,  
481 further research using a larger sample size and investigating within different populations (*i.e.*,  
482 elite woman athletes) is warranted. Data from the initial 54-part online survey are self-reported,  
483 and therefore reliant on memory recall. Additionally, this study used an adapted version of the  
484 MSi tool developed by Bruinvels *et al.* (2021), however, quantifying symptoms in this way has  
485 not been formally validated. Moreover, it is important note that this study focused on three pre-  
486 defined cycle phases, as such this data disregards the late luteal phase whereby there is a swift  
487 and substantial ratio change in sex hormone concentrations. Indeed, the late luteal phase is  
488 thought to be a key window whereby the magnitude of symptoms might be most affected which  
489 could theoretically have a greater influence on performance and training outcomes (Bruinvels  
490 *et al.*, 2022). Thus, in the future, studies should consider adopting a more fluid research design  
491 that allows for the investigation of multiple timepoints across the MC (*i.e.*, inclusion of the late  
492 luteal phase) or OCP use, as this will help provide a complete picture of potential effects,  
493 allowing sportswomen to perform and train consistently across their entire respective cycle.  
494 Furthermore, although the current study utilised two (*i.e.*, calendar-based counting and urinary  
495 ovulation detection kits) out of the possible three recommended methods to identify MC phase  
496 and confirm an ovulatory cycle for experimental designs within this field, the methods used do  
497 not provide any information regarding endogenous sex hormone concentrations (Thompson *et*  
498 *al.*, 2019). Since MC phase was not subsequently verified by serum for both oestrogen and  
499 progesterone (due to restrictions because of the COVID-19 pandemic) it slightly reduces our  
500 confidence in the accuracy of the sex hormone environment implied by the *phase* definitions  
501 used in the present study (*i.e.*, if the actual sex hormone concentrations matched the predicted  
502 sex hormone concentrations; Elliott-Sale *et al.*, 2021). Whilst we have a high degree of  
503 confidence in the determination of phase one and two, as oestrogen and progesterone need to  
504 be low to menstruate, and a positive urinary ovulation test result infers the pre-ovulatory peak  
505 in oestrogen, phase three is estimated and thus, where possible, future studies need to improve  
506 methodological quality. However, it is essential to acknowledge the real-world application of  
507 the methods utilised in the present study. For example, it can be impractical and expensive to  
508 take serum blood samples from all women to verify phase of cycle within an applied  
509 environment and instead the use of non-evasive, cost-effective, and immediate methods, such

510 as BBT and urinary ovulation detection kits offer useful insights into potential sex hormone  
511 concentrations (Hicks *et al.*, 2022). Only naturally menstruating women and <sub>m</sub>OCP users were  
512 included in the current study, however previous research shows that negative symptoms are  
513 more common in progestin-only HC users (Martin *et al.*, 2018, Parker *et al.*, 2020). Similarly,  
514 the brand, composition of synthetic oestrogen and progestin, dosage, and androgenicity of  
515 <sub>m</sub>OCP used by participants in the pill group differed which could have influenced  
516 symptomology. Therefore, future research should consider investigating symptoms and  
517 perceived performance and training effects in active women using different forms of HC, and  
518 where possible try to achieve a homogenous sample. It is also necessary to acknowledge that  
519 symptomology is complex, and it remains impossible to decipher whether the reported  
520 symptoms were directly related to the MC or <sub>m</sub>OCP use. Further, it is important to consider the  
521 individual nature of the MC and responses to <sub>m</sub>OCP use, and that physiology (McNulty *et al.*,  
522 2021) and lifestyle factors (*i.e.*, diet, exercise, sleep, and stress) might not be the same across  
523 consecutive MCs or <sub>m</sub>OCPs within the same individual. As such, it is possible that symptoms  
524 might differ largely between individuals and between cycles within the same individual.  
525 Therefore, practically it is key to consider these effects on an individual level, as some women  
526 might be affected and others not, and future studies should explore variability in symptoms  
527 within individuals from one cycle to the next to facilitate a deeper understanding of individual  
528 responses. Finally, data were collected during the COVID-19 pandemic, thus it is unknown  
529 whether, and to what extent, this might have had an influence on the cycle related symptoms  
530 experienced during this time (Phelan *et al.*, 2021). Despite these limitations, our dataset  
531 provides a new insight into the symptoms experienced by some naturally menstruating women  
532 and <sub>m</sub>OCP users, which should be considered by active women and those working with them.

