The Biocultural Entanglement of Athlete Training Responses Across the Menstrual Cycle in Recreational Runners

by

Sara Woodman Szabo

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Faculty of Kinesiology, Sport, and Recreation

University of Alberta

Abstract

Background: Recent progress in exercise science research has facilitated greater understanding of female athlete physiology, in particular regarding the menstrual cycle (MC) and human performance. Yet, a comprehensive understanding of this topic remains tentative (Casto, 2022). Existing research has focused on defined MC phases, and therefore, the transitions between phases and daily responses across cycles are less understood (Bruinvels et al., 2022). Furthermore, given the variability in MC experiences, it is necessary to gain more knowledge of how exercising females experience and perceive the MC in relation to their athletic training (Brown et al., 2021). This indicates clear gaps in the current MC research including: how training response is influenced by the MC and how female athletes perceive their MC experience. Thus, the purpose of this study was two-fold. First, to explore how physiological and perceptual responses to training are impacted across eight MC time points (T1-T8). Second, to qualitatively explore how trained female runners experience the MC. **Methods:** A new materialist approach that combined physiological and psychosocial elements of female athletes' experiences with MC, was used to address the aforementioned research gaps. First, daily training and MC data were collected from sixteen naturally menstruating female distance runners between the ages of 22-40 (mean age 35 ± 4.9 years) using an electronic survey, sent every evening for three consecutive cycles. Physiological measures and perceptual responses to training were: supine resting heart rate (HR), basal body temperature (BBT), duration of training (minutes), perceived rating of exertion (sRPE), satisfaction with training (0 = Extremely Unsatisfied to 10=Extremely Satisfied), motivation to train (0=Extremely Unmotivated to 10=Extremely Motivated) and overall muscle feel (0=Extremely Light to 10=Extremely Heavy).

Daily total training stress (TTS a.u.) was calculated as total duration of each training session multiplied by sRPE for that same session. Participants identified if they experienced any MC symptoms (list of 21) each day. Survey data from two participants were excluded from statistical analysis due to a) menstrual cycle irregularity found during monitoring and b) incomplete data set. Repeated measures ANOVAs determined differences in physiological responses, self-reported perceptions to training, and MC symptoms across 8 cycle time points ($p \leq 0.05$). Follow-up interviews (5 individual, 5 group; mean duration 87 mins) were completed with sixteen participants and analyzed thematically. **Results:** Quantitative analysis revealed a difference in basal body temperature (BBT) across the MC ($p = <0.001$) but no main effect was observed in other survey measures. Post hoc pairwise comparisons found significant differences between MC time points in HR, SAT and MF. Statistical analysis on 13 out of 21 MC symptoms revealed that fatigue, stomach cramps and bloating all differed across the MC ($p =< 0.003$, $p= <0.001$ and $p= <0.002$, respectively). No main effect was observed but post hoc pairwise comparisons found significant differences between MC time points in other symptoms including: increased body temperature, feeling stressed, poor concentration, irritability, heavy legs, headache, disturbed sleep, lower back pain, and reduced motivation. Through qualitative analysis of the interview data, four main themes were developed: a) *the body: physical cycle specifics*, b) *the mind: feelings of exercise*, c) *resilience is both a blessing and a curse*, and d) *embracing menstrual cycle as a positive.* **Conclusion:** Overall, a standard use of athlete monitoring found that cycle phase, and the transitions between, influenced athlete responses to training, as well as MC symptoms. This is the first study to take an 8 time-point approach to understanding how the MC influences athlete status. My investigation illustrates the temporal localization of physiological, perceptual and symptomatologic responses to the MC and endurance training,

reinforcing that transitions between phases should be considered to establish a more comprehensive investigation between the cultivated experiences of training and the MC. Further, the differences observed in subjective responses such as satisfaction and muscle feel, supplemented by qualitative insights, help inform how female athletes perceive their training and mind/body experiences at various points across the MC. There is currently no conclusive consensus for whether or not, and how, the MC impacts performance (McNulty et al., 2020). However, this study demonstrates that effective integration of qualitative and quantitative data enables a more holistic and nuanced understanding of training response in female athletes.
Keywords: new materialism, endurance training, total training stress, lived experience of female athletes

Preface

This thesis is an original work by Sara Woodman Szabo. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, project name “Exploring the subjective perceptions and objective responses to training stress throughout the menstrual cycle in women endurance athletes”, No. Pro00115475, Approved January 17, 2022.

Dedication

In loving memory of Uncle Chris, my guiding example of humility and kindness.

"There's so much left to know and I'm on the road to find out." – Yusef/Cat Stevens

Acknowledgements

I want to echo the sentiments of a participant, who spoke of the importance of *the village*, all the people who contribute in various way to help one another. This thesis is the collective accomplishment of my village, their tremendous support was essential in helping me achieve an endeavor of this magnitude.

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Chapter 1: Introduction

1.1 Preamble

Scientific research of the menstrual cycle (MC) and sport has largely focused around the impact on performance: laboratory-based attempts to quantify whether or not, and to what degree, the cyclical fluctuations of estrogen and progesterone effect different aspects of sport performance and physiology. Initially, I was a consumer of this work, a curious female athlete genuinely intrigued by the ways in which my performance, training, and athlete experience might be improved. Then I became an active recipient, trying to devise a way to apply these (inconclusive) learnings into my own experience. Hence, I integrated space for cycle tracking into the already data-rigorous training logs I had designed for myself. The prescription of my training as a distance runner and Nordic skier was not consequentially transformed. However, the addition of menstrual tracking, merely counting days and noting cycle phase within my training logs, was thought-provoking. Perhaps more importantly, this process stimulated further curiosity and inspired discussion with my sport scientist. My personal investigation was supplemented by the collection of anecdotal information gained over many communal miles, a natural setting for knowledge sharing, with my immediate community of women runners. I paid close attention to the mutual feelings of enthusiasm for what we *could* learn as well as the simultaneous feelings of frustration for what we had *not* learned. It became clear to me that if the scientific community were to move beyond an athlete-centred approach to training and towards a female-athlete-centred approach to training, many would greet this zealously.

1.2 Background

Sport performance and the menstrual cycle is a growing area of research. Menstruation is a critical biological cycle whereby fluctuations of estrogen and progesterone hormones support

reproductive function in females. However, hormonal fluctuations do not exclusively impact the reproductive system but additionally, have complex effects on the cardiovascular, respiratory, metabolic and neuromuscular systems (McNulty et al., 2020). Thus, it is only logical that research exploring the menstrual cycle and sport performance has increased over recent years. Growth in this particular field of inquiry addresses a need to better understand the effects of hormonal fluctuations on exercise performance while demonstrating progress towards greater gender equity in sport science that is both necessary, and overdue.

A recent systematic review and meta-analysis of current literature (see McNulty et al., 2020) in this topic did not provide guidance on modifying exercise throughout the menstrual cycle but rather advised practitioners to use an individualized approaches with each athlete. This ambiguity is partly due to low quality of research with inconsistent methodological consideration which elicits conflicting findings (Elliott-Sale et al., 2021; McNulty et al., 2020; Meignie et al., 2021). Additionally, there are differences between menstrual cycles across females that inevitably change over the course of the lifespan, suggesting a universal guide to directing training and performance in female athletes may never be feasible (Elliott-Sale et al., 2021). However, to develop a comprehensive and individualized understanding of a given athlete, it is recommended that sport scientists monitor the menstrual cycle (Antero et al., 2023; Bergström et al., 2023; Cristina-Souza et al., 2019; Elliott-Sale et al., 2020; Pitchers & Elliot-Sale, 2019; Solli et al., 2020), and evaluate menstrual cycle factors alongside traditional internal load measures such as perception of effort, heart rate and training stress (Halson, 2014). By doing so, practitioners will be able consider the impact of the menstrual cycle, at an individual level, with the same focus given to any other physiological determinant of performance (Brown et al., 2021). Additionally, research indicates that 93% of athletes report experiencing negative

physical or psychological symptoms throughout their menstrual cycle including, but not limited to, stomach/abdominal cramping, reduced energy levels, general discomfort, negative mood states, and reduced motivation (Findlay et al., 2020). According to Brown and colleagues (2021), a better understanding of how an individual experiences and perceives the menstrual cycle and exercise proves necessary. However, this is only a starting point because it does nothing to improve how the menstrual cycle, as an intrinsic biological process, can be systematically incorporated into training load determination. In failing to merge disciplinary insights gained through experiential and experimental research, applied sport practitioners continue to overlook the menstrual cycle as a key factor in training load.

Moreover, research emphasizes that few sport environments exist within which menstruation can be openly and honestly discussed (Brown et al., 2021). From a sport science perspective, this is unsurprising since studies in this field remain exceedingly male dominated (Costello et al., 2014; Cowley et al., 2021). In fact, a recent analysis found that within six sport and exercise science journals, only 34% of participants accounted for were female and only 6% of publications were research studies conducted exclusively on females (Cowley et al., 2021). Further, a clinical, medical perspective has been the dominant approach to studying athlete health topics in females, such as menstruation, yet this approach is void of any social and cultural connections to menstruation that may be integral to destigmatizing the topic (Thorpe, Clark, et al., 2020). Therefore, pursuing an entangled understanding of the subjective perceptions of the menstrual cycle, and of the menstrual cycle as a physiological consideration to performance, is an endeavor that demands a transdisciplinary research approach to enable work across sport disciplines. Using a mixed methods study design, I will draw upon new materialism – described by Thorpe, Clark, et al. (2020) as a means to innovatively explore ways of knowing by working

across disciplines, creating a dialogue amongst scholars from social and physical sciences – to interrogate the boundaries of sport science and disrupt the existing gender imbalance.

1.3 Purpose

The purpose of this study was to explore, using both quantitative physiological and qualitative interview data, how female endurance athletes perceive and respond to training stress throughout the menstrual cycle (MC). The objectives of the proposed study were:

1. To understand how female endurance athletes perceive their MC to impact their training, and consequently, their training stress.
2. To determine what objective insight can be achieved by consistently monitoring, simultaneously, athlete training and MC data.
3. To adapt findings into individualized portfolios for each athlete that may be used to facilitate and guide future training monitoring.

1.4 Research Questions and Hypotheses

My qualitative interviews were structured based on two research questions: a) *What impact will female athletes perceive the MC as having on their training?* and b) *How will female athletes feel about tracking their MC when training?* In regards to the quantitative athlete monitoring stage, I hypothesized that higher ratings of perceived exertion (sRPE), higher ratings of muscle feel, lower ratings of satisfaction, lower ratings of motivation, and more menstrual symptoms would be reported during the final days of the MC of Phase 4 (approximately 3 days prior to period) and early days of Phase 1 (day 1 and 2 of menstruation) of the MC. The hypothesized changes in these measures were expected during these particular points within the cycle due to pre-menstrual syndrome as well as socially constructed myths which associate menstruation with weakness and hindered performance. Additionally, I hypothesized that

objective measures (i.e., AM resting heart rate, basal body temperature) would be highest during Phase 4 of the menstrual cycle when progesterone levels are most elevated. While the above hypotheses indicate different cycle points where subjective and objective measures are thought to be highest, I further hypothesized that the highest perceptual measures (i.e., satisfaction of training, motivation to train) and lowest values of *both* subjective (i.e., sRPE, muscle feel) and objective measures (i.e., AM resting heart rate, basal body temperature) would be reported during Phase 2 (immediately prior to ovulation) of the menstrual cycle when estrogen is highest in isolation of progesterone.

1.5 Impact of the Research

Insights generated from this study will, ideally, assist sport scientists (both academics and applied practitioners) by distilling how menstrual cycle symptoms, overall exercise effort and additional measures of athlete fatigue might be incorporated into the evaluation of training response in female endurance athletes. Further, participants continued with the independent nature of their exercise training programs – with deeper individual analyses, this could help to inform which types of workouts are either preferred or modified by participants at various points throughout the cycle. This research exemplifies how female-specific physiology should be considered when monitoring athlete training, offering a starting point for how sport scientists can alternately engage with standard load monitoring programs and more considerately approach training prescription for female athletes. Furthermore, the long-term outcome of this work is to guide new considerations for training female endurance athletes, both exercise prescription and monitoring, where menstrual cycle factors are incorporated as an essential component to training to optimize performance, enhance recovery and improve communication between sport practitioners and athletes. The present research is especially important as it equips female

athletes with much needed agency in sport science through an approach to training that is no longer informed exclusively by male athlete insights. As such, female athletes may be positioned with heightened attentiveness and awareness of the relationship between menstrual cycle and athletic training which could thereby promote more open dialogue around menstruation and facilitate more informed choices about their training.

1.6 Procedure

The study included naturally menstruating, with confirmed ovulation, female athletes between the ages of 22-40 years who were engaged in competitive (i.e., actively engage in consistent training for a specific event) endurance sport. As best as possible, I ensured homogeneity of hormonal profiles across study participants because this helps to reduce the variability in hormonal status between participants as well as the variability in population between studies (Elliott-Sale et al., 2021). Mixed-method data generation strategies were two-fold. Quantitative data collection involved an athlete questionnaire and training log: athletes completed an intake questionnaire followed by a menstrual cycle/training log that asked participants to input subjective and objective data about their menstrual cycle and athletic training on a daily basis. Training logs were recorded for three consecutive menstrual cycles, or approximately 12 weeks, depending on the cycle length of each individual athlete. Subsequently, training logs were supplemented by qualitative semi-structured interviews to explore individual athletes' perceptions, and reflections, about the menstrual cycle and training. A mix of individual and group (2-3 participants) interviews were completed: participants selected the format with which they felt most comfortable or best suited their schedule. Interviews were conducted using Zoom, an online conferencing platform. Although this qualitative data was collected separately from the quantitative data, my study sought to extend beyond the boundaries of each discipline

and thus, as the principal investigator I completed analysis across both data sets. Data were reviewed by both members of my supervisory committee, hence facilitating knowledge sharing across fields of study.

Chapter 2: Literature Review

2.1 Overview of the Menstrual Cycle

Generally, three menstrual-related classifications of females exist including: eumenorrheic females, females with menstrual cycle irregularities, and females using hormonal contraceptive (Hackney & Elliott-Sale, 2021). Whilst distinct hormonal profiles exist for all of these groups, a thorough exploration of each is beyond the scope of this thesis. Thus, the following literature review will focus exclusively on eumenorrheic or naturally menstruating females, given the sample population for the present study. The menstrual cycle is a vital component of physiological function and reproductive health in women (Constantini et al., 2005). Menstruation, also known as a period, refers to the release (discharge of blood and tissue) of the endometrial wall, the lining of the uterus. This occurs approximately every 21-35 days in women between the approximate ages of 13-50 years and lasts about 3-7 days (McNulty et al., 2020; Oosthuyse & Bosch, 2010; Solli et al., 2020; Williams et al., 2017) as a result of the female egg, or ovum, not being fertilized by sperm to form an embryo (Pitchers & Elliot-Sale, 2019). The complex regulation of the menstrual cycle is enabled by the hypothalamus, producing gonadotrophin-releasing-factor (GnRH); the anterior pituitary gland, producing follicle stimulating hormone (FSH) and luteinizing hormone (LH); the ovaries, the follicles, and the corpus luteum, which produce endogenous hormones estrogen and progesterone (Reilly, 2000; Williams et al., 2017).

Broadly, the menstrual cycle is divided into two main phases referred to as the follicular and luteal phases which are separated by ovulation and differentiated by fluctuations of estrogen and progesterone (Isacco et al., 2012; Lebrun et al., 2020). However, menstrual cycle phases are

often defined in greater detail and subdivided as the early follicular, mid-follicular, late-follicular, ovulation, early luteal, mid-luteal and late luteal phases (Oosthuyse et al., 2023). Following menstruation, the follicular phase, predominated by the anterior pituitary hormones (FSH and LH), is the stage when estrogen influences the reconstruction of the uterine lining and gradually, an egg matures until ovulation occurs (Dawson & Reilly, 2009; Pitchers & Elliot-Sale, 2019). In response to elevated FSH and LH levels, the ovary secretes estradiol, one of three estrogen hormones, which rises to a peak approximately 24 hours prior to ovulation and subsequently triggers a positive feedback loop to the hypothalamic-pituitary-axis to release LH for a surge resulting in ovulation (Dawson & Reilly, 2009). Following ovulation, the luteal phase begins and increased secretions of estrogen and progesterone hormones occur. In this phase of the cycle, progesterone acts to prepare the endometrium for implantation of the egg (ovum) and together, estrogen and progesterone activate a negative feedback loop to the hypothalamic-pituitary-axis, preventing further release of FSH and LH (Dawson & Reilly, 2009; Pitchers & Elliot-Sale, 2019). If the egg is fertilized by sperm, an embryo is formed and pregnancy occurs. However, should fertilization of the ovum not occur, estrogen and progesterone decline significantly, the corpus luteum deteriorates and the entire menstrual cycle begins again as the uterine lining begins to break down (Dawson & Reilly, 2009; Pitchers & Elliot-Sale, 2019).

It is evident in this summary that estrogen and progesterone levels fluctuate somewhat predictably throughout the cycle. Estrogen is lowest during menstruation, rises gradually during the follicular phase, with its highest peak preceding ovulation, then lowers slightly following ovulation before rising again and remaining moderately high during the luteal phase. Meanwhile, progesterone is lowest during menstruation but remains low through the follicular phase until rising to elevated levels during the luteal phase with its highest peak around the mid-luteal point.

Undoubtedly, estrogen and progesterone hormones impact female physiology and, although the two hormones often have different target organs promoting differing physiological responses, they do occasionally act to enhance or antagonize the actions of one another (Sims & Heather, 2018).

2.2 Effects of Endogenous Estrogen & Progesterone

Female endogenous hormones include estrogen (estradiol, E2) and progesterone (P4) which are secreted by the ovaries, follicles and corpus luteum at varying levels throughout the menstrual cycle. At times these hormones can act in isolation, synergistically, or antagonistically (Constantini et al., 2005; Lebrun et al., 2020). Estrogen secretion precedes the secretion of progesterone and thus, primes the target tissue on which progesterone will act by stimulating the synthesis of progesterone receptors essential for the mediation of particular physiological effects (Sims & Heather, 2018). Meanwhile, progesterone is an antagonist to estrogen because it causes the turnover of estrogen receptors to accelerate, thereby decreasing the responsiveness to estrogen in certain tissues (Sims & Heather, 2018). Each hormone significantly influences physiological function by acting upon systems such as the cardiovascular, respiratory, metabolic, and autonomic nervous systems.

As previously stated, both estrogen and progesterone are at their lowest levels during menstruation. Estrogen, however, rises gradually during the follicular phase as the growing follicle slowly matures and then rises to its most elevated state, in isolation of progesterone, just prior to ovulation. It remains moderately high during the luteal phase alongside high levels of progesterone and consequently, some estrogenic effects are inhibited. In isolation, estrogen elicits greater parasympathetic nervous system (PNS) activity by acting to increase choline uptake as well as acetylcholine synthesis, which is the principal neurotransmitter of the vagus

nerve, a main component of the PNS (Kokts-Porietis et al., 2020; Sims et al., 2021). Consequently, a lower AM resting heart rate is likely to be observed during this hormonal phase. Further, estrogen acts as a vasodilator by stimulating the production and activity of nitric oxide and inhibiting sympathetic nervous system activity (SNS) (Dawson & Reilly, 2009). Vasodilation of blood vessels in conjunction with increased pulmonary diffusion capacity and increased plasma volume caused by estrogen cumulatively results in an increase in blood supply to the heart and muscle tissue (Lebrun et al., 2020; Rael et al., 2021). In regards to metabolism, estrogen acts to promote glycogen uptake and storage within the muscle and liver, as well as increases free fatty acid availability and the use of oxidative pathways to utilize free fatty acids as a fuel source (Lebrun et al., 2020). This results in greater glycogen sparing and fat utilization during exercise (Constantini et al., 2005; Janse de Jonge, 2003; Lebrun et al., 2020; Oosthuyse & Bosch, 2010; Oosthuyse et al., 2005). Moreover, estrogen acts to enhance plasma glucose availability as well as the uptake of glucose into type I muscles (Oosthuyse & Bosch, 2010; Oosthuyse et al., 2005; Sims & Heather, 2018). It has been postulated that progesterone may also impact substrate utilization, shifting metabolism in favour of fat, though researchers suggest the role of progesterone has yet to be fully established; it remains unclear which hormone is more metabolically dominant and during which menstrual cycle phase this is most observable (Constantini et al., 2005; Devries, 2016). However, recent research has evidenced an increase in fat oxidation during the luteal phase of the menstrual cycle, when both estrogen and progesterone are elevated (Hackney et al., 2022). It is, though, also important to note that nutritional status will influence substrate oxidation during exercise which may have a consequential impact on the aforementioned hormonal effects on substrate utilization (Boisseau & Isacco, 2022; Isacco et al., 2012). Further, progesterone influences female physiology in a variety of ways. Like estrogen,

progesterone acts on the autonomic nervous system (ANS) but in this instance, progesterone increases central norepinephrine release, resulting in increased sympathetic nervous system activity (Sims et al., 2021). Progesterone is also known to increase resting heart rate as well as elevate basal body temperature (approximately 0.3C) by increasing the thermoregulatory set point (Constantini et al., 2005; Lebrun et al., 2020; Oosthuyse et al., 2005; Sims & Heather, 2018). Another significant physiological impact progesterone elicits is an increase in ventilation stimulated by a progesterone-induced increase in the chemosensitivity of hypothalamic receptors, thereby causing the threshold of the medullary respiratory centre to lower (Rael et al., 2021). This results in effects on the respiratory system that occur concurrently including partially compensated respiratory alkalosis as well as an increase in the resting hypercapnic ventilatory response and hypoxic ventilatory response, resulting in increased resting ventilation (Dombovy et al., 1987; Janse de Jonge, 2003). The various ways by which progesterone impacts female physiology may have effects on how exercise is perceived, specifically when considering endurance performance.

