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

ABSTRACT

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

1.0 INTRODUCTION

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

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

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

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

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

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

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

2.0 METHODS

2.1 Participants

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

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

2.2 Design

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

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 $_{m}$OCP 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 $_{m}$OCP *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 $_{m}$OCP *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

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

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

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

these profiles, reflecting $_{m}$OCP consumption and withdrawal, are pseudo-phases as they are 'artificial' *phases* in comparison with the phases of the MC, but for the purposes of this study will be referred to as *phases*.

2.4 Data analysis

2.4.1 54-part online survey

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

2.4.2 Daily cycle and symptom tracking

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

2.5 Statistical analysis

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

3.0 RESULTS

3.1 Participant characteristics

Self-reported, descriptive, MC and $_{m}$OCP characteristics data are displayed in Supplementary File 5.

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

The reported type and frequency of each symptom, for each group, are shown in Figure 1. There was no difference in the 'total number of symptoms' reported (naturally menstruating: 12 ± 4 symptoms; $_{m}$OCP: 11 ± 4 symptoms; $P = 0.353$), the 'Si score' (naturally menstruating: 26 ± 10; $_{m}$OCP: 22 ± 10; $P = 0.200$), 'average symptom severity' (naturally menstruating: 3 'moderate' [*Mdn*]; $_{m}$OCP: 2 'mild' [*Mdn*]; $P = 0.145$), and the overall 'Si × severity score' (naturally menstruating: 68 [*Mdn*] ± 90 [*IQR*]; $_{m}$OCP: 50 [*Mdn*] ± 56 [*IQR*]; $P = 0.113$) between naturally menstruating women and $_{m}$OCP users.

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

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

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

There was a difference in 'symptom frequency per *phase*' across $_{m}$OCP *phases* ($P < 0.001$; Figure 4, Panel A), whereby pill users experienced a greater frequency of symptoms during phase one (35 ± 24 symptoms) compared with all other $_{m}$OCP *phases* (phase two: 18 ± 20 symptoms, $P = 0.001$ [95% CI 6 to 28]; phase three: 13 ± 17 symptoms, $P < 0.001$ [95% CI 9 to 34]; phase four: 19 ± 21 symptoms $P < 0.003$ [95% CI 5 to 27], respectively), but there was no difference between any of the $_{m}$OCP consumption *phases* ($P = 0.079$, $P = 1.000$, and $P =$

0.376, respectively). There was no difference in 'symptom severity per *phase*' across $_{m}$OCP *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 x severity score' differed across $_{m}$OCP *phases* (*P* < 0.001; Figure 4, Panel B), whereby the '*phase* symptom frequency × severity score' was greater during phase one (73 ± 55 Au) of the $_{m}$OCP *cycle* compared with all other $_{m}$OCP *phases* (phase two: 36 ± 39 Au, *P* = 0.002 [95% CI 11 to 61]; phase three: 30 ± 46 Au, *P* = 0.005 [95% CI 11 to 75]; phase four: 42 ± 51 Au, *P* = 0.022 [95% CI 4 to 59], respectively), however there was no difference between any of the $_{m}$OCP 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 $_{m}$OCP *phases* on aspects of exercise performance and training in naturally menstruating women and $_{m}$OCP 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 $_{m}$OCP 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 $_{m}$OCP users reported no differences in perceived recovery time following a training session across $_{m}$OCP *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 × 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 $_{m}$OCP *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 × severity score' provide an estimate of the change in odds for the corresponding response variable per unit increase in '*phase* symptom frequency × severity score'. A higher '*phase* symptom frequency × severity score' was

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

4.0 DISCUSSION

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

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

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

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

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

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

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

4.1 Limitations and future directions

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

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

4.2 Practical implications

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

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

5.0 CONCLUSION

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

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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 $_{m}$OCP *phase* (phase one: '$_{m}$OCP withdrawal', days 1 to 7 of pill-free days; phase two: '$_{m}$OCP consumption, days 1 to 7'; phase three: '$_{m}$OCP consumption, days 8 to 14'; and phase four: '$_{m}$OCP 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	-	-
	$_{m}$OCP	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	-	-
	$_{m}$OCP	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	-	-
	$_{m}$OCP	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	-	-
	$_{m}$OCP (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	-	-
	$_{m}$OCP	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	-	-
	$_{m}$OCP	10	48	2	10	9	43	9	43	9	43

Perceive performance to be improved	Naturally menstruating	3	14	4	19	14	67	9	43	-	-
	$_{m}$OCP	8	38	1	5	12	57	12	57	12	57
Perceive performance to be reduced	Naturally menstruating	6	29	8	38	1	5	1	5	-	-
	$_{m}$OCP	9	43	12	57	0	0	0	0	0	0
Feel more fatigued prior to, during and post a training session	Naturally menstruating	1	5	11	52	0	0	3	14	-	-
	$_{m}$OCP	7	33	14	67	0	0	0	0	0	0
Feel more energised prior to, during and post a training session	Naturally menstruating	3	14	3	14	13	62	7	33	-	-
	$_{m}$OCP	13	62	2	10	7	33	7	33	7	33
Experience reduced motivation towards training	Naturally menstruating	2	10	10	48	0	0	3	14	-	-
	$_{m}$OCP	8	38	13	62	0	0	0	0	0	0
Experience increased motivation towards training	Naturally menstruating	4	19	2	10	12	57	10	48	-	-
	$_{m}$OCP	12	57	0	0	9	43	9	43	9	43
Perceive recovery to take longer post a training session	Naturally menstruating	4	19	10	48	0	0	1	5	-	-
	$_{m}$OCP	12	57	9	43	0	0	0	0	0	0
Perceive recovery to be quicker post a training session	Naturally menstruating	5	24	1	5	14	67	8	38	-	-
	$_{m}$OCP	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 ($_{m}$OCP) *phases* (phase one: '$_{m}$OCP withdrawal', days 1 to 7 of pill-free days; phase two: '$_{m}$OCP consumption, days 1 to 7'; phase three: '$_{m}$OCP consumption, days 8 to 14'; and phase four: '$_{m}$OCP 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	-
		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)	-
	$_{m}$OCP	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
		1.04 (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 (0.99 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*).