#### 533 **4.2 Practical implications**

534 These findings emphasise the importance of continued awareness of cycle related symptoms  
535 and their potential impact on exercise performance and recovery time post training to inform  
536 best practice. Given the similarities in symptomology between naturally menstruating and  
537 <sub>m</sub>OCP users, regular screening of symptom profiles across all sportswomen (irrespective of  
538 reproductive hormonal profile) is advised based on these results, and the use of methods  
539 provided in the present study to monitor symptoms might be considered as a suitable tool within  
540 a practical setting. Moreover, given the potential perceived negative effect of symptoms on  
541 exercise performance and training outcomes at different timepoints across the MC and <sub>m</sub>OCP

542 *cycle*, real-time, consistent, symptom mapping should be considered to identify and predict key  
543 windows of opportunity for symptom management strategies, and thus limit any potential  
544 negative effect of symptoms on performance or training outcomes. Additionally, the inter-  
545 individual variability in symptoms experienced and their association with perceived  
546 performance and training outcomes in the present study supports an individualised approach.  
547 For example, it is likely that individuals who experience a high number of symptoms and  
548 perceive these symptoms to influence performance and training will report the biggest benefit  
549 of symptom mapping alongside proactive symptom management.

550

## 551 **5.0 CONCLUSION**

552 This study provides an in-depth insight into the type, frequency, and severity of symptoms  
553 experienced by a group of naturally menstruating women and mOCP users, across pre-defined  
554 cycle *phases*, relative to their perceived impact on exercise performance and recovery time  
555 post-training. Results revealed that symptoms were common in these women, but there were  
556 no differences in symptomology between groups. The type, frequency, and severity of  
557 symptoms changed across cycle *phases*, with a greater magnitude of symptoms reported whilst  
558 bleeding. A higher '*phase* symptom frequency × severity score', was associated with reduced  
559 exercise performance and a longer recovery time post-training whilst bleeding. Practically,  
560 these results emphasise the need for active women, and those working with them, to consider  
561 real-time monitoring of symptoms, and any associated impact on exercise performance and  
562 recovery, rather than relying on retrospective data. This recommendation is applicable  
563 regardless of sex hormone profile. In turn, this should be accompanied, where needed, by  
564 individualised management strategies to minimise any negative effects of symptoms on  
565 exercise performance and recovery, particularly around key phases where the magnitude of  
566 symptoms might be greater. Further high-quality investigation is needed to understand the  
567 influence of symptomology on objective markers of exercise performance and recovery.

568

## 569 **REFERENCES**

570 Ansdell, P., Brownstein, C. G., Škarabot, J., Hicks, K. M., Simoes, D. C., Thomas, K., ... &  
571 Goodall, S. (2019). Menstrual cycle-associated modulations in neuromuscular function and

572 fatigability of the knee extensors in eumenorrhic women. *Journal of Applied*  
573 *Physiology*, 126(6), 1701-1712.

574 Armour, M., Parry, K. A., Steel, K., & Smith, C. A. (2020). Australian female athlete  
575 perceptions of the challenges associated with training and competing when menstrual  
576 symptoms are present. *International Journal of Sports Science & Coaching*, 15(3), 316-323.

577 Bennink, H. J. C. (2004). Are all estrogens the same?. *Maturitas*, 47(4), 269-275.

578 Brown, N., Knight, C. J., & Forrest, L. J. (2021). Elite female athletes' experiences and  
579 perceptions of the menstrual cycle on training and sport performance. *Scandinavian Journal of*  
580 *Medicine & Science in Sports*, 31(1), 52-69.