2.3 The Menstrual Cycle and Sport Science

Understanding the effects of both estrogen and progesterone, it would be reasonable to assume that endurance performance may be improved during the late follicular phase, just prior to ovulation, when estrogen levels are highest in isolation and these impacts can be maximized without possible thermoregulatory and ventilatory strain caused by progesterone. Additionally, researchers have hypothesized that lower blood lactate levels may be observed during the follicular phase as a result of the greater oxidative capacity since this reduces the reliance of anaerobic pathways to produce ATP during high intensity submaximal exercise (Sims & Heather, 2018). However, no significant differences in blood lactate values have been

demonstrated in the research (Burrows & Bird, 2000). Further experimental research that has been conducted to determine benefits or impairments to endurance performance in various phases of the menstrual cycle but no significant difference in athletic performance across the menstrual cycle has been identified. For example, one study explored athletic performance in sixteen trained female found a slight reduction in absolute and relative VO_{2max} during the luteal phase but anaerobic performance, high intensity endurance capacity, and isokinetic muscle strength were unaffected by menstrual cycle phase (Lebrun et al., 1995). Similarly, another study measuring endurance performance in rowers found no significant changes in power output, oxygen consumption, heart rate, or blood lactate values at submaximal (anaerobic threshold) or maximal (VO_2) exercise intensities (Vaiksaar et al., 2011). More recently, a systematic review and meta-analysis on the body of literature in this area concluded that exercise performance may be "trivially reduced during the early follicular phase" (McNulty et al., 2020, p. 1821) as compared to other phases throughout the menstrual cycle. Further, Meignie et al. (2021) suggested that given the complexity of human performance, determining consensus about how the menstrual cycle influences parameters of performance is a challenging endeavour.

However, it is apparent that despite conclusive physiological evidence to indicate improved endurance performance in specific phases of the menstrual cycle, athletes subjectively identify impacts to performance. For instance, a study exploring the perceived influence of menstrual phase on marathon performance in recreational runners reported that 57% and 43% of runners experienced their best performance during the luteal phase and follicular phase of the menstrual cycle, respectively (Greenhall et al., 2021). Findings from the latter study, indeed, demonstrate subjective insights that may have been influenced by an array of additional factors, including but not limited to, the physical environment, race course, and physical and/or

psychosocial status of the runner on race day and therefore these results should be approached with caution. Nonetheless, it is evidence to suggest that some athletes *do* perceive a difference in their athletic abilities across the cycle. In addition, the existing social science research on this topic has employed quantitative methods to investigate the various symptoms experienced throughout the menstrual cycle and the consequences certain symptoms may have on training and/or performance. A 2017 study surveyed 430 women to investigate the perceived side effects of hormonal contraceptive (HC) use and the menstrual cycle in elite athletes, revealing 77.4% of non-HC users experienced negative menstrual cycle side effects, most commonly reporting stomach cramps, back pain and headaches/migraines (Martin et al., 2017). This has been further substantiated by recent research which outlines stomach cramps/abdominal pain as the most common negative symptom experienced during the menstrual cycle (Brown et al., 2021; Findlay et al., 2020). Physical symptoms such as bloating, lower back pain, reduced energy levels, gastrointestinal changes, heavy bleeding, breast pain/tenderness, and general discomfort in addition to psychological symptoms such as reduced motivation, negative mood states, anxiety and feelings of agitation, worry, or distraction have also been commonly reported among women athletes (Armour et al., 2020; Bruinvels et al., 2021; Findlay et al., 2020; Solli et al., 2020). Symptoms were reported to be most prevalent during the few days prior to and the onset of bleeding, with the greatest psychological symptoms occurring in the week before menstruation and most physical symptoms occurring immediately before or at the beginning of menstruation (Brown et al., 2021; Findlay et al., 2020). In addition to understanding the frequency and type of menstrual cycle symptom experienced by women athletes, recent research has suggested that a tool to capture the severity of menstrual symptoms would be of value (Bruinvels et al., 2021). Evaluating the severity of menstrual symptoms may enhance understandings of how women

perceive the menstrual cycle to impact their training. It is apparent that the array of physical and psychological symptoms stated to accompany the menstrual cycle are not trivial and if an athlete were experiencing symptoms of greater severity, this might be especially disruptive to performance. Thus, it would reasonable to expect changes such as a reduced desire to train or a higher perceived exertion during training as a result.

Not surprisingly, within existing literature many women have reported feeling as though their menstrual cycle has an impact on their performance. Solli et al. (2020) surveyed 140 endurance athletes competing in cross-country skiing or biathlon and found that 49% of athletes reported reduced performance and 71% of athletes reported reduced physical fitness, defined as perceived training quality, during specific phases of the menstrual cycle. Specifically, the surveyed athletes claimed to experience their worst fitness (47%) and worst performance (30%) during menstruation; however, their best fitness (.24%) and performance (18%) were reported during phase 2, following the cessation of bleeding (Solli et al., 2020). Another study conducted by Armour et al. (2020) surveyed 124 athletes competing in either individual or team sport, ranging from recreational to international competition levels, with training volume varying anywhere from 1-3 hours/week up to those training more than 20 hours/week. Across this diverse population, 50% of athletes felt their training was negatively influenced by their menstrual cycle, yet very few athletes reported altering their training as a result (Armour et al., 2020). Similarly, interviews with elite female rugby players revealed that although over two thirds of athletes perceived their training to be negatively impacted by their menstrual cycle, athletes did not abstain from training as a result (Findlay et al., 2020). Increased attention to this topic over the last few years has contributed to existing knowledge on this topic by providing insight to how female athletes feel throughout their menstrual cycle as well as self-reported

perceptions of how they experience training and/or performance in competition. Yet, similar to the existing quantitative research, methodological concerns limit the practical applications that be drawn from these study findings. For example, heterogenous study populations can impact the ability for research findings to effectively inform practice. Clearly, each athlete is as an individual with a unique menstrual cycle and training experience which makes achieving complete homogeneity across participants unreasonable. However, recent study populations have included participants of varying hormonal status with athletes using different hormonal contraceptives (i.e., oral contraceptive pill, implant, intrauterine device, vaginal ring) and others not currently using hormonal contraceptives (Brown et al., 2021; Findlay et al., 2020; Solli et al., 2020). Additionally, the sport populations in recent studies have been extensive: one study included land-based sports, water-based sports, individual and team sport (Armour et al., 2020); another weightlifting, climbing, athletics, judo, and gymnastics (Brown et al., 2021); and one included running, swimming, cycling, dance, gym classes, racket sports, cross training, martial arts, and team sports (Bruinvels et al., 2021). While the range of sport types indeed capture a diverse population of female athletes, this diversity fails to account for the different physiological and mechanical needs of each sport as well as the training demands of different sports and competitive levels. Given the physiological effects of the endogenous hormones it is likely that the performance of each sport, with its own physiological and mechanical needs, will be uniquely enhanced or impaired at different times of the menstrual cycle. Meanwhile, female athletes using hormonal contraceptives will likely have a dissimilar experience due to the lack of endogenous hormone fluctuations. The training demands of a particular sport and competitive level of the athlete may further cause variations across individuals. Menstrual cycle disturbances such as luteal phase defects have been reported to be as high as 79% in exercising women (De

Souza, 2003); while this was assumed to be associated with strenuous or high volume training, evidence suggests such perturbations occur in moderately trained and recreational athletes as well (De Souza et al., 1998). Additionally, exercise training that reduces body fat content, especially among sports where leanness is emphasized, can reduce the peripheral production of estrogen, thus causing disruptions to menstrual function (Dawson & Reilly, 2009). Furthermore, certain menstrual symptoms may be more detrimental to training and performance in some sports. For example, gastrointestinal changes may be exceptionally bothersome for athletes involved in high-impact sport and heavy bleeding may be a significant concern for athletes required to wear certain uniforms. Evidently, there are a number of factors to consider when determining a study population and some may be more relevant than others depending on the aim of the study, but the absence of these considerations in recent research causes confusion for how to draw practical applications.

Some findings should be considered from the research highlighted above. First, an array of physical and psychological symptoms impact women throughout the menstrual cycle, most often experienced in the few days prior and beginning days of menstruation. Second, despite many women perceiving their training to be negatively impacted by their menstrual cycle, few appear to make alterations to their training as a result. There are currently no studies that explore ongoing responses to training measured on a daily basis, most studies either perform experimental testing at a given time within the cycle or ask for experiential insights acquired reflectively via questionnaire or interview. Additionally, few, if any, studies have included mixed-method approaches to measure both subjective, experiential data alongside objective, physiological responses to training. Addressing this gap in the research with a study which takes

into account the methodological considerations in this area stands to offer valuable knowledge to the current body of literature.

2.4 Menstruation: Experiences and Attitudes

Given that an objective of the present study was to explore how female endurance athletes perceive their menstrual cycle to impact their athletic training, an informed understanding of the experiences and attitudes towards menstruation among girls and women was necessary. Recent qualitative research exploring both positive and negative experiences with menstruation revealed profoundly negative associations with menstruation despite prompts to share positive experiences, indicating that women may lack a "schema for imagining menstruation in positive ways" (Fahs, 2020, p. 10). Likewise, dominant discourses that consider menstruation as negative, shameful, embarrassing, unhygienic, and something to keep hidden have been reiterated across research exploring experiences with menstruation (Beausang & Razor, 2000; Burrows & Johnson, 2005; Jackson & Falmagne, 2013). Within recent research, adolescent girls ages 12 to 16 years described menstruation as kept "secret by society at large" (Secor-Turner et al., 2022, p. 5). Similarly, Jackson and Falmagne (2013) found that during qualitative interviews, young women between the ages of 18 to 21 intentionally concealed and hid menstruation as they described secretive disposal of menstrual hygiene products and adopted evasive language when discussing menstruation. Among adolescent girls and young women involved in physical activity, concerns associated with menstruation and sport are centred around fears of leaking or visible bleeding, feelings of discomfort/experiencing menstrual symptoms that may impair performance, and fears of disappointing their coach or teammates if performance is hindered (Harvey et al., 2020; Moreno-Black & Vallianatos, 2005; Secor-Turner et al., 2022).

Although some did feel these concerns created a barrier to physical activity, other young women athletes found physical activity offered a relief and distraction from menstrual related symptoms and led to improved mood states (Harvey et al., 2020). In a study that explored the lived experiences of menstruation among women adventure racers, the author found that most women did not perceive menstruation to inhibit their opportunities at sporting success (Dykzeul, 2016). Although the adventure racers interviewed for this study did not feel that menstruation obstructed their enjoyment of sport or served as justification to evade sport participation, they continued to construct menstruation as something to conceal (Dykzeul, 2016). Further, none of the athletes described their experiences of menstruation as pleasant but rather as an annoyance and a process that must be "endured as part of the requirement of having a female body" (Dykzeul, 2016, p. 47). Elite female swimmers have similarly expressed menstruation as something to overcome, particularly when striving to maintain intense athletic training while experiencing physical discomfort or having to tolerate symptoms such as cramping or heaviness during a competition (Caballero-Guzmán & Lafaurie-Villamil, 2020). Menstruation as something to endure presents a common theme throughout the literature, a theme that aligns with previously highlighted findings from social scientific quantitative research. Even when menstrual symptoms cause distress, discomfort, and pain, women perceive the experience as "part and parcel" (Santer et al., 2008, p. 285) being female and "a necessary inconvenience that women must accept" (Jackson, 2018, p. 154). As a result, girls and women may feel obliged to suffer through the discomfort of their symptoms by adopting a "grin and bear it" philosophy (Costos et al., 2002). When discussing the menstrual cycle and sport, women adventure racers spoke about menstruation as if it was an illness or injury, describing menstrual pain as something "to deal with or get through" (p. 39) and concealing tampons within first-aid kits (Dykzeul, 2016). As a

means to shift this perception, Fahs (2020) suggested referring to menstruation as a "vital sign" – a reframing that may allow women to consider menstruation under a new lens, not merely as a painful inconvenience but as a healthy and positive part of life as well.

Despite many negative perceptions, there are also women who experience positive physical and psychological changes before and during menstruation. For instance, one study conducted focus groups across a sample of 47 women and some expressed positive changes such as increased energy, feelings of elation, well-being, and excitement during the pre-menstruation phase (King & Ussher, 2012). Further, many declared pre-menstruation as a source of motivation and a time for engaging in self-care (King & Ussher, 2012). Similar positive changes have been stated among athletes, who claim menstruation as helpful to their performance since they perceived to swim faster if they competed while menstruating (Caballero-Guzmán & Lafaurie-Villamil, 2020). Additionally, some women athletes adopted an accepting attitude toward menstruation. Women who experienced a natural menstrual cycle, particularly, felt that hormonal fluctuations may facilitate a more embodied experience, increased awareness of their body, and greater willingness to discuss menstruation (Dykzeul, 2016).

An interesting aspect of the reviewed research is that all of the studies focused their inquiry on menstruation, specifically. Yet, hormonal fluctuations and possible changes in emotional and physical experiences may occur at other phases, aside from merely during menstruation, of the cycle. In my study, therefore, I asked women about their experiences *throughout* the cycle. Ultimately, the highlighted qualitative studies exemplify how the experience and perceptions of menstruation vary across girls and women, despite many shared concerns and grievances. As illustrated, women appear to be divided, experiencing menstruation as either predominantly positive or negative. In addition, some women used emotional language

and others only practical terminology when speaking about menstruation (Fahs, 2020). In one study, where young women described their perceptions and attitudes of menstruation, the researchers uncovered a tension between subjective experience and objective phenomenon as women referenced menstruation using terms such as “natural” or “mechanistic” (Newton & Hoggart, 2015). These various experiences, perceptions and dialogue related to menstruation reveal the individualistic and contextual nature of the menstrual cycle. As Burrows and Johnson (2005) suggested, the “splitting of experience into positive and negative aspects inevitably simplifies a multiplex phenomenon” (p. 242). Thus, it is imperative to acknowledge the complexity of how women may experience and perceive menstruation. While some attitudes expressed may appear dichotomous, ultimately the menstrual cycle is both a biological and cultural occurrence whereby the scientific interpretations of menstruation coexist alongside the social and cultural interpretations (Kissling, 1996). Further, it is important to note that some women may find it difficult to imagine menstruation as a positive experience, an attitude likely constructed by the aforementioned dominant discourses.

Regardless of individual attitudes toward menstruation, one common and important view to acknowledge among women is the insufficient communication and ongoing discomfort to openly discuss menstruation (Jackson & Falmagne, 2013; Secor-Turner et al., 2022). This is particularly notable as it emphasizes the lasting stigma which conveys menstruation as a shameful experience that must be hidden. In sport populations, especially those at greater risk of developing menstrual dysfunction, this is a serious problem because an unwillingness to discuss menstrual cycle concerns may lead to a lack of appropriate and expedient support. As such, greater efforts should be made to normalize open discussion about menstruation to help reduce the communication taboo (Kissling, 1996). Within the context of sport environments, Moreno-

Black and Vallianatos (2005) have stressed the need for more insight about how women experience menstruation in order to help establish open dialogue and conversation about the menstrual cycle and athletics among coaches, sport scientists, and athletes. A logical starting point to introduce this discussion would be to incorporate women's experiences of menstruation into traditional, physiological methods of monitoring training, thereby reconsidering the menstrual cycle as a 'vital sign' of athlete health in naturally menstruating female athletes.

2.5 Quantifying Training Load and Monitoring Athlete Training

Over the years sport scientists have worked to determine physiological measurements that facilitate greater understandings of sport performance and help inform coaching practice. However, the scientific anchors which form the basis for understanding have changed as knowledge has progressed and although laboratory measures have been successful factors in determining and defining success in sport, scientists have struggled to offer a "single measure that will [tell] the coach what is really important" (Foster, 2019, p. 141). Foster (2019) suggested the real value of sport science lies in understanding the training response, as opposed to specific physiological parameters. A need to better understand the training response while concurrently managing fatigue has consequently generated more interest in monitoring athlete training loads to determine if an athlete is adapting positively or negatively to the cumulative stress imposed by training and competition (Thorpe et al., 2017). This task presents sport scientists with the challenge of prudently monitoring and managing, simultaneously, the training load and recovery of an individual athlete to "optimize their performance capacity and avoid deleterious outcomes such as underperformance, injury, or illness" (Saw et al., 2017, p. 127). Training load is comprised of the external and internal loads which are imposed upon the athlete through training. External load is defined as the physical work completed by the athlete, independent of internal

characteristics (i.e., what was done in training), and is helpful in understanding an athlete's capabilities (Foster et al., 2017; Halson, 2014; Impellizzeri et al., 2019; Thorpe et al., 2017). Standard markers of external load are often specific to the sport for which training is being prescribed. For the sport of running, external load could be measured by pace (minutes/km) or distance (kilometers) run. Although training is often prescribed using external load markers, the training response should not be quantified using exclusively external load since these measures do not quantify the stress experienced by an athlete thereby failing to account for how an athlete feels (Napier et al., 2020; Paquette et al., 2020). Internal load represents the psychophysiological response resulting from the execution of external training factors (i.e., acute response to training) and is essential for determining both the stress imposed by training as well as the subsequent adaptation (Foster et al., 2017; Halson, 2014; Impellizzeri et al., 2019; Thorpe et al., 2017). Standard internal load markers include measures such as rating of perceived exertion (RPE), heart rate (HR) during exercise, and blood lactate concentrations (Halson, 2014). Further, external and internal load measures can be merged to determine the training impulse (TRIMP), a principle to quantify daily training which fundamentally progressed how training is monitored (Banister et al., 1999; Foster et al., 2017). Banister and colleagues first developed the idea of training impulse, a score expressed in arbitrary units that is calculated by multiplying the duration and intensity of exercise (heart rate response) to demonstrate gains in both fitness and fatigue from a particular training session (Banister et al., 1999; Foster et al., 2017). Another method to determine training impulse was subsequently developed using rating of perceived exertion (RPE). The original RPE scale (Borg, 1970) uses fifteen grades from 6-20 to rate the intensity of physical work, with ratings anchored using verbal expressions ranging from 'very, very light' to 'very, very hard'. Borg (1982) then modified this scale and developed a category

scale with ratio properties using a simple number range of 0-10 and easily understood anchors ranging from ‘nothing at all’ to ‘very, very strong’. Both versions of the perceived exertion scale are valuable, however, Borg noted the original ratio scale is best for applied studies, such as exercise testing, whereas the modified category ratio scale is more suitable for determining direct levels of intensity as well as other subjective symptoms, such as breathing or pain (Borg, 1982; Borg, 1990). Foster and colleagues (2001) later modified the category ratio scale to develop the session RPE (sRPE) scale; verbal anchors were adjusted, ranging from ‘rest’ to ‘maximal’ to reflect American English. The 0-10 sRPE scale was developed as a simple method to determine exercise training intensity within the TRIMP concept, where the assigned sRPE rating “represents a single global rating of intensity for the entire training session” (Foster et al., 2001, p. 111). Numerous studies have identified sRPE as a way to quantify exercise intensity that is simple to understand and use, is applicable across various activity modes and populations, and does not require technical equipment or an anchoring maximal exercise test (Foster et al., 2021; Foster et al., 2001; Napier et al., 2020; Wallace et al., 2014). To determine training impulse using sRPE, the exercise score for a given session is calculated by multiplying the duration of exercise by the assigned sRPE value (Foster et al., 2001). Considering the simplicity and breadth of applicability of sRPE, the latter method is arguably a more useful approach to determine training impulse.