581 Bruinvels, G., Goldsmith, E., Blagrove, R., Simpkin, A., Lewis, N., Morton, K., ... & Pedlar,  
582 C. (2021). Prevalence and frequency of menstrual cycle symptoms are associated with  
583 availability to train and compete: a study of 6812 exercising women recruited using the Strava  
584 exercise app. *British Journal of Sports Medicine*, 55(8), 438-443.

585 Bruinvels, G., Hackney, A. C., & Pedlar, C. R. (2022). Menstrual cycle: the importance of both  
586 the phases and the transitions between phases on training and performance. *Sports*  
587 *Medicine*, 52(7), 1457-1460.

588 Clarke, A. C., Bruinvels, G., Julian, R., Inge, P., Pedlar, C. R., & Govus, A. D. (2021).  
589 Hormonal contraceptive use in football codes in Australia. *Frontiers in Sports and Active*  
590 *Living*, 3, 634866.

591 Constantini, N. W., Dubnov, G., & Lebrun, C. M. (2005). The menstrual cycle and sport  
592 performance. *Clinics in Sports Medicine*, 24(2), e51-e82.

593 Del Río, J. P., Alliende, M. I., Molina, N., Serrano, F. G., Molina, S., & Vigil, P. (2018). Steroid  
594 hormones and their action in women's brains: the importance of hormonal balance. *Frontiers*  
595 *in Public Health*, 141.

596 Elliott-Sale, K. J., Smith, S., Bacon, J., Clayton, D., McPhilimey, M., Goutianos, G., ... & Sale,  
597 C. (2013). Examining the role of oral contraceptive users as an experimental and/or control  
598 group in athletic performance studies. *Contraception*, 88(3), 408-412.

599 Elliot-Sale, K. J., McNulty, K. L., Ansdell, O., Goodall, S., Hicks, K. M., Thomas, K., ... &  
600 Dolan, E. (2020). The Effects of Oral Contraceptives on Exercise Performance in Women: A  
601 Systematic Review and Meta-analysis. *Sports Medicine*, 50(10), 1785-1812.

602 Elliott-Sale, K. J., Minahan, C. L., de Jonge, X. A. J., Ackerman, K. E., Sipilä, S., Constantini,  
603 N. W., ... & Hackney, A. C. (2021). Methodological considerations for studies in sport and  
604 exercise science with women as participants: a working guide for standards of practice for  
605 research on women. *Sports Medicine*, 51(5), 843-861.

606 Ferries-Rowe, E., Corey, E., & Archer, J. S. (2020). Primary dysmenorrhea: diagnosis and  
607 therapy. *Obstetrics & Gynecology*, 136(5), 1047-1058.

608 Findlay, R. J., & Macrae, E. H. R. (2020). Forrest (née Whyte), LJ (2020). How the menstrual  
609 cycle and menstruation affect sporting performance: Experiences and perceptions of elite  
610 female rugby players. *British Journal of Sports Medicine*, 54(18), 1108-1113.

611 Gaskins, A. J., Wilchesky, M., Mumford, S. L., Whitcomb, B. W., Browne, R. W., Wactawski-  
612 Wende, J., ... & Schisterman, E. F. (2012). Endogenous reproductive hormones and C-reactive  
613 protein across the menstrual cycle: the BioCycle Study. *American Journal of*  
614 *Epidemiology*, 175(5), 423-431.

615 Guo, S. W., Mao, X., Ma, Q., & Liu, X. (2013). Dysmenorrhea and its severity are associated  
616 with increased uterine contractility and overexpression of oxytocin receptor (OTR) in women  
617 with symptomatic adenomyosis. *Fertility and Sterility*, 99(1), 231-240.

618 Heather, A. K., Thorpe, H., Ogilvie, M., Sims, S. T., Beable, S., Milsom, S., ... & Hamilton, B.  
619 (2021). Biological and socio-cultural factors have the potential to influence the health and  
620 performance of elite female athletes: a cross sectional survey of 219 elite female athletes in  
621 Aotearoa New Zealand. *Frontiers in Sports and Active Living*, 27.

622 Hicks, K. M., Hackney, A. C., Dooley, M., & Bruinvels, G. (2022). 13.3 Testing the female  
623 athlete. *Sport and Exercise Physiology Testing Guidelines: Volume I-Sport Testing: The British*  
624 *Association of Sport and Exercise Sciences Guide*, 368.

625 Lebrun, C. M. (1994). The effect of the phase of the menstrual cycle and the birth control pill  
626 on athletic performance. *Clinics in Sports Medicine*, 13(2), 419-441.

627 Martin, D., Sale, C., Cooper, S. B., & Elliott-Sale, K. J. (2018). Period prevalence and  
628 perceived side effects of hormonal contraceptive use and the menstrual cycle in elite  
629 athletes. *International Journal of Sports Physiology and Performance*, 13(7), 926-932.

630 McKay, A. K., Stellingwerff, T., Smith, E. S., Martin, D. T., Mujika, I., Goosey-Tolfrey, V.  
631 L., ... & Burke, L. M. (2022). Defining training and performance caliber: a participant

632 classification framework. *International Journal of Sports Physiology and Performance*, 17(2),  
633 317-331.

634 McNulty, K. L., Elliott-Sale, K. J., Dolan, E., Swinton, P. A., Ansdell, P., Goodall, S., ... &  
635 Hicks, K. M. (2020). The effects of menstrual cycle phase on exercise performance in  
636 eumenorrhoeic women: a systematic review and meta-analysis. *Sports Medicine*, 50, 1813-  
637 1827.

638 McNulty, K., Hicks, K., & Ansdell, P. (2021). Variation in physiological function within and  
639 between menstrual cycles: uncovering the contributing factors. *Experimental*  
640 *Physiology*, 106(7), 1405-1406.

641 Nolan, D., Elliott-Sale, K. J., & Egan, B. (2022). Prevalence of hormonal contraceptive use  
642 and reported side effects of the menstrual cycle and hormonal contraceptive use in powerlifting  
643 and rugby. *The Physician and Sportsmedicine*, 1-6.

644 Oxfeldt, M., Dalgaard, L. B., Jørgensen, A. A., & Hansen, M. (2020). Hormonal contraceptive  
645 use, menstrual dysfunctions, and self-reported side effects in elite athletes in  
646 Denmark. *International Journal of Sports Physiology and Performance*, 15(10), 1377-1384.

647 Parker, L. J., Elliott-Sale, K. J., Hannon, M. P., Morton, J. P., & Close, G. L. (2022). An audit  
648 of hormonal contraceptive use in Women's Super League soccer players; implications on  
649 symptomology. *Science and Medicine in Football*, 6(2), 153-158.

650 Phelan, N., Behan, L. A., & Owens, L. (2021). The Impact of the COVID-19 Pandemic on  
651 Women's Reproductive Health. *Frontiers in Endocrinology*, 12.

652 Puder, J. J., Blum, C. A., Mueller, B., De Geyter, C., Dye, L., & Keller, U. (2006). Menstrual  
653 cycle symptoms are associated with changes in low-grade inflammation. *European Journal of*  
654 *Clinical Investigation*, 36(1), 58-64.

655 Read, P., Mehta, R., Rosenbloom, C., Jobson, E., & Okholm Kryger, K. (2022). Elite female  
656 football players' perception of the impact of their menstrual cycle stages on their football  
657 performance. A semi-structured interview-based study. *Science and Medicine in*  
658 *Football*, 6(5), 616-625.

659 Rechichi, C., Dawson, B., & Goodman, C. (2009). Athletic performance and the oral  
660 contraceptive. *International Journal of Sports Physiology and Performance*, 4(2), 151-162.