By monitoring athlete training, sport scientists are able to better understand the training response and concurrently assess athlete health which in itself is a critical determinant of sport performance. Especially among endurance athletes who often train independently, it is critical that comprehensive individual data is collected to optimize training and good overall health of the athlete (Roos, 2013). In addition to evaluating training response and quantifying training

load, as outlined above, a complete approach to monitoring athlete training should include physiological indicators of recovery as well as subjective self-report measures that offer insight to physical and psychological status. Athlete recovery is often evaluated using heart rate measures such as resting heart rate (resting HR) or heart rate variability (HRV) but there exist methodological inconsistencies in HRV assessment and therefore, supine or seated resting HR is currently viewed as a best practice for monitoring the autonomic nervous system status of an athlete (Schneider et al., 2018). Generally, a lower resting HR indicates increased parasympathetic nervous system activity while a higher resting HR is indicative of increased sympathetic nervous system activity. Lower resting HR is a prominent indicator of cardiovascular adaptation to endurance training (Smith, 2003) and therefore lower resting HR values will typically be observed among well-trained athletes (Schneider et al., 2018). Further, when consistent and long-term monitoring of resting HR upon wakening is used, meaningful shifts in an athlete's fatigue status may be determined (Buchheit, 2014). Additionally, subjective self-report measures should be incorporated into the monitoring process. Questionnaires and athlete diaries have been cited as simple and inexpensive tools which allow sport scientists and/or coaches to obtain subjective information to supplement physiological measures of training response (Halson, 2014). Commonly used subjective self-report measures include the Profile of Mood States (POMS), the Recovery-Stress Questionnaire (REST-Q) and the Daily Analysis of Life Demands for Athletes questionnaire (DALDA) which have all been "widely investigated and appear to be useful for athlete monitoring" (Saw et al., 2016, p. 4). Some research suggests that self-report measures might display heightened sensitivity to acute and chronic training loads than common objective measures (Thorpe et al., 2017) while other evidence states self-reported measures may be less reliable and sensitive due to greater error from the athlete and their

environment (Saw et al., 2017). Despite their utility, if questionnaires are especially lengthy and are administered frequently the risk of poor compliancy and questionnaire fatigue is likely, therefore, personal comments collected through training diaries might offer the most important and genuine subjective insight (Halson, 2014; Roos, 2013). Alternately, Foster et al. (2001) have suggested that systematically checking in by asking an athlete "How do you feel?" may be a simple but effective way to monitor the training response. Thus, in lieu of periodically having an athlete complete a lengthy questionnaire, including an open-ended 'How do you feel?' comment box within a training log offers ample space for an athlete to comment on their overall physical and psychosocial status on a daily basis. Subjective body feel is another useful measure which asks the athlete to rate the local feeling in the muscles from 'light' to 'heavy' and consequently aids in monitoring the degree of recovery and effect of training load, as well as facilitates communication between the coach and/or sport scientist and the athlete (Gustafsson et al., 2008). Ultimately, effective monitoring should incorporate a training log that collects measures of external and internal load from which training load can be quantified, assesses recovery using resting HR, and asks for self-report subjective insight from the athlete in a pragmatic method, administered daily.

2.6 Evaluating Training Stress in Female Athletes

Although a comprehensive approach to monitoring training may be outlined above, concerns specific to female athletes, such as menstrual health, are absent from much of the literature which guides principles for monitoring athlete training. Consistently tracking the menstrual cycle and associated symptoms alongside athletic training within a daily log is a useful strategy that should be encouraged among all female athletes and may facilitate a greater understanding of the training response in this population. Further, athletic training in women,

particularly in sports demanding high training loads, and insufficient energy intake to support training can have adverse effects on menstrual health in both young and matured female athletes (Dawson & Reilly, 2009; Mountjoy et al., 2018). For example, delayed onset of menstruation in young athletes is referred to as primary amenorrhea whereas matured athletes with established "regular" cycles can experience menstrual dysfunction such as a shortened luteal phase, prolonged menstrual cycles known as oligomenorrhea, and in severe cases may experience cessation of menstrual cycle, known as secondary amenorrhea (Castanier et al., 2021; Dawson & Reilly, 2009). The prevalence of amenorrhea in the general population is low (2-5%) but this increases in female athletes among whom the highest prevalence of amenorrhea has been reported to be up to 70% (Castanier et al., 2021). Often, the greatest risk presents in sports such as long-distance running, dancing and gymnastics where thin body types have been idealized and fat mass may be very low (Castanier et al., 2021; De Souza, 2003). Other menstrual irregularities such as luteal phase deficiency has been reported as high as 79% in exercising women (De Souza, 2003). Among recreational runners accumulating approximately 32 km/week in mileage, the prevalence and incidence of luteal phase deficiency and anovulatory cycles was observed at 48% and 79%, respectively (De Souza et al., 1998). Yet, there is currently no evidence to inform whether the daily internal training load of an athlete is impacted by menstrual cycle phase or by menstrual symptoms (Cristina-Souza et al., 2019). Not only does this indicate a significant gap in the research attempting to understand the menstrual cycle in the context of sport performance and athlete health but also illustrates where existing research related to monitoring and evaluating training response has failed thus far.

Additionally, although measuring rating of perceived exertion for a given session provides helpful information about the effort an athlete felt they exerted during the training bout,

this value does not provide any insight about the affective experience of an athlete. Hardy and Rejeski (1989) emphasized that while RPE effectively represents "sensations related to the stress and strain of physical work, [it] might not accurately reflect the affect a person feels during exercise" (p. 305). To elucidate, it is possible for two individuals to provide identical ratings of perceived exertion by both rating a training bout as 'hard' while each having different feelings about the level of exertion (Hardy & Rejeski, 1989). Further, when considering affective responses to exercise within the general public, it is no surprise that enjoyable exercise sessions lead to improved exercise adherence (Osorio, 2020). Although a stronger commitment to exercise adherence is likely present among athletes, affective responses to exercise such as enjoyment and satisfaction may still be important for facilitating future exercise motivation and inspiring successful subsequent training bouts. Thus, asking athletes to rate how satisfied they feel about a given training session may present useful feedback about the affective and psychological response to training. Borrowing from Borg's category ratio (CR) scale (Borg, 1990), a session satisfaction scale can be created using numbers from 0-10 whereby 0 implies the athlete is extremely unsatisfied and 10 implies the athlete is extremely satisfied with their training session. Further, a subsequent follow-up question asking the athlete to rate their motivation toward future training sessions, again using a simple 0-10 CR scale, can be posed. Implementation of such scales can help to capture crucial insight regarding the affective response to exercise and how this response contributes to emotions about future sessions.

Recommendations for sport scientists to adopt a holistic approach to athlete monitoring – that is, acknowledge multiple sources of stressors imposed upon an athlete through physiological, psychological and social sources – have been ongoing (Kennedy et al., 2020; Smith, 2003). However, there remains a lack of attentiveness to the concomitant physiological, psychosocial

and social effects of, and impact on, the menstrual cycle in combination with endurance training. This indicates a clear disregard for what a holistic approach to monitoring actually means in female athletes. I believe this oversight may most effectively be addressed by designing and executing research studies that are, indeed, holistic. Therefore, this research aims to redefine how the training response is evaluated in female endurance athletes by exploring how women's physiological responses and their individual experiences of their menstrual cycle are entangled, thus demanding a more comprehensive approach to monitoring female athletes which has yet to be outlined in sport science literature.

Chapter 3: Methods

3.1 New Materialism and Biocultural Entanglement

The present inquiry was guided by a new materialist approach, in particular, the concept of biocultural entanglement (Frost, 2014; Thorpe, Brice, et al., 2020; Thorpe, Clark, et al., 2021), to facilitate an innovative exploration into how women endurance athletes perceive training efforts throughout their menstrual cycle. The menstrual cycle, in the sporting context, is an intriguing illustration of biocultural entanglement as "the biological functioning and menstrual status of the body shapes and impacts upon [sport] performance" in addition to the cultural ideas of menstruation as a shameful, 'taboo' discussion topic (Thorpe, Brice, et al., 2020, p. 136). As previously outlined, the menstrual cycle influences physiological functioning and inflicts menstrual symptoms which can impact how a woman responds to training. Furthermore, women's participation in sport, including distance running, has been fraught with "hegemonic notions of femininity, ideas about women's frailty, and notions of what constitutes an appropriate female running body" (Chase, 2016, p. 73). Certainly, the menstrual cycle and female reproductive capacities have, in part, shaped such perceptions. Women's participation in distance running has increased over many decades. This has served to challenge and disprove these dominant ideas and perceptions about the female body and its physical capacities (Chase, 2016). Yet, it is possible that these perceptions continue to impact women athletes today as "norms do not exist outside of the body, [rather], the biological body lives these norms – absorbing and responding to them" (Thorpe, Brice, et al., 2020, p. 133). Engaging with new materialism allowed me to examine how the menstrual cycle, women athletes' views about it and endurance training are entangled. They are "mutually articulated forces" (Smith & Monforte, 2020, p. 5) that concomitantly cultivate the ways that women athletes perceive, and respond to

their biological bodies as well as their physiological and psychosocial experiences in sport. New materialist scholars Thorpe and colleagues (2020) argued for including both physiological and human perception to holistically understand phenomena under investigation. For my study, this means understanding the menstrual cycle not only as a biological process, but also as an act of athletic training, women's personal experiences, and the broader sport culture that shapes these experiences. From this perspective, the act of training is an effect of human physiology, psychology, overall well-being and lifestyle.

Researchers should consider approaching the topic of menstruation in a way that recognizes the continuous interplay between psychosocial and physical body experiences (King & Ussher, 2012). In my study, I focused on comparing the physiological, bodily responses and the women's experiences to better understand the specific interplay between the two. Consequently, new materialism proved appropriate for this study as it offers new ways of conducting research, with a central tenet being the rejection of the distinct boundaries which confine the individual lived experience and natural worlds (Thorpe, Brice, et al., 2020). Further, new materialism offers an opportunity to creatively work across disciplines, crafting a dialogue amid scholars from social and physical sciences (Thorpe, Clark, et al., 2020). Similarly, from a quantitative perspective, new materialism injects innovation into the "sport science apparatus [which] has remained highly westernized and patriarchal, thus limiting other ways of knowing sporting, moving, and performing bodies" (Thorpe, Brice, et al., 2020, p. 165). From a qualitative research perspective, Markula (2019) suggested the aim of new materialist work is "to include the material into the social analysis of the world" (p. 4). According to Thorpe and colleagues (2020), "the biological dimensions of women's bodily and embodied experiences" (p.120) are often ignored or overlooked in social science research on sport, thus, limiting the

ability to "develop more complex and nuanced understanding" (p.120) of such experiences. Within the scientific domain, insufficient integration of social dimensions – that is, the lived experiences and perceived understandings – in understanding the menstrual cycle has similarly limited our efforts to establish complex and nuanced comprehension of female physiology. Ultimately, new materialism as an approach to athlete health research offers a novel way to generate holistic insights while challenging the traditional scholarly practices within disciplines.

New materialist scholars are increasingly "reimagining the body as biocultural entanglement" (Thorpe, Brice, et al., 2020, p. 141) and thereby generating new opportunities to comprehend women's sporting bodies within the intersection of social and biological ways of knowing (Thorpe, Brice, et al., 2020). Recently, sport scholars have called for the adoption of biocultural approaches for investigating low-energy availability (LEA) in sportswomen, stating that although interest in this field of study continues to grow, scientific research remains focused on physiological aspects of LEA, "neatly separating the biological from the social and/or psychological dimensions of women's embodied experiences" (Thorpe, Brice, et al., 2021, p. 3). Likewise, research exploring the menstrual cycle and sport performance in women athletes is neatly separated by discipline – focused either on the various physiological aspects (i.e., training adaptations, performance benefits and/or limitations) of training through the menstrual cycle or on the embodied and lived experience of the menstrual cycle for women athletes. For endurance athletes, the substantial physiological demands of training can impact hormonal function, at times hindering or supporting menstrual function, yet concurrently an athlete's menstrual status and biological functioning impact performance, including both the ability to train and the perception of how training feels (Thorpe, Brice, et al., 2020). Thus, it is apparent that as we truly consider the intersection of biological and individual aspects of menstruation and sport

performance, “it becomes impossible to demarcate the biological from the cultural” (Thorpe, Brice, et al., 2020, p. 136). Although respective academic disciplines (i.e., physiology, social science) are necessary for furthering scholarship in this important area of study, exclusively conducting research under the binaries of objective/subjective and experimental/experiential fails to accurately acknowledge the biocultural entanglement of this topic. In this way, using a new materialist approach to investigate the perception of training alongside physiological measures of internal training load enabled a rich exploration into the phenomenon of how female endurance athletes experience training stress throughout the menstrual cycle.

3.2 Methodological Considerations for Menstrual Cycle Research

The existing body of research in this area is rapidly growing. However, a thorough understanding of this topic remains limited due to inconsistent research design, inadequate menstrual cycle phase verification, and heterogeneity in study populations (i.e., eumenorrheic women, HC user, post-menopausal), sport types, and training levels, which yield low quality research and conflicting findings (Elliott-Sale et al., 2021; Janse de Jonge et al., 2019; McNulty et al., 2020). Therefore, an understanding of the important methodological considerations for conducting research around the menstrual cycle is essential. One particular consideration for research in this area is the nomenclature around the phases of the menstrual cycle. Simply put, the menstrual cycle is divided into three phases: follicular (begins at the onset of menses), ovulation, and luteal (post ovulation to next menses). However, studies in this area are inconsistent, naming anywhere from two to seven menstrual cycle phases, which creates confusion and limits the ability to draw conclusions across studies (Elliott-Sale et al., 2021). The current consensus by Elliott-Sale et al. (2021) identifies four phases of hormonal profiles within

the menstrual cycle where significant changes in estrogen and progesterone occur (see Appendix A). For the present study, these four phases are used when describing the menstrual cycle phases.

Further, verification of menstrual cycle phase is another area where inconsistencies occur and thus generate lower quality research. Methods of verification include serum analysis of hormonal levels using blood samples; hormone testing using saliva; phase confirmation using urinary ovulation detection tests; measurement of basal body temperature; and calendar-based counting (Janse de Jonge et al., 2019; McNulty et al., 2020; Pitchers & Elliot-Sale, 2019). Despite the various methods available, measuring estrogen and progesterone to verify specific hormonal phases via blood sample is the most effective method to confirm menstrual cycle phase – without blood analysis, precise hormonal status remains unclear (Janse de Jonge et al., 2019; McNulty et al., 2020). However, this method may not be available to all researchers as it can be costly and requires certain expertise as well as access to laboratory equipment. Urinary ovulation testing allows for an efficient and non-invasive verification option that participants can perform independently at home by testing their urine with an ovulation predictor kit to identify the surge of luteinizing hormone (LH) in urine, typically ovulation occurs within 14-26 hours of this urinary LH surge (Janse de Jonge et al., 2019; O'Donnell et al., 2022). Basal body temperature is impacted by the hyperthermal influence of progesterone and is easily and widely tested for research purposes by measuring body temperature immediately upon waking with a sensitive thermometer (scale of 0.05°C) (Janse de Jonge et al., 2019). It should be noted that it is possible for basal body temperature to be impacted by factors such as stress, sleep, medication or illness, therefore, it is an insufficient method in isolation (Janse de Jonge et al., 2019; McNulty et al., 2020). In the absence of blood sampling, the present study adopted a combined verification strategy using calendar-based counting, with urinary ovulation detection kits to confirm

ovulatory phase further supplemented by daily measurement of basal body temperature to indirectly establish hormonal status. This combination of verification strategies is currently considered the silver tier for methodological control (Smith et al., 2022).

3.3 Sample Size Calculation

$n/group=(2\sigma^2)/ [(\mu\_2-\mu\_1)^2]* f(\alpha,\beta)$

The above formula can be used to calculate sample size where σ is the standard deviation of the comparison group, μ_1 and μ_2 are the means of the comparison and intervention groups, respectively, and f is the f-value.

For α=0.05 and β=0.2, f=7.9.

For Heart Rate (Early Follicular to Late Follicular) Oosthuyse, 2005 $= \frac{(2 \times 11^2)}{[(160\text{-}164 \text{ bpm})^2] * 7.9}$ $= \frac{242}{126.4}$ = 1.9 per group	Peak Power Comp Cyclists Vaiksaar, 2011 $= \frac{(2 \times 41.8^2)}{[(261.3 - 256.1)^2] * 7.9}$ $= \frac{3{,}494.48}{213.6}$ = 16.4 per group	Perceived Muscle Soreness (Early Follicular to Late Follicular) Romero-Parra et al., (2021) $= \frac{(2 \times 16^2)}{[(27 - 30)^2] * 7.9}$ $= \frac{512}{71.1}$ = 7.2 per group

Based on the above sample size estimate where the range of participants could be as little as 2 and as much as 17, I proposed recruiting at least 10 individuals. A sample of 10 participants would likely provide sufficient effect size for this study, given that heart rate (AM resting) and perceived body feel were two of the main outcome measures, where both measures were hypothesized to be highest during Phase 4 and lowest during Phase 2 of the menstrual cycle. In addition to perceived body feel, participants were asked to report on other perceptual measures as part of the study protocol, including rating of a training session using perceived exertion (sRPE), perceived satisfaction, and perceived motivation. Therefore, including a sample size

estimate based on perception is of value. Furthermore, it was difficult to ascertain a proposed sample size for this research approach, which was dependent on the type of data being generated and the analysis required. I expected to encounter challenges with participant recruitment due to limitations imposed by the inclusion and exclusion criteria, outlined in the following sections. As well, the amount of data generated between the athlete monitoring stage and interviews is extensive, and thus I believed a sample size of 10 participants would be manageable, whereby data saturation could be reasonably achieved.

3.4 Recruitment and Inclusion/Exclusion Criteria

Initially, I sought out to recruit eumenorrheic female athletes between the ages of 18-40 years who were currently engaged in competitive (i.e., actively participate in consistent training for a specific event) endurance sport, specifically long-distance running (i.e., distances of 5km or greater). The criteria used to define a regular menstrual cycle was a cycle between $\geq$ 21 days and $\leq$ 35 days**,** resulting in 9 or more consecutive periods per year and ovulation was verified with evidence of LH surge (Elliott-Sale et al., 2021; Dawson & Reilly, 2009). Women with menstrual irregularities, either self-reported or diagnosed, were excluded from participating in the study to ensure as much homogeneity of hormonal profiles as possible. In addition, any women currently using a form of hormonal contraceptive (HC) were excluded from the study and participants were required to have stopped using hormonal contraceptive for a minimum 3 months prior to study recruitment to allow for re-establishment of a natural cycle. Further, women were excluded if they were $\leq$ 12 months postpartum, breastfeeding or peri-menopausal.

Recent research has reported that nearly half (47.1%) of elite athletes take hormonal contraceptives (Larsen et al., 2020). Therefore, it was reasonable to assume that recruiting naturally cycling women who were not actively using any form of hormonal contraceptive may

present a challenge – this was not the case. Rather, following approval from the Review Ethics Board at the University of Alberta (see Appendix B for approval letter), participant recruitment began with a social media post shared from my personal Instagram/Facebook account. Within 48 hours of posting the recruitment materials, 119 women had reached out to express interest in participating. To confirm their eligibility status, I administered a study eligibility form (Appendix C), including questions to determine eligibility based on the above outlined inclusion/exclusion criteria, to each individual wanting to participate. Of the initial 118 individuals who had expressed interest to participate, 42% (n = 49) were deemed ineligible for not meeting the study inclusion criteria, 8% (n = 9) did not complete the eligibility form, and 50% (n = 60) were considered eligible for the study. To account for this response to recruitment, an amendment was made to increase the initial sample size from 10 to 20 participants. This increase in sample size would also allow for drop-out to ensure a well powered sample size.

After the ethics amendment was approved an invitation to participate in the study, including the Information and Consent Form (see Appendix D) outlining all study details, was sent to the eligible individuals in chronological order (i.e., participants who completed the eligibility form first received invitations first). Each participant was allowed one week to review the Information and Consent Form and, then, indicate if they wanted to participate in the study or not. If I did not receive a response after a week, I sent a follow-up email and allowed an additional 3 days to respond. I planned to stop contacting the individual if no response was received after this time but that was not necessary because all the women I contacted responded within the outlined timelines. Out of the total 60 women who were eligible to participate, I contacted 28 women with invitations to participate. Women were contacted in chronological order, meaning these 28 women completed the study eligibility form first and therefore, were the

first to receive an invitation to participate in the study. Six women declined due to travel or work commitments that would inhibit their ability to complete the survey on a daily basis. Two were interested in participating but were excluded because they no longer fit the inclusion criteria due to a) absent menstruation after completing the eligibility form and b) continued fertility treatment. The remaining twenty women that I contacted agreed to participate in my study. Once this sample of twenty women was achieved, I stopped contacting women with invitations to participate.

3.4.1 Identifying Menstrual Cycle Irregularities

Whilst I aimed to recruit eumenorrheic female athletes to participate in my study, I recognized that without blood serum analysis of hormonal levels, participants were not able to be accurately classified as eumenorrheic (Smith et al., 2022). Further, my study protocol revealed cycle variability and disturbances of menstrual bleeding among my sample. The main characteristics of menstrual cycle regularity include cycle frequency, heaviness of flow and duration of flow – all of which can display variability and perturbations of the eumenorrheic menstrual cycle are referred to as menstrual irregularities (Elliott-Sale et al., 2021; Fraser et al., 2011). Among athletes and active women, menstrual cycle irregularities have been suggested to exist along a continuum ranging from luteal phase deficiency and anovulation (least visible) to oligomenorrhea and amenorrhea (most visible) (De Souza, 2003; Prior, 2022). The severity of physiological disruption classifies amenorrhea as most severe, followed by oligomenorrhea, then anovulatory cycles and finally cycles of normal length with shortened luteal phases (Prior, 2022).

For the purpose of this thesis, I will briefly define each irregularity: absent menstrual bleeding (amenorrhea), infrequent menstrual bleeding (oligomenorrhea), anovulation and luteal phase deficiency. Amenorrhea can be further defined as: a) primary amenorrhea which is the

failure to reach menarche by age 15 in adolescent girls; or b) secondary amenorrhea which occurs in mature women with previously established regular cycles and involves a cessation of menstrual bleeding for a 90-day duration as a result of complete follicular and luteal suppression (De Souza, 2003; Fraser et al., 2011; Prior, 2022). Oligomenorrhea refers to infrequent menstrual bleeding where only one or two periods are experienced within a 90-day period (Fraser et al., 2011). Anovulation is defined by no egg release and no corpus luteum, therefore, progesterone levels are low in these cycles, while estradiol levels remain near-normal (Prior, 2022). Anovulatory cycles are concerning because "silent ovulatory disturbances within normal cycle lengths are common and not clinically obvious" (Prior, 2022, p. 7). Luteal phase deficiency (LPD) is clinically defined as an inadequate luteal phase (< 10 days) whereby inadequate production of progesterone results in insufficient transformation and consequential poor quality of the endometrium, unable to support implantation (Fraser et al., 2011). The ovarian system in women with LPD remains sufficient enough to ovulate and, among athletes with LPD, there is no suppression of mean estradiol in the luteal phase (Fraser et al., 2011). Notably, compared to non-active women, LPD occurs at a much higher prevalence and has been cited as the most common menstrual cycle irregularity in exercising women (De Souza, 2003). Furthermore, research by De Souza et al. (1998) revealed that among 24 recreationally active women, running approximately 32 km per week, almost half (46%) experienced inconsistent menstrual cycles where intermittent presentations of ovulation, LPD and anovulation occurred. As such, it is perhaps not unexpected to have uncovered some disturbances to cycle regularity within my sample. To specify, one participant (P4) engaged in the athlete monitoring stage of the study (described in Chapter 3, Section 3.5.2) between February 8 to April 30, 2022 (82 days). During this time, she only once experienced minor menstrual bleeding which she described as: "a twinge

of blood… but it went away later in the day". Further, this participant was unable to confirm ovulation throughout her 82 days of monitoring. Despite these disruptions, she stated that her menstrual related symptoms remained consistent with what she normally experienced. Based on these findings, I encouraged her to seek medical guidance where she was diagnosed with low iron and low energy availability. Additionally, as revealed through the athlete monitoring stage, two participants (P9 & P17) each experienced one long cycle (> 35 days) where P9 had cycle lengths of 27, 36, and 23 days and P17 had cycle lengths of 25, 38, and 28 days. Although current methodological guidelines define the typical eumenorrheic cycle as 21 to 35 days in length (Elliott-Sale et al., 2021; Smith et al., 2022), variability does exist where a normal menstrual cycle can range from 20 to 45 days (Lebrun et al., 2020). Per this information and the above definitions of oligomenorrhea, it is difficult to accurately define whether or not a cycle perturbation in fact occurred in these participants. These two participants were each able to confirm ovulation. Furthermore, without access to blood serum analysis of progesterone, I cannot determine if luteal phase deficiency occurred among either of these participants (De Souza, 2003). As such, to ensure accurate and transparent classification of my participants, I defined my quantitative sample, with the exclusion of P4, as naturally menstruating with confirmed ovulation. My qualitative sample, which included P4, was defined as naturally menstruating with confirmed ovulation, and, one participant who experienced irregular, anovulatory cycles.

3.5 Data Collection and Analysis

The following sections outline the respective data collection strategies for the quantitative (Sections 3.5.1 & 3.5.2) and qualitative (Sections 3.5.3 & 3.5.4) stages of this study.

3.5.1 Quantitative Methods: Intake Questionnaire and Background Information

Prior to beginning data collection, study participants first completed an intake questionnaire to gain insight about menstrual cycle and sport history for each athlete. This provided context about their individual training and menstrual health history for the subsequent monitoring phase (see Appendix E for the intake questionnaire).

3.5.2 Quantitative Methods: Athlete Monitoring Stage

Each athlete began the athlete monitoring stage of the study at the same time point in their own cycle (Day 1) and were monitored for three consecutive menstrual cycles. The athlete monitoring stage occurred between February 7, 2022 and June 14, 2022 and a total of 1267 responses were collected. All participants were provided an instructions sheet (Appendix F), providing detailed directions and guidance for the monitoring stage. Urinary ovulation test strips provided by OVRY, Corduroy Enterprises (Revelstoke, Canada) and Vinca Lite basal body thermometers by Femometer (Princeton, USA) were delivered, by post or local-drop off, for each participant to use throughout the monitoring stage. The athlete monitoring stage consisted of tracking cycle and training data across the three consecutive cycles as per current expert recommendations (Elliott-Sale et al., 2021). This approach also allowed for pattern identification between menstrual cycles, where "regular" menstrual cycle can extend up to 35 or in some, even 45 days (Elliott-Sale et al., 2021; Lebrun et al., 2020). The daily training/menstrual cycle questionnaire was developed in Survey Monkey, a proprietary research grade online questionnaire software owned by Momentive (San Mateo, California). The questionnaire was sent directly, via a custom web-based link, to each participant's personal email address every evening at 8PM local time (or at an alternate time, upon request). The daily training/menstrual cycle questionnaire downloaded from Survey Monkey can be found in Appendix G.

Participants were asked to provide physiological, menstrual cycle, and self-reported perceptual information each day as part of the athlete monitoring survey. Physiological measures included supine resting heart rate (HR) and basal body temperature (BBT) as well as exercise-related physiological measures including: type of training completed (i.e., rest, aerobic, long slow distance, aerobic power, anaerobic power, anaerobic capacity, race, muscular strength); duration of training session(s) in minutes; and rating of perceived exertion (sRPE) for each training session(s). Participants were allotted space to report on up to two training sessions per day. Further, participants were asked to self-report the following perceptual measures including: a) their overall satisfaction (SAT) with the training bout that day, b) how motivated (MOT) they felt about their next training session, and c) their overall muscle feel (MF) that day, all of which were reported on a CR-scale of 0-10. The minimum of 0 on each scale represented Extremely Unsatisfied, Extremely Unmotivated and Extremely Light while the maximum of 10 on each scale represented Extremely Satisfied, Extremely Motivated, and Extremely Heavy. Further detail regarding sRPE, TTS, and each self-reported perceptual scale are provided in Appendix H. Finally, an open-ended question asking, "How do you feel today?" was posed to offer an opportunity for the participant to provide additional subjective comments.

In addition to the above physiological measures, participants were asked to self-report their menstrual cycle day and to identify any menstrual cycle symptoms they were experiencing that day. A list of 21 symptoms was provided and included the following: fatigue, weakness, tender breasts, increased body temperature, increased breathing, feeling stressed, poor concentration, stomach cramps, muscle aches, nausea, irritability, heavy legs, headache, disturbed sleep, diarrhea, constipation, food cravings, bloating, lower back pain, anxiousness, reduced motivation. The option to select 'Other' and identify any additional symptoms not listed

was also available. This list of symptoms was established based on current literature around menstrual cycle symptomatology, as well as symptoms provided in Fitr Woman, Orreco (Galway, Ireland) and Garmin Connect (Lenexa, USA), apps that track both fitness and the menstrual cycle. Fitr Woman lists 20 possible menstrual related symptoms for users to select from, I included 18 of these symptoms, excluding 'illness' and 'injury'. Instead, participants were instructed to note any illness/injury in the open-ended comment box of the survey. Garmin Connect lists 13 physical symptoms related to the menstrual cycle. I included 12 of these 13 symptoms, excluding 'acne' because, to my knowledge, this would not impact the response to, or perception of, exercise training. In addition, I included 'reduced motivation' and 'anxiousness' since, according to my literature review, female athletes frequently cited these symptoms.

Detailed instructions for the method and measurement protocol of each physiological measure were provided to study participants in their instructions guide (see Appendix F). Resting HR was taken every morning upon waking while lying in supine position. Participants were encouraged to record their heart rate manually, however recording using a heart chest strap or reading the optical heart rate provided by a sport watch (e.g., Garmin, Suunto, Coros), if worn overnight, was permitted. BBT was recorded (to 2 decimal places) each morning immediately upon waking, before getting out of bed, using a digital sublingual thermometer provided for participants. Ovulation can be predicted using a urinary ovulation detection test which identifies the presence of luteinizing hormone (LH) in urine. Study participants were provided with OVRY Ovulation Test Strips (Revelstoke, Canada) for the purpose of this study and encouraged to follow the test strip instructions, beginning ovulation testing approximately mid-cycle and continuing to test until a positive result was recorded.

3.5.3 Qualitative Methods: Interviews

Following the athlete monitoring stage, further data were collected using qualitative semi-structured interviews. Within qualitative inquiry, interviews are used purposefully to engage in conversation, inviting participants to share their unique perspectives, experiences and feelings (Smith & Sparkes, 2016). These interviews offered the opportunity to comprehensively discuss how participants perceive their menstrual cycle to impact their training (i.e., certain types of training, certain times of their cycle, specific symptoms that disrupt training), their experience with cycle tracking, and the menstrual cycle as a conversation (i.e., discussed with coach, friends, teammates). A total of ten interviews were completed, five of which were individual interviews and five were group interviews including 2-3 participants per group (mean duration 87 mins).

3.5.4 Qualitative Methods: Interview Guide and Interview Structure

Semi-structured interviews use a pre-determined interview guide to direct the conversation, asking open-ended questions that will invite rich descriptions and offer ample opportunity for the individual to share their experiential insight (Smith & Caddick, 2012). Initially, an interview guide was developed based on the literature review (see Appendix I). However, towards the end of the athlete monitoring stage, I determined a revision was necessary. A revised version of the interview guide (Appendix I) was, then, informed by open-ended comments from participants, collected from the prior athlete monitoring stage. In each of the surveys administered daily during the monitoring stage, participants responded to an open-ended question, “How are you feeling today?”. After approximately 11 weeks of athlete monitoring (Feb 7 to Apr 18, 2022), I retrieved a total of 882 responses (576 answered and 306 skipped) from the “How are you feeling today?” question for analysis. Some participants left comments related to COVID-19 (i.e., if they had tested for COVID-19 or what day of isolation they were

on) or provided brief, sometimes one-word answers about their overall feeling that day (i.e., "feeling decent overall" or "great"). These comments were still categorized into themes (*COVID-19 related* and *miscellaneous)* but were not used to inform the interview guide.

Through qualitative thematic analysis of the open-ended responses to the survey, five themes were developed: a) *menstrual cycle comments/symptoms*, b) *body (physical sensations)*, c) *mind (emotional sensations)*, d) *fatigue*, and e) *external life stressors*. A summary of these themes, including examples of responses from participants, is provided in Table 1. These themes then formed the interview guide, as well as an additional theme of questions pertaining to the athlete monitoring and cycle tracking experience generally.

Table 1. Theme development from the open-ended survey responses in the athlete monitoring stage.

Theme	Example Responses
Menstrual Cycle Specific (Comments/Symptoms)	Started this morning not wanting to run – tired, bloated, heavy – but the workout was amazing and felt better during and after.
	I feel tired and "heavy" today. My lower back hurts during this time of my period and it makes me want to not do anything. My mood is also very up and down today, I feel a little extra stressed.
	Pretty good, only back pain and cramps but mood wise OK.
	Stomach bloating has reduced significantly today which made me feel leaner, faster, and more confident running.
Body (Physical Sensations)	My run today was amazing, Strong and super enjoyable.
	DOMS in legs from long run day before but good recovery session.
	Some fatigue in legs during workout, residual from weight lifting.
	Muscles feel light and I'm in a good mood but have reduced energy levels. Hard to get out the door to run today but the run was solid and I hit the goal. Went better than I thought it would.
Mind (Emotional Sensations)	Generally, well. More anxious and restless today, but had a long sleep despite waking up multiple times so I felt generally well rested. Workout went well and I had normal energy levels despite lower energy levels throughout the day.
	Feeling good! Mentally was tough to get out the door. Was feeling tired. But rewarded with a solid effort today.
	Frustrated with myself. Didn't sleep enough, didn't eat enough or at the right time and consequently had a run where I just tried not to throw up and a strength session where I just tried not to cry, and then I ate cookies and worked until 11pm and didn't break the cycle for tomorrow.
	Today felt great! Felt mentally strong and focused for the workout and overall good headspace mentally today.
Fatigue	Feeling pretty tired after very basic activities.
	Quite fatigued. Didn't feel like I could swim as fast as normal and felt lethargic.

	Exhausted, but not at my breaking point yet. Tough to get into the run after a big day yesterday, but felt better as it went on and finished feeling shockingly fresh considering how much I have done in the last couple days.
	Very “blah” day and couldn’t put anything together to work out, and body was not feeling it today.
External Life Stressors	Life stress ugh. Body is ok. Pushed run way too late, cold and dark and blah.
	Tired, stressed out and worn out from work— but well-recovered from my race? Body feels shockingly good in terms of not being sore, and working out today felt good, but mentally I am totally burnt out.
	I'm having a busy week at work with a long commute, which is affecting the quality of my running. I'm getting the miles in but they feel harder than usual.
	Okay physically, but had to stay late at work and couldn't do my workout.

Furthermore, I decided to modify the structure of the interviews, offering participants the opportunity to engage in either an individual one-on-one interview, or a group interview (2-3 participants per group). Group interviews, I felt, might facilitate deeper conversations as discussion is stimulated by interactions among participants (Smith & Sparkes, 2016). Although conversations around the menstrual cycle can be sensitive for some, I wanted to create a safe and supportive environment that allowed for open communication among women with shared experiences as female distance runners. After the athlete monitoring stage, the qualitative interviews were conducted as soon as possible, ideally within one month, to allow participants to reflect on the process wherein significant attention had been given to both training and the menstrual cycle. On average, interviews were conducted 18.5 days after completion of the athlete monitoring stage (minimum 5 days, maximum 49 days). The longest delay in interview scheduling occurred with one individual interview because of conflicting schedule demands. Out of the sixteen participants, five completed individual interviews; one participant requested an individual interview, stating she felt more comfortable in a one-on-one setting, and the other four engaged in individual interviews due to scheduling or based on when they finished the athlete monitoring stage (i.e., finished much sooner or much later than others). Five group interviews were conducted, all consisting of two participants per group, despite attempts to establish larger

interview groups. All interviews were conducted virtually using Zoom and were audio and video recorded through the Zoom platform.

3.6 Data Analysis

3.6.1 Quantitative Analysis

Statistical Analysis

Statistical analyses were completed on the physiological (heart rate, basal body temperature and total training stress) and self-reported perceptual (satisfaction, motivation and muscle feel) measures. Total training stress for each day, expressed in arbitrary units, was quantified post hoc by multiplying the total duration of each training session in minutes by perceived rating of exertion (sRPE) for a given session. Statistical analyses of all survey data were completed using IBM SPSS (Statistical Package for the Social Science, version Mac OS 29.0.0.0). Repeated measures ANOVAs were used to determine differences in physiological responses and self-reported perceptions to training across 8 time points of the menstrual cycle (see Table 2). Statistical significance was set at p-value ≤ 0.05. Two participants were excluded from this analysis due to a) identification of a menstrual cycle irregularity in P4, as established in Section 3.4.1 and b) an incomplete data set in P12.

Cycle Phase Verification & Data Organization

Current consensus by Elliott-Sale et al. (2021) identifies four phases of hormonal profiles within the menstrual cycle (MC) where significant changes in estrogen and progesterone occur. For the present study, this criterion was used to establish the four distinct MC phases: early follicular, late follicular, ovulation, and late luteal. However, I deduced it would be important to understand the physiological measures and MC related symptoms change between the phases as well, thus identifying a total of eight MC time points. See Table 2 for a breakdown of time points

and the corresponding MC phase and phase verification strategy, where applicable. Verification of menstrual cycle phase is critical to confirm participants are within the appropriate hormonal stage and include serum analysis of hormonal levels using blood samples; hormone testing using saliva; phase confirmation using urinary ovulation detection tests; measurement of basal body temperature; and calendar-based counting (Elliott-Sale et al., 2021; Janse de Jonge et al., 2019). Despite various available methods, measuring estrogen and progesterone to verify specific hormonal phases via blood sample is the most effective method to confirm menstrual cycle phase, without blood analysis, precise hormonal status remains unclear (Janse de Jonge et al., 2019; McNulty et al., 2020). Urinary ovulation detection kits confirmed ovulatory phase and further supplemented this strategy with daily measurement of basal body temperature to indirectly establish hormonal status. Additionally, participants to calendar-counted their cycle day as part of the daily questionnaire, where responses were confirmed for accuracy of reported date upon data entry.

Following the completion of the monitoring stage and in preparation for statistical analyses, data were organized into the 8 menstrual cycle time points outlined in Table 2. To determine the menstrual cycle time points, menstruation was identified and divided into T1 (day 1) and T2 (days 2-5); ovulation was then identified using two criteria: positive urinary ovulation test and increase in basal body temperature, recorded as T5. Using the identification of these points, the remaining time points (T3, T4, T6, T7 and T8) were established and corresponding days for each time point were recorded. It is important to note that while menstruation (Day 1-5) is often reported as one singular phase, it has been divided into two separate time points described as 'Early Follicular[1] and 'Early Follicular[2]' to offer a new understanding of how the first day of menstruation may differ from the following days in this phase. This decision was

made because participants in the follow-up qualitative interviews, many participants distinctly referenced Day 1 apart from the remaining bleeding days, thus an exploration of additional time points in the analysis. Data for each participant were reviewed to identify any gaps (i.e., missing days) which were filled using the mean value from the corresponding data points in the alternate cycles. For some participants, gaps in data were not able to be filled appropriately resulting in incomplete data sets and thus that cycle was excluded from analyses. In total, five participants tested positive for COVID-19 during the monitoring stage, these cycles were excluded from analyses understanding that physiological and symptom data may be consequently influenced. These participants were not required to complete an additional cycle's worth of the athlete monitoring stage. Data for each participant were then organized into the time points and the mean of each measure (HR, BBT, TTS, SAT, MOT and MF) for all included cycles was calculated for each participant, for statistical analyses. For symptoms, statistical analyses were completed on 13 out of 21 possible symptoms. Symptoms of 'fatigue', 'bloating', 'disturbed sleep', 'stomach cramps', 'heavy legs' and 'feeling stressed' were selected for analyses because they were the most reported (> 100 responses) symptoms throughout the athlete monitoring phase and were referenced during follow-up qualitative interviews with participants. Additionally, symptoms of 'reduced motivation', 'irritability', 'poor concentration', 'headache', 'anxiousness', 'lower back pain' and 'increased body temperature' were selected for analyses because they were also discussed in the interviews. Similar to the physiological measures, symptoms data were organized into the 8 time points by assigning a value for symptom incidence on a given day, where 1=symptom experienced and 0=symptom not experienced. The mean incidence for each time point, across all included cycle was recorded for each participant, for statistical analyses of menstrual cycle symptoms.

Table 2. Description of menstrual cycle time points including corresponding menstrual cycle phase and verification strategies to confirm phase, where applicable.

Time Point	Menstrual Cycle Phase	Phase Verification
T1	**Phase 1:** Early Follicular[1] (Day 1)	Indicated by onset of bleeding
T2	Early Follicular[2] (Days 2-5)	Indicated by continued bleeding (up to day 5)
T3	Mid Follicular	
T4	**Phase 2:** Late Follicular	Occurs in the 14-26h prior to ovulation
T5	**Phase 3:** Ovulation	Occurs in the 12-36hr after a positive urinary ovulation test
T6	Early Luteal	
T7	**Phase 4:** Mid Luteal	≥ 7 days following positive ovulation test
T8	Late Luteal	

3.6.2 Qualitative Analysis

After each interview was completed, it was immediately transcribed verbatim using an online digital transcription service (i.e., Otter.ai). I, then, reviewed the transcript while listening to the corresponding audio data, to ensure accuracy of the transcript and then re-read it again to thoroughly familiarize myself with the data. These interview data were then analyzed using inductive thematic analysis guided by the six phases of data analysis as recommended by Braun and Clarke (2006). Following initial familiarization with the interview transcripts, data were coded and themes were be developed by assembling codes together to identify patterns and meaning across the data (Braun et al., 2016). This process was completed across data from each interview question and subsequently across each overarching interview. I present the final themes in Chapter 4, Section 4.2.

3.7 Sample

A total of twenty participants were invited to participate in my study, which began with the athlete monitoring stage. Four participants (P1, P11, P13, P16) stopped completing the athlete monitoring survey, which was sent out daily, and therefore their participation was terminated. P1 participated for 18 days non-consecutively throughout her first cycle; P11

participated for 15 days consecutively in her first cycle; P13 completed the surveys daily for her first menstrual cycle and completed 12 days non-consecutively in her second cycle; P16 completed the surveys daily for her first cycle and completed 15 consecutive days of her second cycle. Each participant continued to receive daily email reminders for survey completion but were terminated if 10 consecutive days were incomplete. This resulted in 16 participants, all of whom completed the athlete monitoring stage and the qualitative interviews. However, as mentioned in Section 3.6.1, two participants were excluded from statistical analyses due to the identification of a menstrual cycle irregularity (P4) and an incomplete data set (P12). All sixteen participants who completed the athlete monitoring stage, prior to exclusion for analysis purposes, then engaged in the qualitative interviews. Thus, the samples for the quantitative (n = 14) and qualitative (n = 16) stages of the study differ slightly.