- 661 Robinson, A. T., Wenner, M. M., Bunsawat, K., Watso, J. C., Giersch, G. E., & Charkoudian,  
662 N. (2021). When it's time for the sex talk, words matter. *American Journal of Physiology-*  
663 *Heart and Circulatory Physiology*.
- 664 Schoep, M. E., Nieboer, T. E., van der Zanden, M., Braat, D. D., & Nap, A. W. (2019). The  
665 impact of menstrual symptoms on everyday life: a survey among 42,879 women. *American*  
666 *Journal of Obstetrics and Gynecology*, 220(6), 569-e1.
- 667 Solli, G. S., Sandbakk, S. B., Noordhof, D. A., Ihalainen, J. K., & Sandbakk, Ø. (2020).  
668 Changes in self-reported physical fitness, performance, and side effects across the phases of  
669 the menstrual cycle among competitive endurance athletes. *International Journal of Sports*  
670 *Physiology and Performance*, 15(9), 1324-1333.
- 671 Stricker, R., Eberhart, R., Chevaller, M. C., Quinn, F. A., Bischof, P., & Stricker, R. (2006).  
672 Establishment of detailed reference values for luteinizing hormone, follicle stimulating  
673 hormone, estradiol, and progesterone during different phases of the menstrual cycle on the  
674 Abbott ARCHITECT® analyzer. *Clinical Chemistry and Laboratory Medicine*  
675 *(CCLM)*, 44(7), 883-887.
- 676 Sulak, P. J., Scow, R. D., Preece, C., Riggs, M. W., & Kuehl, T. J. (2000). Hormone withdrawal  
677 symptoms in oral contraceptive users. *Obstetrics & Gynecology*, 95(2), 261-266.
- 678 Thompson, B., & Han, A. (2019). Methodological recommendations for menstrual cycle  
679 research in sports and exercise. *Medicine and Science in Sports and Exercise*, 51(12), 2610-  
680 2617.
- 681 Thompson, B., Almarjawi, A., Sculley, D., & Janse de Jonge, X. (2020). The effect of the  
682 menstrual cycle and oral contraceptives on acute responses and chronic adaptations to  
683 resistance training: a systematic review of the literature. *Sports Medicine*, 50, 171-185.
- 684 Wong, C. L., Farquhar, C., Roberts, H., & Proctor, M. (2009). Oral contraceptive pill as  
685 treatment for primary dysmenorrhoea. *Cochrane Database of Systematic Reviews*, (2).
- 686 Yonkers, K. A., O'Brien, P. S., & Eriksson, E. (2008). Premenstrual syndrome. *The*  
687 *Lancet*, 371(9619), 1200-1210.

688

689 **TABLES**

Table 1. Perceived effect of menstrual cycle *phase* (*i.e.*, phase one: ‘early follicular phase’; phase two: ‘late follicular/ovulatory phase’; and phase three: ‘mid-luteal phase’) and combined, monophasic, oral contraceptive pill *mOCP phase* (phase one: ‘*mOCP* withdrawal’, days 1 to 7 of pill-free days; phase two: ‘*mOCP* consumption, days 1 to 7’; phase three: ‘*mOCP* consumption, days 8 to 14’; and phase four: ‘*mOCP* consumption, days 15 to 21’) on aspects of exercise performance and training in naturally menstruating women (n = 21) and pill users (n = 21).

Outcome	Group	Not applicable		Phase 1		Phase 2		Phase 3		Phase 4	
		n	%	n	%	n	%	n	%	n	%
More likely to decrease the number of training sessions	Naturally menstruating	6	29	11	52	0	0	0	0	-	-
	<i>mOCP</i>	8	38	12	57	1	5	1	5	1	5
More likely to increase the number of training sessions	Naturally menstruating	8	38	1	5	10	48	7	33	-	-
	<i>mOCP</i>	9	43	0	0	12	57	12	57	12	57
More likely to miss a training session	Naturally menstruating	2	10	16	76	0	0	0	0	-	-
	<i>mOCP</i>	10	48	11	52	0	0	0	0	0	0
More likely to miss competition	Naturally menstruating (n = 4)	2	50	2	50	0	0	0	0	-	-
	<i>mOCP</i> (n = 4)	2	50	2	50	0	0	0	0	0	0
Perceive a training session to be harder	Naturally menstruating	3	14	12	57	1	5	5	24	-	-
	<i>mOCP</i>	5	24	16	76	0	0	0	0	0	0
Perceive a training session to be easier	Naturally menstruating	6	29	3	14	11	52	8	38	-	-
	<i>mOCP</i>	10	48	2	10	9	43	9	43	9	43