The quantitative sample (n = 14) included naturally menstruating women, all with confirmed ovulation. Within the qualitative sample (n = 16), most participants were naturally menstruating with confirmed ovulation (n = 15), though one experienced irregular anovulatory menstrual cycles (n = 1). Across both samples, women ranged in age from 22 to 40 years where the mean age was 34.6 ± 5.2 years and 35 years ± 4.9 for the quantitative and qualitative samples, respectively. All participants self-identified as distance runners, actively engaging in training for a running competition. Following the participant classification recommendations for sport and exercise research provided by McKay et al. (2022), the majority of participants in both samples (79%, n = 11 for quantitative and 81%, n = 13 for qualitative) self-identified as 'Tier 2: Trained/Development'. In both samples, two women self-identified as 'Tier 1: Recreationally Active' and one self-identified as 'Tier 3: Highly Trained/National'. See Table 3 for details of participant classification framework (McKay et al., 2022). To respect the anonymity of

participants, each individual has been assigned both a pseudonym and participant ID number (i.e., P2, P3). Pseudonyms are used throughout the qualitative interview findings whereas participant ID numbers are provided throughout the quantitative survey findings. Pseudonyms, participant ID numbers and additional demographic information can be found in Chapter 4, Table 4. A detailed breakdown of the recruitment process for my sample, as well as a detailed outline of how many participants were included in both the quantitative and qualitative analyses is provided below (Figure 1).

Figure 1. Flowchart of Recruitment and Participant Involvement.

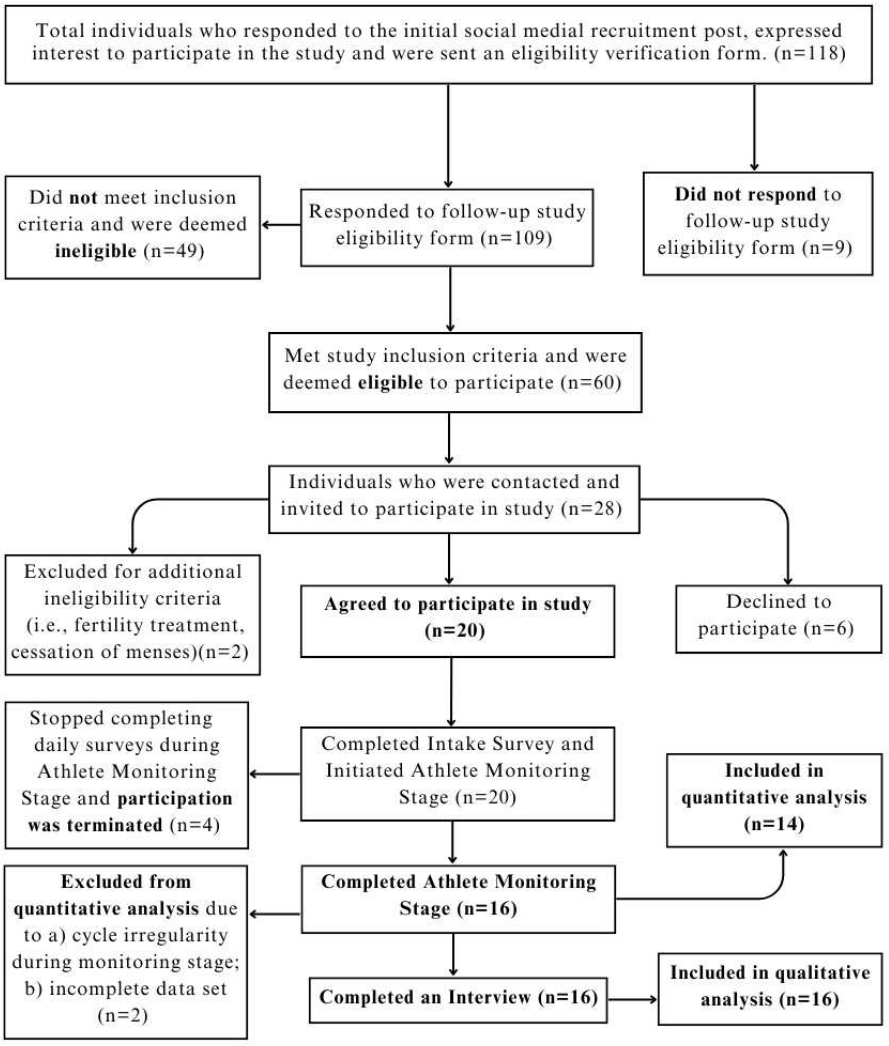

Table 3. Participant Classification Framework, adapted from (McKay et al., 2022)

Tier	Criteria for classification
Tier 5: World Class	• Olympic and/or world medalists. • World-record holders and athletes achieving within 2% of world-record performance and/or world-leading performance. Mean performance standards for females for endurance/long-distance sports: 5000m (min:s) = 14:22.10; 10,000m (min:s) = 29:35.90; Marathon (h:min:s) = 2:22:22
Tier 4: Elite/International Level	• Competing at the international level. • Achievement of within ~7% of world-record performance and/or world-leading performance. Mean performance standards for females for endurance/long-distance sports: 5000m (min:s) = 15:17.10; 10,000m (min:s) = 31:42.60; Marathon (h:min:s) = 2:31:03
Tier 3: Highly Trained/National Level	• Competing at the national level. • Achievement of within ~20% of world-record performance and/or world-leading performance. Mean performance standards for females for endurance/long-distance sports: 5000m (min:s) = 16:38.00; 10,000m (min:s) = 34:23.40; Marathon (h:min:s) = 2:50:41
Tier 2: Trained/Developmental	• Local-level representation. • Regularly training ~3 times per week, within a specific sport and with the purpose to compete.
Tier 1: Recreationally Active	• Individual meets the minimum activity guidelines outlined by the World Health Organization for adults aged 18–64 years old (at least 150 to 300 min moderate-intensity activity or 75–150 min of vigorous-intensity activity a week, plus muscle-strengthening activities 2 or more days a week) • May participate in multiple sports/forms of activity.
Tier 0: Sedentary	• Individual does not meet the minimum activity guidelines outlined by the World Health Organization. • Engage in occasional physical activity (i.e., walking to work, household activities).

The above participant classification framework is adapted and includes information from Table 1 and Table 5 within the following article: McKay, A. K. A., Stellingwerff, T., Smith, E. S., Martin, D. T., Mujika, I., Goosey-Tolfrey, V. L., Sheppard, J., & Burke, L. M. (2022). Defining Training and Performance Caliber: A Participant Classification Framework. *International Journal of Sports Physiology and Performance*, *17*(2), 317-331. Retrieved from: https://doi.org/10.1123/ijspp.2021-0451

Chapter 4: Results

4.1 Quantitative Results

4.1.1 Intake Survey

Data collected from the intake survey provided some basic background information about menstrual cycle history including: self-reported length of menses, overall cycle duration, and commonly experienced menstrual cycle related symptoms. Further, collecting information such as athlete training age, tier classification, and whether the individual was self-guided or coached provided some context about each participant's history with sport and the menstrual cycle. This background information for all sixteen participants, regardless of exclusion from statistical analysis, is outlined in the following discussion and accompanying tables. The age range of participants was 22-40 years (mean age: 35 years ± 4.9) and additional participant demographics can be found in Table 4. The participants indicated experiencing menarche on average at 13 ± 1.3 years of age. Most (n=10, 62%) perceived their menstruation to occur for 3-5 days, while the rest (n=6, 38%) perceived menstruation to last 5-7 days. Cycle length was estimated to be between 26-30 days in 75% of participants (n=12), 3 participants (19%) estimated their cycle length to be between 31-35 days, and one participant (n=1, 6%) indicated she did not know the length of her cycle.

Table 4. Participant demographics including self-reported menstrual cycle information.

Participant ID	Pseudonym	Age	Height (cm)	Weight (kg)	Age of Menarche	Length of Menses (days)	Length of Cycle (days)
P2	Courtney	22	162	45	13	3-5	26-30
P3	Ruth	38	160	58	13	3-5	26-30
P4*	Sophie	36	175	62	12	5-7	26-30
P5	Katherine	37	167	75	13	5-7	31-35
P6	Lisa	34	164	64	13	5-7	31-35
P7	Rebecca	35	171	55	12	3-5	26-30
P8	Amy	32	170	58	13	3-5	26-30

P9	Zoe	33	165	58	13	3-5	26-30
P10	Paula	40	163	55	12	3-5	26-30
P12*	Angela	39	160	54	13	3-5	Unknown
P14	Jessie	26	175	76	12	3-5	26-30
P15	Layla	39	160	52	16	5-7	26-30
P17	Vanessa	39	177	61	15	5-7	31-35
P18	Hannah	35	157	53	11	3-5	26-30
P19	Julia	37	173	63	14	3-5	26-30
P20	Daniella	38	172	63	12	5-7	26-30

*Participants marked with an asterisk indicate those excluded from statistical analysis due to a) menstrual cycle irregularity determined through the monitoring stage or b) providing an incomplete data set.

In addition to basic demographic information and menstrual cycle history, the intake survey asked questions about training history of each athlete and some questions about their experience with the menstrual cycle. Using the performance standards for classification of female athletes in middle-distance and long-distance endurance sport described by McKay et al. (2022), participants were asked to self-identify within a specific athlete tier, summarized as follows: 'Tier 1, Recreationally Active'; 'Tier 2, Trained/Development'; 'Tier 3, Highly Trained/National Level'; 'Tier 4, Elite/International Level'; and 'Tier 5, World Class/Olympic'. Per these criteria, most participants (n=13, 81%) identified as 'Tier 2: Trained/Development, some (n=2, 13%) identified as 'Tier 1, Recreationally Active', and one (n=1, 6%) identified as 'Tier 3: Highly Trained/National Level'. Most participants (n=9, 56%) had been training and competing in endurance sport for more than 5 years and most (n=10, 62%) worked with a coach to guide their training. However, the majority of participants (n=11, 69%) stated they did not discuss their menstrual cycle with their coach, some because they were not currently working with a coach, and others because the coaching was not individual enough, the topic was not initiated by the coach, the athlete did not feel it was important enough to discuss, or they felt equipped to manage it independently. Half of the participants (n=8, 50%) felt they were

'Somewhat Knowledgeable' about general menstrual cycle physiology and most (n=14, 88%) indicated they tracked their menstrual cycle using a smartphone app, with the most cited app being Garmin Connect (n=6, 38%). See Table 5 for further details.

Table 5. Intake survey responses about menstrual cycle awareness and athlete training history

How knowledgeable do you feel about the menstrual cycle?	Number (n = 16)
Not at all knowledgeable	0
Slightly knowledgeable	1
Somewhat knowledgeable	8
Moderately knowledgeable	5
Very knowledgeable	2
How long have you been training as an endurance athlete?	Number (n = 16)
< 1 year	0
1-3 years	2
3-5 years	5
5-10 years	4
10-15 years	2
> 15 years	3
Athlete Tier Classification (Self-Selected)	Number (n = 16)
Tier 0: Sedentary	0
Tier 1: Recreationally Active	2
Tier 2: Trained/Development	13
Tier 3: Highly Trained/National Level	1
Tier 4: Elite/International Level	0
Tier 5: World Class	0
Do you currently work with a coach to guide your training?	Number (n = 16)
Yes	10
No	6
If yes, do you discuss your menstrual cycle with your coach?	Number (n = 16)
Yes, frequently.	1
Yes, occasionally.	4
No.	11
Do you track your menstrual cycle?	Number (n = 16)
Yes	14
No	2

The athlete monitoring stage revealed that on average, participants trained 5.3 days per week±0.8 overall. The minimum average training frequency was 3.4 days per week and the maximum training frequency was 6.6 days per week. This was calculated by determining the frequency of training days for every Monday to Sunday interval within the monitoring data for each participant, using all available weeks for all participants.

4.1.2 Physiological Responses and Self-Reported Perceptions to Training

Statistics, including mean and standard deviation, for each survey measure across the cohort are shown in Table 6. Significant difference was observed in basal body temperature (BBT) across the menstrual cycle ($p = <0.001$). There was no main effect for heart rate (HR), total training stress (TTS), satisfaction (SAT), motivation (MOT) or muscle feel (MF) across menstrual cycle. Post hoc pairwise comparison found significant difference between menstrual cycle time points in heart rate, satisfaction, and muscle feel. For HR, there was a significant difference ($p = 0.035$) between mid-follicular (T3) and ovulatory (T5), where mean HR were 52.3 ± 7.6 and 53.5 ± 8.7 respectively. For SAT, there were significant differences between T1 and T2 (6.8 ± 1.1 and 6.2 ± 0.8, $p = 0.021$), T1 and T6 (6.8 ± 1.1 and 6.1 ± 1.2, $p = 0.014$), and T6 and T7 (6.1 ± 1.2 and 6.7 ± 1.4, $p = 0.039$). For MF, significant differences were seen between ovulation at (T5, 5.3± 1.4) and each of the subsequent luteal phase time points (T6, 4.7 ± 1.3, $p = 0.022$; T7, 4.6 ± 1.5, $p = 0.041$; and T8, 4.6 ± 1.3, $p = 0.036$). The mean menstrual cycle length across the three cycles for each participant can be found in Table 7.

Table 6. Mean ± Standard Deviation for heart rate (HR), basal body temperature (BBT), total training stress (TTS), motivation (MOT), and muscle feel (MF).

MC Time Point	HR	BBT	TTS	SAT	MOT	MF
T1	53.5 ± 7.5	36.4 ± 0.3	257.3 ± 325.2	6.8 ± 1.1* Satisfied	6.4 ± 1.3 Motivated	4.8 ± 1.3 OK
T2	53.0 ± 6.3	36.4 ± 0.2	271.6 ± 127.6	6.2 ± 0.8* Satisfied	6.5 ± 1.1 Motivated	4.6 ± 1.3 OK
T3	52.3 ± 7.6*	36.3 ± 0.2	281.9 ± 125.1	6.6 ± 0.9 Satisfied	6.5 ± 1.1 Motivated	5.2 ± 1.3 OK
T4	53.0 ± 8.6	36.3 ± 0.2	258.4 ± 216.4	6.3 ± 2.3 Satisfied	6.4 ± 1.3 Motivated	4.9 ± 1.6 OK
T5	53.5 ± 8.7*	36.5 ± 0.2	247.0 ± 147.6	6.2 ± 1.2 Satisfied	6.1 ± 1.5 Motivated	5.3 ± 1.4* OK
T6	52.8 ± 8.0	36.5 ± 0.2	264.0 ± 151.2	6.1 ± 1.2* Satisfied	6.4 ± 1.2 Motivated	4.7 ± 1.3* OK
T7	53.0 ± 7.9	36.6 ± 0.2	277.0 ± 219.6	6.7 ± 1.4* Satisfied	6.3 ± 1.2 Motivated	4.6 ± 1.5* OK
T8	52.9 ± 7.9	36.6 ± 0.2	246.2 ± 133.6	6.3 ± 1.2 Satisfied	6.4 ± 1.0 Motivated	4.6 ± 1.3* OK

Table 7. Cycle length (days) of participants across athlete monitoring phase.

Participant	Cycle 1	Cycle 2	Cycle 3	Average Cycle Length
P2	27	29*	25	27
P3	29	31	26*	29
P5	31	32*	29	31
P6	32	29*	35	32
P7	30	27	26	28
P8	24	30	27	27
P9	27	36*	23*	29
P10	25	26	27	26
P12	24	26	21	24
P14	30	25	27	27
P15	28	27	28	28
P17	25	38	29*	31
P18	29	28	27	28
P19	28	26	25	26
P20	28	28	23	26

*Cycles excluded from statistical analyses because the participant contracted COVID-19 during or due to inconsistent tracking resulting in an incomplete data set for a given cycle.

4.1.3 Self-Reported Menstrual Cycle Related Symptoms

Means and standard deviation, for the symptoms which were included in statistical analysis for the cohort, in each phase are shown in Table 8. Significant difference was observed in fatigue across the menstrual cycle ($p = <0.003$) where participant reporting of this symptom indicates greater fatigue in the first day of menstruation (T1) compared to all other time points across the menstrual cycle (T2-T8). A difference was seen for stomach cramps ($p = <0.001$), which participants reported experiencing more in the first day (T1) of menstruation than all other time points across the cycle (T2-T8), and for bloating ($p = <0.002$), which participants reported experiencing more in both day one of menstruation (T1, Early Follicular[1]) compared to most other time points T2-T7; more in T2 compared to T3 and T4; as well as more in the late luteal time (T8) compared to the mid-late follicular phases (T3-T4) and the early and mid-luteal times (T6, T7).

There was no main effect for reports of the following symptoms: increased body temperature, feeling stressed, poor concentration, irritability, heavy legs, headache, disturbed sleep, lower back pain, anxiousness, or reduced motivation across menstrual cycle but post hoc pairwise comparison found significant difference between menstrual cycle time points in all the aforementioned symptoms, except anxiousness. A difference was observed in perceived body temperature where participants reported 'Increased Body Temperature' more in first day of menstruation (T1) compared to the mid-follicular (T3, $p = 0.048$) and ovulatory points (T5, $p = 0.045$) as well as the late luteal point (T8) compared to mid-follicular (T3, $p=0.023$), ovulatory (T5, $p =0.023$) and the mid-luteal (T7, $p = 0.039$) point. Participants reported 'Feeling Stressed' more during the first day of menstruation (T1) compared to ovulation (T5, $p = 0.036$) as well as during the late luteal point (T8) compared to the late follicular point (T4, $p = 0.035$). Participants reported the symptom, 'Poor Concentration' more in the early follicular point (T2) compared to the mid-follicular point (T3, $p = 0.049$), indication poorer concentration in the early follicular time point. A difference was seen in 'Irritability' where reports of feeling irritable were higher in the late luteal time (T8) compared to both the mid-follicular and ovulatory times (T3, $p = 0.032$ and T5, $p = 0.035$, respectively). For 'Heavy Legs', a difference was seen between various time points: first, heavy legs were reported more on the first day of menstruation (T1) compared to the mid-follicular and mid-luteal points (T3, $p = 0.037$ and T7, $p = 0.012$, respectively); and second, heavy legs were reported less in the mid-follicular phase (T3) compared to the early luteal and late luteal time points (T6, $p = 0.031$ and T8, $p = 0.025$, respectively). Similarly, for 'Headache', a difference was observed across many points: first, participants reported experiencing headaches more in the early follicular time (T2) compared to the mid-follicular, late follicular and mid-luteal times (T3, $p = 0.047$; T4, $p = 0.023$; and T7, $p = 0.024$, respectively); second, participants

experienced headaches more in the mid-follicular time (T3) compared to the mid-luteal time (T7, $p = 0.05$); and finally, participants experienced headaches more in the late luteal time (T8) compared to mid-follicular, ovulatory, early luteal and mid-luteal times (T3, $p = 0.044$; T5, $p = 0.037$; T6, $p = 0.02$; and T7, $p = 0.016$, respectively). For perceptions of 'Disturbed Sleep', participants reported disturbed sleep less frequently in the mid-follicular phase (T3) compared to menstruation, early follicular, ovulatory, early luteal and late luteal times (T1, $p = 0.035$; T2, $p = 0.016$; T5, $p = 0.028$; T6, $p = 0.034$; and T8, $p = 0.014$, respectively). Additionally, disturbed sleep was reported less frequently in the late follicular time (T4) compared to the late luteal time (T8, $p = 0.021$). For the symptom of 'Lower Back Pain', participants reported experiencing low back pain more in the early follicular time (T2) compared to late follicular (T4), ovulatory (T5), early luteal (T6) and mid-luteal (T7) times ($p = 0.028$). Finally, a difference was seen in the symptom 'Reduced Motivation' where participants reported this symptom more in the late luteal time (T8) compared to the mid-follicular time (T3, $p = 0.047$). This analysis illustrates how investigation of symptom frequency within distinct menstrual cycle phases, as well as the time points between, provides a more comprehensive understanding of how symptoms are experienced across the menstrual cycle in this cohort. However, this analysis was completed across the group level and menstrual cycle symptom experiences can be different across individuals. To provide further insight to the individual variation, see Table 9 which illustrates the frequency (expressed as percentage) of symptom experienced within each menstrual cycle time point, across all three cycles, in each participant. With this visual representation, it is evident that the symptomatic experience cannot be generalized across a group and further investigation into the individual experiences is needed.

Table 8. Mean ± Standard Deviation for menstrual cycle symptoms.

Symptom	T1	T2	T3	T4	T5	T6	T7	T8	Mean
SYM 1	0.51±0.45[a**]	0.31±0.28	0.13±0.15	0.20±0.25	0.15±0.26	0.22±0.26	0.11±0.18	0.21±0.25	0.23 p=0.003
SYM 4	0.20±0.35[c*]	0.06±0.11	0.00±0.00	0.04±0.13	0.00±0.00	0.02±0.05	0.02±0.09	0.10±0.15[n*]	0.06 p=0.064
SYM 6	0.19±0.30[d*]	0.14±0.25	0.03±0.07	0.20±0.09	0.00±0.00	0.07±0.13	0.06±0.15	0.12±0.22[o*]	0.08 p=0.056
SYM 7	0.12±0.25	0.11±0.19[g*]	0.01±0.05	0.02±0.09	0.05±0.12	0.04±0.12	0.07±0.14	0.10±0.19	0.07 p=0.212
SYM 8	0.76±0.36[a***]	0.21±0.20	0.01±0.02	0.0±0.0	0.05±0.12	0.02±0.05	0.06±0.15	0.17±0.29	0.16 p=<0.001
SYM 11	0.20±0.37	0.05±0.13	0.02±0.04	0.06±0.15	0.02±0.09	0.05±0.11	0.02±0.09	0.14±0.16[p*]	0.07 p=0.139
SYM 12	0.24±0.32[e*]	0.11±0.15	0.05±0.07[k*]	0.12±0.24	0.11±0.22	0.09±0.10	0.05±0.18	0.12±0.13	0.11 p=0.134
SYM 13	0.14±0.25	0.10±0.14[h*]	0.02±0.04[j*]	0.02±0.09	0.02±0.09	0.03±0.06	0.0±0.0	0.09±0.12[q*]	0.05 P=0.051
SYM 14	0.27±0.40	0.15±0.16	0.04±0.08[l*]	0.07±0.19[m*]	0.23±0.32	0.15±0.20	0.14±0.31	0.20±0.22	0.16 p=0.086
SYM 18	0.39±0.34[b*]	0.20±0.29[f*]	0.02±0.04	0.0±0.0	0.12±0.28	0.07±0.10	0.07±0.18	0.28±0.29[s**]	0.14 p=0.002
SYM 19	0.13±0.23	0.07±0.11[i*]	0.02±0.05	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.04±0.13	0.03 p=0.060
SYM 20	0.06±0.15	0.04±0.08	0.0±0.0	0.0±0.0	0.02±0.09	0.02±0.05	0.0±0.0	0.06±0.10	0.02 p=0.239
SYM 21	0.10±0.22	0.09±0.16	0.04±0.08	0.06±0.15	0.04±0.13	0.08±0.12	0.09±0.27	0.12±0.17[r*]	0.08 p=0.611

[*]p<0.05, [**]p<0.003, [***]p<0.001

a= more reported in T1 vs. T2 – T8; b= more reported in T1 vs. T2 – T7; c= more reported in T1 vs. T3 & T5; d= more reported in T1 vs. T5; e= more reported in T1 vs. T3 & T7; f= more reported in T2 vs. T3 & T4;g= more reported in T2 vs. T3; h= more reported in T2 vs. T3, T4 & T7; i= more reported in T2 vs. T4, T5, T6 & T7; j= more reported in T3 vs. T7; k= less reported in T3 vs. T1, T6 & T8; l= more reported in T3 vs. T1, T2, T5, T6 & T8, m= less reported in T4 vs T8; n= more reported in T8 vs. T3, T5 & T7; o= more reported in T8 vs. T4; p= more reported in T8 vs. T3 & T5; q= more reported in T8 vs. T3, T5, T6 & T7; r= more reported in T8 vs. T3; s= more reported in T3, T4, T6 & T7

Table 9. Individual experience of menstrual cycle-related symptoms experienced across eight time points for 3 consecutive menstrual cycles.

Participant	Symptom	T1	T2	T3	T4	T5	T6	T7	T8
P2	SYM 1	100%	50%	38%	0%	0%	50%	50%	18%
	SYM 6	50%	63%	15%	0%	0%	33%	50%	27%
	SYM 21	0%	0%	8%	0%	0%	25%	100%	27%
	SYM 14	100%	13%	15%	0%	0%	25%	0%	0%
	SYM 8	100%	25%	0%	0%	0%	0%	0%	0%
	SYM 19	50%	13%	0%	0%	0%	0%	0%	0%
	SYM 18	50%	0%	0%	0%	0%	0%	0%	0%
	SYM 13	0%	38%	0%	0%	0%	0%	0%	9%
	SYM 4	0%	0%	0%	0%	0%	17%	0%	18%
	SYM 20	0%	25%	0%	0%	0%	0%	0%	9%
	SYM 7	0%	25%	0%	0%	0%	0%	0%	0%
	SYM 11	0%	0%	8%	0%	0%	0%	0%	9%
	SYM 12	0%	13%	0%	0%	0%	0%	0%	0%
P14	SYM 18	100%	92%	0%	0%	33%	6%	0%	27%
	SYM 1	100%	67%	0%	0%	0%	0%	0%	45%
	SYM 11	100%	50%	0%	0%	0%	0%	0%	36%
	SYM 7	67%	58%	0%	0%	0%	0%	0%	45%
	SYM 4	67%	17%	0%	0%	0%	0%	0%	45%
	SYM 8	67%	58%	0%	0%	0%	0%	0%	0%
	SYM 21	33%	50%	0%	0%	0%	0%	0%	36%
	SYM 6	33%	58%	0%	0%	0%	0%	0%	27%
	SYM 12	0%	42%	0%	0%	0%	0%	0%	9%
	SYM 14	0%	33%	0%	0%	0%	0%	0%	9%
	SYM 13	33%	0%	0%	0%	0%	0%	0%	0%
	SYM 19	0%	8%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	8%	0%	0%	0%	0%	0%	0%
P8	SYM 1	100%	75%	43%	67%	67%	67%	33%	88%
	SYM 6	33%	58%	22%	33%	0%	33%	33%	81%
	SYM 12	100%	17%	13%	0%	33%	17%	67%	38%
	SYM 21	67%	33%	22%	33%	0%	28%	33%	56%
	SYM 7	67%	42%	17%	0%	0%	44%	33%	56%
	SYM 14	0%	33%	17%	33%	33%	11%	0%	56%
	SYM 8	67%	25%	4%	0%	33%	0%	33%	0%
	SYM 13	33%	17%	0%	0%	33%	22%	0%	31%
	SYM 4	67%	33%	0%	0%	0%	0%	0%	19%
	SYM 11	0%	8%	13%	33%	0%	11%	33%	0%
	SYM 20	0%	17%	0%	0%	0%	6%	0%	31%
	SYM 19	0%	8%	17%	0%	0%	0%	0%	0%
	SYM 18	0%	0%	0%	0%	0%	0%	0%	0%
P9	SYM 4	100%	25%	0%	0%	0%	0%	0%	13%

	SYM 11	100%	0%	0%	0%	0%	0%	0%	13%
	SYM 18	0%	0%	0%	0%	100%	0%	0%	13%
	SYM 8	100%	0%	0%	0%	0%	0%	0%	0%
	SYM 6	100%	0%	0%	0%	0%	0%	0%	0%
	SYM 14	0%	25%	0%	0%	0%	0%	0%	0%
	SYM 1	0%	0%	0%	0%	0%	0%	0%	25%
	SYM 7	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 12	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 13	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 19	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 21	0%	0%	0%	0%	0%	0%	0%	0%
P6	SYM 8	100%	13%	0%	0%	0%	0%	50%	76%
	SYM 14	50%	13%	0%	0%	50%	42%	0%	47%
	SYM 1	0%	25%	5%	50%	50%	17%	0%	41%
	SYM 18	50%	13%	0%	0%	0%	25%	0%	76%
	SYM 12	50%	0%	5%	50%	0%	17%	0%	29%
	SYM 11	0%	0%	0%	50%	0%	8%	0%	53%
	SYM 4	50%	0%	0%	50%	0%	0%	0%	6%
	SYM 21	0%	0%	0%	50%	0%	17%	0%	12%
	SYM 19	0%	13%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 6	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 7	0%	0%	0%	0%	0%	0%	0%	0%
P7	SYM 14	0%	0%	5%	0%	33%	28%	33%	19%
	SYM 20	33%	0%	0%	0%	33%	11%	0%	24%
	SYM 7	0%	0%	0%	0%	33%	0%	0%	0%
	SYM 6	0%	0%	0%	0%	0%	6%	0%	10%
	SYM 1	0%	0%	0%	0%	0%	11%	0%	0%
	SYM 8	0%	0%	5%	0%	0%	0%	0%	5%
	SYM 11	0%	0%	0%	0%	0%	0%	0%	10%
	SYM 18	0%	0%	0%	0%	0%	0%	0%	10%
	SYM 21	0%	0%	0%	0%	0%	0%	0%	5%
	SYM 19	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 13	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 12	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 4	0%	0%	0%	0%	0%	0%	0%	0%
P18	SYM 13	67%	8%	0%	0%	0%	0%	0%	21%
	SYM 8	67%	8%	0%	0%	0%	0%	0%	11%
	SYM 4	0%	0%	0%	0%	0%	6%	33%	37%
	SYM 18	33%	0%	0%	0%	0%	0%	0%	32%
	SYM 1	0%	0%	0%	0%	0%	0%	33%	5%
	SYM 12	33%	0%	0%	0%	0%	0%	0%	0%
	SYM 11	0%	0%	0%	0%	0%	0%	0%	16%
	SYM 21	0%	0%	0%	0%	0%	0%	0%	5%
	SYM 6	0%	0%	0%	0%	0%	0%	0%	0%

	SYM 7	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 14	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 19	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	0%	0%	0%	0%	0%	0%	0%
P5	SYM 14	100%	38%	25%	0%	100%	58%	100%	42%
	SYM 1	100%	13%	20%	50%	50%	17%	0%	17%
	SYM 8	100%	0%	0%	0%	0%	8%	0%	8%
	SYM 12	0%	0%	15%	50%	0%	25%	0%	8%
	SYM 6	50%	0%	0%	0%	0%	0%	0%	0%
	SYM 20	50%	0%	0%	0%	0%	0%	0%	0%
	SYM 18	0%	0%	10%	0%	0%	0%	0%	33%
	SYM 11	0%	0%	0%	0%	0%	0%	0%	33%
	SYM 7	0%	0%	0%	0%	0%	0%	0%	25%
	SYM 13	0%	0%	5%	0%	0%	0%	0%	0%
	SYM 19	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 21	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 4	0%	0%	0%	0%	0%	0%	0%	0%
P19	SYM 1	67%	42%	20%	33%	0%	6%	0%	23%
	SYM 13	67%	42%	13%	33%	0%	6%	0%	27%
	SYM 7	33%	25%	0%	33%	33%	6%	33%	9%
	SYM 14	67%	42%	0%	0%	0%	6%	0%	36%
	SYM 12	67%	25%	0%	0%	0%	11%	0%	23%
	SYM 8	100%	25%	0%	0%	0%	0%	0%	0%
	SYM 18	33%	17%	0%	0%	33%	6%	0%	14%
	SYM 11	33%	8%	0%	0%	33%	0%	0%	18%
	SYM 19	67%	8%	0%	0%	0%	0%	0%	5%
	SYM 21	0%	25%	0%	0%	0%	0%	0%	27%
	SYM 6	0%	8%	0%	0%	0%	0%	0%	14%
	SYM 4	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	0%	0%	0%	0%	0%	0%	0%
P3	SYM 8	100%	38%	7%	0%	0%	17%	0%	80%
	SYM 18	50%	25%	4%	0%	0%	17%	50%	80%
	SYM 1	0%	0%	19%	0%	0%	17%	0%	0%
	SYM 11	0%	0%	7%	0%	0%	25%	0%	0%
	SYM 12	0%	0%	4%	0%	0%	8%	0%	20%
	SYM 14	0%	0%	0%	0%	0%	0%	0%	20%
	SYM 13	0%	0%	4%	0%	0%	0%	0%	0%
	SYM 4	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 6	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 7	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 19	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 21	0%	0%	0%	0%	0%	0%	0%	0%
P20	SYM 1	100%	25%	0%	0%	0%	0%	0%	6%

	SYM 18	67%	58%	0%	0%	0%	0%	0%	6%
	SYM 8	100%	17%	0%	0%	0%	0%	0%	6%
	SYM 19	33%	0%	0%	0%	0%	0%	0%	0%
	SYM 12	0%	8%	0%	0%	0%	0%	0%	0%
	SYM 13	0%	8%	0%	0%	0%	0%	0%	0%
	SYM 21	0%	8%	0%	0%	0%	0%	0%	0%
	SYM 7	0%	0%	0%	0%	0%	0%	0%	6%
	SYM 4	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 6	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 11	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 14	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	0%	0%	0%	0%	0%	0%	0%
P15	SYM 8	67%	17%	0%	0%	33%	0%	0%	0%
	SYM 1	33%	58%	5%	0%	0%	6%	0%	0%
	SYM 19	33%	42%	5%	0%	0%	0%	0%	0%
	SYM 18	33%	0%	0%	0%	0%	0%	0%	0%
	SYM 4	0%	8%	0%	0%	0%	0%	0%	0%
	SYM 6	0%	8%	0%	0%	0%	0%	0%	0%
	SYM 7	0%	8%	0%	0%	0%	0%	0%	0%
	SYM 11	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 12	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 13	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 14	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 21	0%	0%	0%	0%	0%	0%	0%	0%
P17	SYM 18	100%	63%	13%	0%	0%	33%	50%	75%
	SYM 1	50%	63%	6%	50%	50%	75%	0%	0%
	SYM 8	100%	63%	3%	0%	0%	8%	0%	50%
	SYM 12	50%	38%	3%	0%	50%	25%	0%	25%
	SYM 21	50%	0%	3%	0%	50%	33%	0%	0%
	SYM 19	0%	13%	0%	0%	0%	0%	0%	50%
	SYM 11	50%	0%	0%	0%	0%	0%	0%	0%
	SYM 14	0%	0%	0%	0%	50%	0%	0%	0%
	SYM 13	0%	13%	3%	0%	0%	8%	0%	25%
	SYM 4	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 6	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 7	0%	0%	0%	0%	0%	0%	0%	0%
	SYM 20	0%	0%	0%	0%	0%	0%	0%	0%
P10	SYM 14	67%	17%	0%	67%	67%	39%	67%	53%
	SYM 12	33%	17%	24%	67%	67%	22%	0%	21%
	SYM 1	67%	17%	24%	33%	0%	39%	33%	32%
	SYM 18	33%	17%	0%	0%	0%	6%	0%	32%
	SYM 21	0%	8%	24%	0%	0%	11%	0%	11%
	SYM 7	0%	0%	0%	0%	0%	6%	33%	0%

	SYM 11	0%	0%	0%	0%	0%	33%	0%	5%
	SYM 20	0%	0%	0%	0%	0%	17%	0%	16%
	SYM 13	0%	8%	6%	0%	0%	6%	0%	11%
	SYM 6	0%	0%	0%	0%	0%	22%	0%	5%
	SYM 4	0%	0%	0%	0%	0%	6%	0%	5%
	SYM 8	0%	8%	0%	0%	0%	0%	0%	0%
	SYM 19	0%	0%	0%	0%	0%	0%	0%	0%

*SYM1=Fatigue; SYM4= Increased Body Temperature; SYM6= Feeling Stressed; SYM7= Poor Concentration; SYM8= Stomach Cramps; SYM11= Irritability; SYM12= Heavy Legs; SYM13= Headache; SYM14= Disturbed Sleep; SYM18= Bloating; SYM19= Lower Back Pain; SYM20= Anxiousness; SYM21= Reduced Motivation

Conclusion

Above findings from the athlete monitoring stage revealed cycle phase, and the transitions between, influenced both physiological and perceptual responses to training. As demonstrated through the above analyses, the eight-time point approach provided further insight to athlete training response across the menstrual cycle that would not have otherwise been attained through exclusive analysis of changes across phases. This contributes a new approach to understanding how the menstrual cycle influences athlete status, and illustrates that transitions between phases should be considered when planning training. Differences observed in subjective responses such as satisfaction and muscle feel can help inform how female athletes perceive their training and the physical body experience at various points across the menstrual cycle. Moreover, difference in symptom presentation across the cycle overall, as well as between time points, reinforces that this is an area for further investigation. In particular, research exploring individual symptom experiences might offer valuable information to enhance our understanding of how female athletes experience, and thus respond, to training. The present analysis of daily athlete monitoring data demonstrates that although significant changes may not be observed across established menstrual cycle phases, a more comprehensive investigation between phases can enrich understandings of training response.

4.2 Qualitative Results: Interview Findings

The qualitative interviews facilitated in-depth discussions during which study participants shared their experiences of engaging in endurance training as menstruating women. Through a thematic analysis, four main themes were developed: a) *the body: physical cycle specifics*, b) *the mind: feelings of exercise*, c) *resilience is both a blessing and a curse*, and d) *embracing menstrual cycle as a positive.* I will first discuss the specific physical body responses occurring throughout the menstrual cycle as shared by the participants. I have divided this section into three sub-themes: a) *timing*, b) *symptoms*, and c) *training-related changes*. Next, I will discuss the emotional feelings women shared in regard to exercise, including the impact of menstrual cycle on mood and mental state. I have divided this section into two sub-themes: a) *mood and movement* and b) *learning self-compassion.* I will then discuss the idea of resilience, a feeling (and state of being) explored by participants. This section is divided into two sub-themes: a) *training regardless* and b) *challenges of endurance training*. Finally, I will discuss the importance of the menstrual cycle for female endurance athletes as shared by the participants. I have divided this section into two sub-themes: a) *vital sign: menstruation as an indicator of positive health* and b) *social values: menstruation as positive femininity.* A summary of themes is provided in Table 10, and each theme is described below.

Table 10. Qualitative Interview Themes.

Overarching Theme	**Sub-Theme**
The Body: Physical Menstrual Cycle Specifics	Timing Symptoms Training Related Changes
The Mind: Feelings of Exercise and Menstrual Cycle	Mood and Movement Learning Self-Compassion
Resilience is Both a Blessing and a Curse	Training Regardless Challenges of Endurance Training
Embracing Menstrual Cycle as a Positive	Vital Sign: Menstruation as an Indicator of Positive Health Social Values: Menstruation as Positive Femininity

The Body: Physical Menstrual Cycle Specifics

Purposeful discussion about the menstrual cycle allowed participants to share details about their individual experiences. Many reflected on the physical, bodily variations during their cycle. For instance, participants reflected on when they felt their best or worst throughout the cycle, the most predominant symptoms experienced, and their individual cycle variations. This theme focuses on these specifics and is divided into the following three sub-themes: a) timing, b) symptoms and c) changes.

Sub-Theme: Timing

Many women were able to identify certain times within their cycle when they physically felt best or worst, particularly when considering exercise training and often, in relation to energy levels. Frequently, women described their most distinctive physical and/or emotional responses to occur during definite phases of the cycle, such as menstruation. The bleed phase, when accompanied by painful symptoms or heavy bleeding, meant exercising was more difficult for some. Yet, others cited this phase as a particularly advantageous time for performance. Sophie commented:

> [T]he week of my period, so when I actually bleed, I seem to have my strongest runs … I feel faster, I feel stronger. I feel like I have a ton of energy, more so than I did the week beforehand. So, my bleeding week usually seems to like produce the fastest and strongest runs for me, or at least I feel that way.

This sentiment was echoed by a few other participants who recalled having performed or raced well while menstruating. Moreover, perceptions of performance (i.e., feeling fast, feeling strong) are likely to vary based on the performance demands imposed during a given time in the cycle. As Amy recognized, her effort, and therefore how successful she perceived the workout to be, varied for different training intensities:

> I would notice that, either just before or while I have my period, I would have really good short speed workouts during intervals on the track … but … a 20-minute tempo, that was way harder than it would normally be… specific kinds of workouts were harder.

In addition to how they felt during exercise, participants commented broadly about how they felt during menstruation as well as the subsequent follicular phase. Some women who consistently struggled with substantial pre-menstrual discomfort attributed menses as a time of relief: "once the bleed begins, it's the release and things actually start to feel better" (Vanessa). Similarly, Rebecca described her period and the follicular phase as a time when she feels "more resilient to stress" and better able to "bounce back and rationalize things". Although this was a broad statement about stress, removed from the context of sport performance, there may be relevant applications to training, such as tolerance to training stress and improved recovery.

Meanwhile, others experienced a renewed sense of strength during the follicular phase and into ovulation, as estrogen levels begin to rise again following menses: "estrogen is back… I can take on the entire world" (Zoe). Feeling better during the follicular phase was a common response across the cohort. Many women felt this phase elicited good quality training, improved feelings of confidence, and greater resilience to both fatigue and stress while noticed improved energy levels mid-cycle, around ovulation. In contrast, the luteal phase of the cycle occurring post-ovulation and pre-menstruation appeared to be a time when more participants felt worse, both generally and in regard to training. Some participants commented that all forms of training felt harder during this phase and others referenced specific days, noting "on day 20 of my cycle… running just felt very terrible" (Ruth) and similarly, "I'm a dead ringer for day 18/19" (Paula). However, it is also possible that not all women experience a prominent day like these.

As demonstrated, there were common experiences around timing, in regard to which

hormonal phases of the menstrual cycle elicited noticeable variations in training response as well as overall physical and emotions. The follicular phase, between menstruation and ovulation, proved to be the time of the cycle where most women had similar physical responses, either in their broad comments or specific training-related statements about how they felt. However, each of the other hormonal phases revealed diverse experiences among the participants, effectively illustrating the inter-individual variability that exists.