Perceive performance to be improved	Naturally menstruating mOCP	3	14	4	19	14	67	9	43	-	-
		8	38	1	5	12	57	12	57	12	57
Perceive performance to be reduced	Naturally menstruating mOCP	6	29	8	38	1	5	1	5	-	-
		9	43	12	57	0	0	0	0	0	0
Feel more fatigued prior to, during and post a training session	Naturally menstruating mOCP	1	5	11	52	0	0	3	14	-	-
		7	33	14	67	0	0	0	0	0	0
Feel more energised prior to, during and post a training session	Naturally menstruating mOCP	3	14	3	14	13	62	7	33	-	-
		13	62	2	10	7	33	7	33	7	33
Experience reduced motivation towards training	Naturally menstruating mOCP	2	10	10	48	0	0	3	14	-	-
		8	38	13	62	0	0	0	0	0	0
Experience increased motivation towards training	Naturally menstruating mOCP	4	19	2	10	12	57	10	48	-	-
		12	57	0	0	9	43	9	43	9	43
Perceive recovery to take longer post a training session	Naturally menstruating mOCP	4	19	10	48	0	0	1	5	-	-
		12	57	9	43	0	0	0	0	0	0
Perceive recovery to be quicker post a training session	Naturally menstruating mOCP	5	24	1	5	14	67	8	38	-	-
		15	71	1	5	5	24	5	24	5	24

Table 2. Estimated odds ratios and 95% confidence intervals for the effect of ‘*phase symptom frequency × severity score*’ on perceived exercise performance and recovery time post-training across menstrual cycle *phases* (i.e., phase one: ‘early follicular phase’; phase two: ‘late follicular/ovulatory phase’; and phase three: ‘mid-luteal phase’) and combined, monophasic, oral contraceptive pill (mOCP) *phases* (phase one: ‘mOCP withdrawal’, days 1 to 7 of pill-free days; phase two: ‘mOCP consumption, days 1 to 7’; phase three: ‘mOCP consumption, days 8 to 14’; and phase four: ‘mOCP consumption, days 15 to 21’) in naturally menstruating women (n = 19) and pill users (n = 21).

Group		Reduced performance				Improved performance				Longer recovery				Quicker recovery			
		Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
‘Phase symptom frequency × severity score’	Naturally menstruating	n = 8	n = 1	n = 1	-	n = 4	n = 14	n = 9	-	n = 10	n = 0	n = 1	-	n = 1	n = 14	n = 8	-
	mOCP	n = 12	n = 0	n = 0	n = 0	n = 1	n = 12	n = 12	n = 12	n = 9	n = 0	n = 0	n = 0	n = 0	n = 5	n = 5	n = 5
		1.07 (1.01 to 1.14)*	-	-	-	0.84 (0.66 to 1.08)	1.00 (0.97 to 1.05)	1.00 (0.97 to 1.04)	-	1.04 (1.00 to 1.07)*	-	-	-	-	0.99 (0.96 to 1.03)	1.01 (0.97 to 1.05)	-
		1.04 (1.00 to 1.08)*	-	-	-	-	0.99 (0.97 to 1.01)	0.99 (0.96 to 1.01)	1.00 (0.98 to 1.02)	1.03 (1.00 to 1.05)*	-	-	-	-	1.01 (0.99 to 1.03)	1.00 (0.98 to 1.02)	1.00 (0.97 to 1.02)

Values are odd ratios (95% confidence interval). \*denotes odd ratios deemed significant ( $P \leq 0.05$ ). -denotes data not available (e.g., no participant reported specific variable in specific *phase*).