Sub-Theme: Symptoms

The menstrual cycle and fluctuating levels of estrogen and progesterone are known to yield a variety of symptoms. All of the women interviewed were able to identify their most common symptoms and at what point within the menstrual cycle they typically occurred. Symptoms that were most cited during the interviews were: bloating, lower back pain, fatigue, cramping, heavy legs, mood changes, anxiousness, digestive issues, and sleep disturbances. The combination of symptoms experienced varied across participants. For example, one interviewee described experiencing "the whole gauntlet of crap" (Jessie) with notable symptoms of bloating, cramps, fatigue and digestive issues. Meanwhile, Vanessa shared that while she did not experience much menstrual cramping, she had "tons of lower back pain" and "the fatigue is off the charts". Increased lower back pain, at times, meant additional musculoskeletal considerations to prevent injury, as Layla stated, "I have to do way more pelvic tilts… the hip flexors tend to get tighter". Likewise, other symptoms posed unique challenges or considerations for training. Bloating and digestive issues, particularly constipation, led to feelings of discomfort and reduced confidence while issues like diarrhea presented other concerns. One participant shared that she would often adjust her running routes or avoid running with others to allow for frequent bathroom breaks without inconveniencing others. Moreover, bloating and water retention meant

body weight exercises were more challenging: “weight training, all of a sudden, starts to feel heavier…why do pull ups feel so hard? It’s because you’re about five pounds heavier than you were three days ago, that probably has something to do with it” (Jessie). Symptoms of heavy legs may additionally impact subjective training responses, since higher ratings of perceived exertion might be noted as a result. Lisa described the feeling of heavy legs as:

> You know when you have done too many hills and then you try and go up a hill and your legs feel garbage? That is what my legs feel like when I run in that week-ish leading up [to my period]. They just don't have anything and it feels like I'm moving like cinderblocks.

Sleep disturbances was another frequently experienced symptom for many participants and one that could impair recovery, affect mood, and impact daily life. Several women attributed sleep disturbances to changes in body temperature where the sensation of “roasting” (Jessie) would disrupt sleep, most often occurring around menstruation and ovulation. Others complained that night sweats would cause them to wake in the night, often having to change clothing, bedsheets, or sleeping location. Night sweats were most frequently experienced in the days prior to bleeding. However, some participants noted that night sweats also occurred after heavy training days: “I even find if I have a big training day, I sweat through the night too … it’s not as bad as when I’m about to get my period but I will sweat through the night too” (Zoe). Certainly, good quality rest is essential for adequate recovery from training and thus, recovery is likely to be impaired during times when sleep disruptions are present.

Sub-Theme: Training-Related Changes

Within an individual, healthy and natural menstrual cycles may still vary and can include changes in overall cycle length, changes in period days, or changes in heaviness of bleeding.

When considering the impact of endurance training, participants recognized exercise to have an impact on both the consistency and variability of their cycle. Hannah revealed that consistent training facilitated consistency in symptoms, period heaviness, and cycle days. In other instances, heavy training caused reductions in both the number of days and heaviness of the bleed phase: “this is probably one of the more intense training cycles I’ve been in… my period was both lighter and shorter by the end of it”.

Similarly, other participants noted that heavier training volume or an isolated increase in training load (i.e., multi-day ultramarathon event) shortened the overall length of their cycle. As Ruth stated, “I have no idea why after running that much, my body’s just like, okay, time to get it going again. I thought for sure I’d maybe not get a period or it would be a longer cycle”. This statement, along with others who believed “it would make more sense to train harder…that cycle length would lengthen out” (Rebecca), reveals existing assumptions about the impact that exercise can have on the menstrual cycle. Further, this indicates that women may be unaware of how menstrual cycle perturbations occur in relation to exercise.

Women also shared how their attitudes toward, or experiences with, their menstrual cycle had changed over the course of their lifespan. For some, changes in sport mode during their athlete life, brought differing comfort levels. As Layla shared, “I have been a competitive athlete since the age of eight…I was a swimmer…there’s nothing worse than having your period and being a swimmer” and therefore, felt less discomfort running through menstruation. Others described how childbirth impacted their menstrual cycle, including differences in postpartum and increased volatility in cycle length postpartum. Other women described how advancing age brought about menstrual cycle changes: “I would say that as I’ve gotten older, my periods have been a lot heavier and a lot harder to exercise through…they’re longer and more bleeding and

more cramping" (Daniella). Maturing age also influenced women's attitudes toward the menstrual cycle. As Katherine reflected:

> [A]s I've gotten older, I think I've started to be more, I don't know if accepting is the word I want, but I think I look at it differently…it becomes less of a pain…or a thing you have to endure versus…a pretty important part about being a woman.

Additionally, women's prior experiences with menstruation and hormonal contraceptives can influence individual attitudes with menstrual health. Ruth recalled:

> I remember when I was younger, I would just take my birth control pills constantly so I wouldn't get [a period] which I'm sure was terrible. And after I went off birth control, I … didn't get a period for like a year…you know, when we're young we don't really like think about, or, I didn't think about that.

In addition, oral contraceptive pills can lead to reduced self-awareness and knowledge of individual menstrual health, since these often cause cessation of menstruation or at minimum, alter a woman's natural cycle. As Paula summarized:

> When I was at my peak performance training in my 20s … I completely ignored my period for years, lost it a couple times, was always on the pill… it's only been about four years where I've had a cycle that I've tracked without any pill or contraception… I had no idea that these symptoms even existed.

Evidently, changes in menstrual cycle can occur and produce ample variability both inter and intra-individually. As highlighted, there are multiple factors that may elicit changes to the menstrual cycle both acutely, between cycles, and chronically, over years. It is also important to note that the individual experience and attitude toward menstrual health is not static and can

transform over time with different sport experiences and changes to both the presence and severity of symptoms.

The Mind: Feelings of Exercise and Menstrual Cycle

The previous theme highlighted the participants' feelings regarding the physical and biological impacts of the menstrual cycle on their training. They did, nevertheless, also discuss the connection between psychological state and exercise, the act of movement and sport performance. This theme illustrates the influence that mood and exercise impart upon each other and is divided into two sub-themes: a) mood and movement, and b) learning self-compassion.

Sub-Theme: Mood and Movement

Every participant acknowledged the benefits of exercise and commented that moving (almost) always feels good, physically and mentally. When experiencing physical symptoms related to the menstrual cycle, many women claimed exercise to be helpful. Lisa remarked that painful or uncomfortable physical symptoms would not change with exercise but that "one thing that does improve with movement is my mood…I'm much happier". It is possible that with an improved mood state, the discomfort and pain associated with physical symptoms may be better tolerated. Additionally, Courtney described running as "a good outlet" that offered a means of managing overwhelming circumstances and Paula shared: "a run is salvation…it doesn't need to be some crazy interval workout or tempo or something…get your stuff on and go… that is salvation for me". For some, however, difficult workouts caused feelings of stress or lower self-confidence. Jessie described her mood-related response to training: "especially with PMS, when I get higher anxiety and irritation… I can pick up on myself being more frustrated if a training session doesn't go the way that I wanted it to…the self-talk becomes a lot more negative". Training then compounded the effects on the already present mood-related symptoms that many

experience in the pre-menstrual phase. Mood symptoms were described in various ways as stress, anxiousness, irritability, anger, reduced motivation, and increased sensitivity. Paula described how pre-menstrual changes in mood impacted her self-esteem: "PMS hits me super hard and mood wise … even to the point of, why am I even doing this? I'm not even good … I should quit, I get really low". Similarly, Sophie shared how her mood is impacted in the days before ovulation as well as before menstruation: "I get very emotional…my moods are all over the place. I'm crying all the time. I'm really weepy. I'm really anxious, hypersensitive". Another added that increased body temperature can impair sleep, leading to increased fatigue and higher levels of perceived exertion in training sessions. A lack of sleep then can also affect one's ability to maintain positive mood states. The aforementioned ripple effect of symptoms exemplifies the multifaceted physiological and psychosocial impact of the menstrual cycle.

While mood and exercise can exist separately from one another, more often than not mood impacted training and training impacted mood. Furthermore, participants recognized that occasionally their *emotional feelings* about training would be directly impacted by their *physical feelings* in training. For instance, Hannah noted: "my mental state around my training is driven by how it feels…if it feels good, if the running is easy, and I feel energetic and powerful, then I will feel good about that". The above statements are indicative of the connectedness between mood and movement. Evidently, it may be challenging for some to be distinguish this influence at times, especially when more negative. However, many participants expressed the process of learning to ease off, to give themselves grace, and to exercise self-compassion.

Sub-Theme: Learning Self-Compassion

Many women spoke about how they realized, in different ways, the importance of self-compassion. Especially for endurance athletes, mental strength is commended and often athletes

contemplate the best approach to training and building this factor to performance. Overcoming negative mood-states may be viewed as a specific requirement for perseverance in some events (i.e., marathon, ultra-marathon) but confronting and recognizing the relationship between mood and exercise may be a powerful tool in training and life. This is important, in particular, when experiencing significant menstrual cycle related mood and mindset disruptions including irritability, low self-confidence, reduced motivation, and anger. Moreover, with the profound impact of exercise on mood, higher levels of perceived exertion due to physical menstrual cycle symptoms may further disrupt mood state. Many participants reflected on such circumstances and especially when they occurred during or around menstruation, the distinct shift in hormonal milieu offered, not an excuse but rather, an opportunity:

> I feel like it gives me permission, if I have a bad day to kind of give myself a little bit more grace… I won't necessarily change the workout, but maybe…I'm going to make sure like I take the time to eat better or I will prioritize [self-care] a little bit more. (Amy)

Furthermore, when experiencing times of increased self-talk or negative mindset, Jessie shared a realization that "you can't always trust your own brain" and in these instances, she focused on the pure enjoyment of moving. Rebecca shared how her approach to training has changed over the years as she matured within the sport. Specifically, she spoke of learning to detach from training metrics and self-imposed pressures to train to accept the ebbs and flows that accompany both endurance performance and menstrual cycle experiences. As Rebecca noted:

> There's certainly been [times] over the years where I put a lot of stock in…making sure I can train a certain way…I'm just significantly less bothered by that…It's so challenging to get to a point where you're realizing that relinquishing a little bit of control and giving yourself a little bit of flexibility and subscribing to things like self-compassion. I think we

> see that maybe as like, if we give ourselves a break, we won't perform at the level that we should…in my personal experience, it has been the opposite…I'm running the best that I ever have.

Some women, unfortunately, learned the importance of easing off and practicing self-compassion as a result of adversity such as injury or illness. As Sophie described:

> I was injured …I had to modify a lot and I was pissed … I'm going to be slower, I'm going to lose all my fitness… it was an eye opener that you can go easier on yourself when you're not feeling it and you're tired and nothing's going to change, it's probably going to benefit you.

While not an ideal approach to learning and gaining skills in self-compassion, it was demonstrated in other interview comments that the sentiment, and consequential lesson, was reverberated. Ultimately, the menstrual cycle and its hormonal fluctuations seem to play a role in this relationship between mood, exercise, and the ensuing responses.

Resilience Is Both a Blessing and a Curse

This theme captures the experiences, and challenges, of training for endurance sport as a menstruating female, navigating challenging menstrual cycle symptoms and fatigue while maintaining a commitment to training. Attitudes toward training while menstruating or experiencing menstrual cycle symptoms varied across the cohort as severity varied. I explore these differences through two sub-themes: training regardless of menstruation and training regardless of its time commitments.

Sub-Theme: Training Regardless

For some participants, the influence of the menstrual cycle and consequential approaches towards training and racing was minimal, but for many others, the relationship between

menstrual cycle and training is complex. Some did not want their menstrual cycle to be an excuse not to train. Others reported that tracking cycles provided reassurance that a poor performance did not instantly render someone "a terrible runner today" (Ruth). Amy shared that neither she nor her coach modified her training based on how she responded throughout her menstrual cycle. As a matter of fact, she described her period as an additional reason to challenge herself in training:

> I would give myself grace if the workout wasn't good, but there is no way…I would not let my period be the reason that I didn't do anything, I would…make sure that every minute on my training plan was done, every rep was done. I would be willing to be dead on the side of the track at the end of the workout if it meant that I was still getting shit done… I definitely would…put pressure on myself to…work twice as hard to overcome this extra hurdle [menstruation].

The amplified desire to persevere through training while menstruating was echoed by Paula, who shared her resentment for the impact she perceived menstruation to have on her body:

> I just have totally tuned out as far as letting it have any impact… it just seems so complicated… then I feel weak…why do I need to let my body be in control of me? It's not fair. My mind is in control of me. You know what I mean? I'm, like, resentful of it.

For some participants, menstrual cycle symptoms lasted for an extended time and therefore, exercising through discomfort was considered necessary, and described as mental training that improved perseverance in long distance events. As Lisa explained:

> With the symptoms… they last for so long… if I was to take that into account, every single time, I'd lose a week and a half, sometimes, of training in a month… I actually

> look at it as… mental training…and then that serves you, hopefully, when the horrible proverbial crap hits the fan in the middle of a longer run.

Evidently, building resilience – to benefit performance and daily life – by way of endurance training was a shared sentiment among participants. Angela credited her training as helping to recognize her ability to complete challenging tasks: "[doing] harder things, physically, [helps] tackle the harder things mentally". In this way, pushing to certain physical limits exemplified resilience, thus facilitating a more confident mindset. Likewise, Sophie explained how her commitment to training generated feelings of resilience:

> I feel very resilient because of all the training that I do… if I can push myself to do a half marathon at six in the morning… I'm barely hanging on, and so fatigued… I can get through whatever's thrown at me… the pressure and this desire…it just makes me feel resilient.

The idea of resilience was not always reflected through hard physical output. Indeed, resilience was sometimes demonstrated when an individual chose to rest. This can be further complicated when the participants' energy levels, physical and emotional responses were impacted by hormonal fluctuations. As Courtney articulated:

> [H]ormonal stuff …that either causes…super resilience…like, I just need to train or it's just… also important to acknowledge your emotions, and maybe you won't actually get the most out of training that day, and maybe a day off, even if it's not on the schedule is the actual most important thing for you to do …I think [there are] two different types of resilience…just grinding through or just like trying to be very smart about it.

However, it is important to note that, occasionally, some women would adjust their training if they felt poorly. As Ruth noted: "sometimes I'll switch speed days around, if I'm really not

feeling very good, because I want to get the biggest benefit out of that day and not just go and slog up a hill". Although many participants were determined to adhere to a specific plan, they understood that modifying training to facilitate recovery would consequently yield a greater training stimulus in subsequent training sessions. The negotiation of training in this way demonstrates self-compassion.

Sub-Theme: Challenges of Endurance Training

In addition to demanding athletic training, every participant managed various commitments in their lives including, but not limited to, demanding careers, academics, and parenting or family responsibilities. It is important to acknowledge that each of these responsibilities contributed to an undeniable load, the impact of which may vary across the menstrual cycle. The balance between stress and recovery, a requisite for optimal athlete health, is delicate and difficult to achieve. Therefore, interview conversations also explored how obstacles such as injury and stress, were managed. In regards to injury, many women spoke about recognizing warning signs of injury and actively sought guidance from healthcare professionals. All of the women were attentive to their injury risk and many included training strategies (i.e., running on soft surfaces, strength training, mobility exercises) as prevention. However, complete prevention of injury can be difficult, especially with compounding factors of different training modes and menstrual cycle symptoms, as Jessie highlighted:

> I did have an injury through the [duration of research study] but it was a more acute injury from weightlifting, but…running high mileage at the time…none of these things ever happen in a vacuum. I was already vulnerable in that…but, definitely… when I start hitting those number of kilometers, number of hours training per week, and that can

> sometimes disrupt my sleep and… disruptive sleep from periods…it all definitely sort of compounds. I can feel myself getting that that danger zone, definitely.

Injuries can be trying to navigate, but the process of injury rehabilitation seemed straightforward for most participants.

Similarly, time constraints could be "a source of frustration" (Rebecca). Often a high level of organization and flexibility was required to complete training. Vanessa described having to calculate "the window of time" for her training and emphasized often needing to accept a shorter training session while navigating the "juggling act" of other life demands. For some, overlapping responsibilities were simpler to take on with a flexible work schedule that allowed training to be completed at the best time. When discussing the presence of stress in each participant's life, some recognized that reduced family demands and limited additional stressors allowed them a sense of balance across priorities. Zoe felt that managing stress posed a greater challenge, particularly at certain times of the menstrual cycle:

> I feel like I have lots of hats…I have a mom hat… I have a business owner and salon [owner] hat. And then I have my running… I try to figure out, like where is the stress coming from…and then who can help me…in that external stress…the week before your period, everything seems to be a little bit more emotional and compounds a little bit more. … am I, over-analyzing this? Is this my hormones and emotions playing in on this?

As illustrated, understanding the source of stress and recognizing when (and how) external support was needed, helps to diminish the stressors. Further, heightened self-awareness around when the hormonal changes and consequential emotional response may be amplifying stressors may be helpful for some to react and respond accordingly.

Conversations of stress management often highlighted a value of training, where many women praised exercise as their form of stress relief, with some yearning for hard sessions to release stress. Paula shared:

> My attitude with exercise now, with so many family commitments, is that it's a real privilege. And so, I find, like, if it's hard, it's grittier for me, it's better, I want it to be hard. Give me, give me the most gut inducing workout so that I can just be on my own, and tough it out, and then rinse it all and then come back and…make supper for everybody. So, I can't really differentiate, exercise is always just a good thing for me.

However, trusting training to relieve stress can backfire since external stressors impact the ability to tolerate physical and mental load. Thus, a reduced capacity to withstand load, as a result of stress, would limit the physical capabilities that can be achieved in training. Further, while a method to relieve stress, training may be its own source of stress, if the desired results were not consistently achieved. As Amy shared:

> [E]xercise is a very important way of managing stress for me…something that I've been finding challenging recently is that training hasn't been going spectacularly the last month. And it's been a real struggle for me… I usually rely on to make me feel better… if everything else in life is shit and training is also shit…I don't have balance, right? And so, I think… I … have been able to learn that being resilient is both a blessing and a curse, and I am… trying to figure out how to recognize for myself when building resiliency and being tough is the right answer and when that's actually doing me more harm than good. And I haven't figured it out yet. But I think the fact that I've recognized that there is a distinction, is important.

As emphasized previously, understanding when, and importantly how, resilience is developed is critical. Although the strength to endure through a strenuous training session, challenging menstrual cycle, or other life stressors were present, the ability to recognize when *not to endure them* may be a truer demonstration of strength.

Embracing Menstrual Cycle as a Positive

This final theme illustrates how participants perceived the menstrual cycle. This includes how they found physical health affecting their training as female endurance athletes as well as the social values associated with it.

Sub-Theme: Vital Sign: Menstruation as an Indicator of Positive Health

Although experiences and perceptions of the menstrual cycle varied across participants, all of the women referenced the importance of menstruation for their physical health especially as sportswomen. Women acknowledged the discomfort and challenges caused by the menstrual cycle and its associated symptoms. Some described a feeling of indifference, suggesting the menstrual cycle to be a "natural part of being a female" (Lisa) and "the way our bodies are" (Angela). Yet still, most spoke about periods as a reference point to confirm the body was functioning optimally, especially as athletes. For instance, Vanessa noted: "I always kind of just look to [my period] as an indicator of health, in that, my body is in agreement with the level of training I'm putting in". Participants across the cohort echoed this statement. For example, Katherine stated: "as someone who is really active and does a lot of endurance running, the fact that I have my period is really important". Moreover, Jessie spoke about the attitudes and beliefs about menstruation, or the absence of, that are perpetuated in certain sport cultures: "there's this…dangerous mentality…this old mentality…that losing your period when you're training is totally normal…and you're doing a good job". Hannah reinforced this statement, also

recognizing the role of energy availability, and, identifying a change in beliefs: “in terms of low energy availability…people are starting to realize that [losing your period] …it may be convenient, but that’s not correct”. Similarly, Paula perceived this shift in sport culture: “the pendulum [is] swinging, swinging back to being like, own it and make sure you have it [MC] because…if it goes away, it’s serious trouble”. They also recognized that enhanced knowledge around menstrual health can facilitate a shift in outlook. As Courtney commented:

> [W]hat a shit show of just feeling like trash… but also, it’s a super cool biological thing that happens… if you know more about it, then there’s more opportunity to maybe embrace it as a positive thing, instead of having a negative connotation to it… this is a really good sign that your body is healthy.

Because menstruation was considered a sign of a healthy body, the experience of cycle tracking proved valuable: it offered heightened self-awareness and indicated that the menstrual cycle, and symptoms, were normal and thus, healthy. Some found cycle tracking useful as it helped to establish cycle predictability that diminished its influence. For instance, Vanessa said: “once it’s expected… it’s less of a big deal”. This established feelings of acceptance of menstrual cycle versus being oblivious about it. When tracking symptoms, Amy noted that seeing a list helped her realize that having a menstrual cycle is not an isolated experience and “this is a very legitimate thing that females have to deal with”.

However, the desire to continue monitoring the menstrual cycle varied across participants: some felt keen to continue learning about their menstrual health with continued consistency while others were eager to turn their attention away from it. Many noted that improved knowledge of their menstrual health might not necessarily impact their approach or ways of training, but that listening to their body was essential. Sophie reflected: “our bodies are

very intuitive…they tell us what's missing…they tell us when they need a break… learning to listen to that and make good decisions is the most important thing".

Sub-Theme: Social Values: Menstruation as Positive Femininity

Some women were able to embrace menstruation as a strength citing it as a deeply authentic experience of femininity, as Sophie shared: "I think having a menstrual cycle is an asset… when I get my period, I feel grounded. I feel like a woman and I feel like being a woman makes me feel really strong". Reiterations of feminine strength were frequent and many resented the societal notions that associate menstruation with suffering, shame, and fragility. Layla recognized the remarkable force that women possess, stating "we can have babies … that just shows you how tough women are". This suggested that instead of feeling embarrassed by menstruation, greater ownership over the force of femininity is warranted. Further, Layla acknowledged a genuine respect for the differences in menstrual cycle experiences, while offering the reminder that "[women] don't need to prove anything". This suggestion should be honoured, especially in endurance sport contexts.

While participants improved their attentiveness to and self-awareness of their menstrual health or confirmed their pre-existing knowledge, many commented that their personal discourse of the menstrual cycle had increased throughout their study participation. Participants revealed talking about the menstrual cycle more frequently and openly while participating in the study, and others noted improved comfort levels around menstrual cycle communication, particularly with coaches. As Julia shared: "I definitely would be probably more open than I was before just because now I'm more aware of what's going on". Ultimately, the process of cycle tracking led to enhanced bodily understanding for each participant and improved comfort in communicating about the menstrual cycle and related topics. When reflecting on the value of menstruation,

participants unanimously acknowledged its important role in female athlete health and also a positive aspect of femininity.

In conclusion, the above themes articulate the various experiences of endurance sport training throughout the menstrual cycle and its physical and emotional influence. It is clear that attitudes toward the menstrual cycle and the intra-individual relationship with this process varied greatly across women. Many spoke of challenges, mostly as a result of symptoms experienced as hormones fluctuate throughout the cycle. As a result, some participants struggled to engage in positive dialogue about their menstrual cycle whereas others spoke to how this uniquely female experience can inspire greater self-awareness and self-compassion. Most importantly, the majority of women identified the importance of menstruating and its impact on women athletes' health.

Chapter 5: Discussion

As I established in my literature review, there are currently no general guidelines on exercise performance across the menstrual cycle (MC). Therefore, experts advise that sport practitioners employ an individualized approach based on each athlete's response to exercise training and performance (McNulty et al., 2020). This is reasonable as many principles of training within sport science are similarly executed with consideration for the individual when they are applied. Currently, researchers continue to investigate the relationship between specific performance measures and menstrual cycle phases with increased consideration for recent methodological guidelines to ensure high-quality studies. Yet, less insight can be ascertained about how female athletes are experiencing and responding to training. To my knowledge, only a few studies have explored the physiological and self-reported perceptual responses to training across multiple consecutive cycles. Therefore, I followed this path of inquiry for my study.

Specifically, in my research, I sought to comprehend, empirically, how female runners respond to training across their menstrual cycles, and crucially, I wanted to do this in a way that might be realistically replicable in practice. It can often be difficult for coaches and sport practitioners to translate findings from laboratory-based physiological exercise science into practice. Hence, I aimed to engage a pragmatic process of knowledge generation by replicating a 'real-world' athlete monitoring protocol which could, ideally, amplify the likelihood of practical uptake from my research. As a surrogate for a coach-monitored training log, I developed an electronic questionnaire to collect exercise training and menstrual cycle data on a daily basis. Athletes completed these training log inspired surveys each day for three consecutive menstrual cycles, providing sufficient time to identify possible patterns across cycles in each participant. These data were then supplemented by qualitative interviews, allowing for comprehension

beyond numbers with an enlightened understanding of each individual as well as the group. The physiological and self-reported perceptual data collected in the athlete monitoring stage could be better contextualized when participants spoke about their menstrual cycle and training experiences in the interviews. The findings herein present an example of how a personalized approach to monitoring training alongside the menstrual cycle may be implemented in practice and moreover, reiterate the value that can be gained from listening to the athlete experience.

In this final section, I will discuss how the quantitative and qualitative results of this study merge and what implications for practice exist. First, I will explore how using a new materialist approach combining physiological data and insights from qualitative interviews can facilitate profound contextual insight not otherwise offered under the traditional disciplinary lens of sport science. Subsequently, I will discuss how the physiological responses to, and lived experience of, endurance training across the menstrual cycle can inform future directions in research and practice. It is my hope that the knowledge generated from this study can assist the sport science community, both applied and academic, by demonstrating how hormonal milieu, menstrual cycle symptoms, additional measures of athlete health and individual athletes' experiences all interact hereby informing a more holistic and comprehensive approach to monitoring training in female endurance athletes.

Invisible Tensions: Understanding Female Athletes and Biocultural Entanglement

Guided by a new materialist approach, the present study invites innovation into current traditions of sport science. This enabled me to reach a more nuanced understanding of the complex and implicit tensions that surround female athletes as the biological, psychological and sociocultural human beings. New materialist scholars identify the need to examine the physical human body as lively matter but further, to realize "everyday practices and movements in every

day spaces and places" (Thorpe, Brice, et al., 2020, p. 11). Herein we can begin to appreciate the "field of force relations" (Markula, 2019) which undoubtedly impact the everyday practices and movements within everyday spaces, places, and roles embodied by female athletes. In a recent study, high performance coaches of predominantly endurance sports indicated that there exist "gendered differences towards nutrition, body image, performance and the importance of the sporting environment", all of which then impact the ways in which they work with women athletes (Schofield et al., 2022, p. 339). Research pertaining to the elite athlete experiences as mothers further elaborates upon this idea, noting that "women negotiate nuanced tensions within a range of cultural discourses tied to gender ideologies and expectations" (McGannon et al., 2018, p. 42). Throughout the interview discussions, recreational female distance runners spoke, both explicitly and implicitly, about navigating this field of forces as moving bodies. As illustrated in the following discussion, the athletes' experiences occasionally served to challenge or reinforce the survey findings. Biological, psychological and cultural tensions seemed to act upon the present cohort of athletes in a few notable ways, among both the mothers and non-mothers. Women expressed desires to defy and embrace femininity by striving to push their physical limits *in spite of* the MC and social constructs of fragility that have been associated with female reproductive systems, particularly in sport contexts (Chase, 2016; Mujika & Taipale, 2019). Cronan and Scott (2008) have highlighted how some women athletes "are able to transcend dominant ideologies about gender relations and the female body" (p. 17) despite women being "taught that strength and toughness as key attributes of sport are not feminine values" (p. 18). In completing a strenuous workout session, participants in my study were able to effectively reject any societal perceptions of weakness associated with menses, subsequently

illustrating a certain feminine-powered resilience. Instead of fragility, women described feelings of strength that are uniquely female *because of* the MC and female reproductive capacities.

Another dichotomy I observed across my study participants was between resilience and self-compassion. As recreational athletes, participants navigated feelings of resiliency alongside opportunities for self-compassion – determining when to push and rest – to best benefit their training and overall wellbeing whilst continually juggling additional life commitments (i.e., work, school, family/parenting). As highlighted in recent research, "female athletes must navigate tensions between the social expectations of femininity, the physical requirements of sport-specific training, and the aesthetic expectations of specific sports" (Heather et al., 2021, p. 2). In my study, participants navigated tensions between their physical body and psychological mind as they negotiated between feelings of resiliency and self-compassion. The role of the MC in this negotiation is nuanced but may unveil tensions amidst the field of forces at play for female athletes. More evidently, women are required to navigate tensions enacted directly by the MC. First, many of the study participants adhered to their training regardless of the varying intensities of physical and emotional symptoms of MC. This echoes previous findings which indicated that athletes rarely altered or abstained from training due to MC-related side effects (Findlay et al., 2020; Solli et al., 2020). Participants often identified this ability to persevere as resiliency, some referred to training through fatigue or stomach cramps as an advantageous stimulus for marathon or ultramarathon events where encountering feelings of fatigue, pain, and discomfort are expected. The persistence to endure, also considered the practice of "digging in" (Hockey & Allen-Collinson, 2016, p. 231), is common in distance running where athletes frequently "continue to train under the burden of heaviness" (Hockey & Allen-Collinson, 2016, p. 232). In this way, athletes are able to accrue "somatic experience[s] of habitual pains" (p.

236). These coping strategies to pain inspired confidence to endure and withstand difficulties in future (Hockey & Allen-Collinson, 2016). Second, despite the persistence to train, women still conveyed self-compassion in how they negotiated their training. For instance, they allowed themselves 'grace' if a workout was not executed precisely as planned during MC. Certainly, each woman experienced their MC and related symptoms differently, making this process of negotiation subject to individual variation and circumstance (i.e., severity/frequency of symptoms and/or details of training prescription). Finally, it is possible that some women felt an unconscious or conscious need to prove themselves as athletes, especially during the bleed phase, while concurrently rejecting the fragility narrative that has been historically perpetuated in sporting contexts (Mujika & Taipale, 2019). All of these issues made training throughout the MC complex.

As demonstrated in my qualitative findings, runners seem to develop the ability to "judge their own limits and corporeal weaknesses" (McNarry et al., 2020, p. 664). As indicated by the interviews, the ability to do so, alongside the menstrual cycle, is influenced by prior sport experiences (and cultures), training age, competitive season, external life stressors, and menstrual status (and experience) – all of these factors are entangled with invisible tensions. Prior sport experiences might impact an athlete's comfort with training throughout the menstrual cycle and their awareness of (or lack thereof) menstrual health as it relates to their sport. A mature training age can encourage greater bodily trust, easing the negotiation between resiliency and self-compassion. Athletes might approach their training with persistence (push) or graciousness (rest), depending on the proximity to competition goals or as elucidated, the symptoms and effects enacted by the menstrual cycle. Therefore, I postulate that to best support female athlete health, we must recognize several invisible tensions since they impact how

women negotiate training as well as how women engage with their physical bodies. Heather and colleagues (2021) have called for a more "appropriate gender balance in coaching and support staff" (p. 7) and better education for coaches and staff about topics of female health. Certainly, achieving greater gender balance among coaches and sport-scientists could influence how women athletes are supported, since there may be greater intrinsic understanding of gendered experiences and the consequential tensions within. Further, I believe we ought to include, and unpack, the aforementioned tensions explored in my study, and work by others (i.e., Heather et al., 2021), in the education of coaches and sport scientists. We will, then, be able to better comprehend the embodied, and individual, experience of being a female athlete.

Menstrual Cycle Tracking: Is Knowledge Power?

The existing relationship between person and menstrual cycle varied across the group. Some women had good pre-existing knowledge of their menstrual cycle, others yearned for more insight, and some were indifferent. Likewise, the attitudes toward the menstrual cycle, as it relates to athletic training, varied. Some women were largely unbothered by hormonal fluctuations whereas others felt more discomfort. The feelings of women who experienced greater distress aligned more with previously cited research where athletes described menses simply as something they had to deal with (Dykzeul, 2016). However, the majority of interviewees (81%, n = 13) explicitly acknowledged the overall importance of the menstrual cycle, recognizing menstruation as an essential indicator of positive health among female endurance athletes. Age played a factor here as participants shared how their attitudes about the MC changed as they got older. For some participants, this involved reflecting on prior use of oral contraceptives to manipulate, and avoid, bleeding. Other interviewees perceived a change in the broader sociocultural landscape of endurance sport where the loss of MC is now acknowledged

as unhealthy. They shared how this was exhibited in podcasts and social media that now facilitates views that menstrual health should be valued. This indicates a positive attitudinal shift (Fahs, 2020) that is particularly encouraging among female distance runners because menstrual irregularities and/or amenorrhea have dangerously and incorrectly been normalized and perceived as acceptable, or even required, among female athletes (Hook et al., 2021; Verhoef et al., 2021).

As evidenced in my results, the MC tracking experience embedded within the athlete monitoring stage was valuable for study participants because women found this improved their self-awareness and confirmed pre-existing knowledge about their cycle and associated symptoms. This consequential self-awareness and predictability were empowering as it diminishes the control that associated discomforts may otherwise possess. Moreover, some found engaging with the cycle tracking processes (i.e., selecting symptoms from a list) helped to normalize menstrual cycle experiences and inspire more menstrual cycle related discourse among their family, peers, or coaches. For instance, one participant shared how she conversed more openly with running partners and colleagues, both male and female, about the MC. These findings echo recent research which explored the experience of using menstrual cycle tracking apps and similarly revealed the process of cycle tracking as a "pedagogy of empowerment" that helps to "render [bodies] knowable" (Riley & Paskova, 2022, p. 7). Menstrual tracking users in my study developed an enhanced awareness, established a sense of control and learned to value their menstrual cycle (Riley & Paskova, 2022). Indeed, not all women wanted to continue cycle tracking on such a granular level but for the most part, many were intent to engage more actively in "obtaining, making sense of, and translating [bodily] information into their daily lives as athletes and women" (Thorpe & Clark, 2020, p. 10). MC tracking should therefore be (carefully)

encouraged more broadly among female athletes and regarded similarly by sport scientists as value added when assembling and evaluating athlete health data. It is, however, increasingly important to recognize issues of data privacy in sport science, particularly the "coercive atmosphere" wherein athletes provide information about their bodies and "the paternalistic nature in which those data are used and abused" (Casto, 2022, p. 1725). Researchers caution that MC tracking may invoke a "particularly dystopian future for female athletes" (p. 1725) as intimate information about hormonal and menstrual health and associated symptoms, becomes readily available knowledge that (male) coaches, sport scientists and practitioners might serve back to female athletes as "prescriptive knowledge for performance enhancement" (Casto, 2022, p. 1725). Thus, integration of MC tracking into athlete health practices must be considered sensitively, but also, should not perpetuate the stigma of the MC as taboo. I explore some potential strategies for practical application later in this discussion.

Bleeding, Bloating, and Beyond: Making Sense of Menstrual Cycle Symptoms

Developing a better understanding of menstrual cycle symptoms among sport scientists is necessary since adverse symptoms have been identified as a barrier to habitual exercise that can compromise training and performance, and may warrant extended exercise recovery (Bruinvels et al., 2022). Recent research suggests that the vast majority, 90% of eumenorrheic exercising women, experience either physical or mood related symptoms associated with their menstrual cycle and among elite athletes, 50-67% perceive symptoms as disruptive to their exercise performance (Bruinvels et al., 2022). Such disruptions to exercise are not entirely unexpected, given that menstrual cycle symptoms have often been cited negatively for causing distress, discomfort, and pain (Santer et al., 2008). The impact of menstrual cycle symptoms on decisions to train and consequential responses to training varied within individuals and across the group of

women who participated in the present study. As illustrated in the qualitative results, some women found it more challenging to initiate or complete their training due to physical symptoms and additionally, mood-related symptoms impacted and were impacted by training. Study participants most frequently reported symptoms of fatigue, bloating, stomach cramps, disturbed sleep, and heavy legs throughout the athlete monitoring stage as well as the interviews. Additionally, the participants made frequent reference to lower back pain and gastrointestinal distress during interview discussions. Of these symptoms, fatigue, bloating and stomach cramps differed significantly across the entire cycle and all three symptoms were most experienced during the first day of menstruation (T1). This aligns with research by Solli et al. (2020) who found that among competitive endurance athletes, stomach pain and bloating were the most frequently reported symptoms, and similarly, both were reported more so during the bleed phase. Existing research suggests that female athletes report symptoms as most prevalent during the few days prior to and during the onset of bleeding with most physical symptoms occurring immediately before or at the beginning of menstruation (Brown et al., 2021; Findlay et al., 2020). Likewise, participants in the present study reported symptoms more during the late luteal (pre-menstruation) time and the subsequent early follicular (onset of menstruation) time. However, a unique aspect of the present study is that the analysis of athlete monitoring data, including training response and reported symptoms, investigated changes within menstrual cycle phases, as defined by (Elliott-Sale et al., 2021), as well as the transitions between phases. Recent work calls for sport scientists to consider the transitions between menstrual cycle phases as rapid and considerable changes to hormonal levels can occur during these times and produce dramatic shifts in hormonal milieu and disrupt homeostasis (Bruinvels et al., 2022). Among the few symptoms that varied significantly across the entire menstrual cycle, fatigue and stomach cramps

were most often reported at the onset of menstruation while bloating was most reported prior to, and during the onset of, menstruation. Other symptoms including perceived increased in body temperature, feeling stressed, poor concentration, irritability, headache, heavy legs, disturbed sleep, lower back pain, and reduced motivation did not demonstrate significant changes in reporting frequency across the entire cycle. This does not mean these symptoms should be ignored. Rather, we can engage in deeper investigation – studying the frequency of symptoms across MC phases and transitions between – to ascertain how the experiences of different symptoms are temporally distributed. Future research might seek to investigate even further and explore the perceived severity of certain symptoms as well as how severity is distributed across MC time points. However, significant changes were observed in the transitions between phases, with seven of the aforementioned symptoms occurring most during the early follicular time points (T1 and T2) and the pre-menstrual time (T8). Specifically, perceived increase body temperature and increased feelings of stress were more experienced during the pre-menstrual days (T8) and the first day of menstruation (T1). Certain physical and psychological symptoms were more experienced during these time points as well: heavy legs were more reported during the onset of menstruation (T1) whilst irritability and reduced motivation were more experienced in the pre-menstruation time (T8). Likewise, symptoms of poor concentration and lower back pain were both experienced more during the early follicular time (T2), in the later days of the bleed phase. The increased presence of symptoms during these time points indicates how temporally localized menstrual related symptoms can be. Hence, investigating symptom presentations across the cycle in its entirety, or only in some phases, might fail to capture the true experience of female athletes. To my knowledge, this is the first study to provide specific insight to the symptoms and training response experienced within and between menstrual cycle phases.

Thus, I reiterate the need for sport scientists to monitor the day-to-day variation of menstrual cycle symptoms (Bruinvels et al., 2022), and further, I recommend that daily monitoring of physiological and self-reported training response measures is considered in the same way.

Objective versus Subjective: The Interaction of Findings and Feelings

Initially, data analysis of the physiological and self-reported perceptual measures was going to be completed over four time points, using defined MC phases only. However, after conducting the qualitative interviews, it became apparent that including additional time points in this analysis would expand the understanding of athlete training response and better achieve my study aims. The reasoning behind this conclusion was two-fold: first, participants described the first day of their MC differently than subsequent bleed phase days and second, participants spoke about the symptoms experienced in the days prior to menstruation and this pre-menstrual time point is not included in defined MC phases. Therefore, I decided to conduct my analysis across eight time points, capturing insight into the physiological, perceptual, and symptomatic variations that occur across the MC phases as well as the transition times between phases. Not only was this approach effective in achieving my study aims – uncovering differences that would not have been captured with a 4-phase approach to analysis – but it emphasizes the value gained from the qualitative data and reiterates the importance of listening to the experiences of female athletes.

Together, the qualitative and quantitative data collected throughout this study provide interesting insight into how female athletes respond to and perceive the experience of training across three consecutive menstrual cycles. Using a variety of athlete monitoring tools, such as the quantification of internal and external training load, sport scientists have been able to understand individual athlete capacities and tolerances to training. This assists coaches to

execute effective training, and importantly, maintain optimal fitness and health (Halson, 2014; Roos, 2013; Sansone et al., 2020). In addition to quantitative strategies, scientists have developed greater appreciation for subjective self-report measures which help understand the psychosocial responses to training and can, at times, provide more heightened sensitivity to acute and chronic training loads than objective measures might (Thorpe et al., 2017). In addition to these methods, and if applicable in practice, open-ended questions that invite further communication and feedback from athletes can provide the most relevant affective insight into the overall health and wellbeing of an athlete. Despite its irrefutable importance within female athlete health, limited consideration to the menstrual cycle and associated symptoms has been integrated into the process of monitoring athlete training. More recently, however, researchers are recommending that it should be included in standard monitoring practices (Antero et al., 2023; Cristina-Souza et al., 2019; Solli et al., 2020; Temm et al., 2022). In this way, and in the aforementioned analysis of physiological measures within and between menstrual cycle phases, the following data presented and discussed is novel.

Upon first glance, the survey data revealed a significant change across the menstrual cycle in basal body temperature (BBT): BBT rises slightly during ovulation and in the time points to follow, as expected given the well-established impact progesterone has on body temperature (Constantini et al., 2005; Lebrun et al., 2020; Oosthuyse et al., 2005; Sims & Heather, 2018). Although there was no overall effect in other physiological and self-reported measures across the entire MC, my analysis approach enabled a deeper investigation to discover where changes between the MC time points (phases and transitions between) did and did not occur. When evaluating total training stress, this measure remained consistent with difference of between minimum 10.3 to maximum 30.8 (a.u.) between time points. This agrees with recent

findings showing no change in training impulse or self-chosen training load (both defined as TRIMP = session duration x sRPE) across menstrual cycle phases during regular training in both track and field athletes and endurance athletes (Cristina-Souza et al., 2019; Oguche, 2022). I can speculate that since most of the participants continued to train regardless of their MC, this consistent training generated consistent training stress scores but this would be scientifically premature. Rather, a more thorough investigation into the reported training volume (minutes) and session rating of perceived exertion (sRPE) which comprise the training stress score – and whether or not these measures changed across MC time points – is warranted.

Further, participants reported feeling most satisfied with their training at the onset of menstruation (Day 1, T1) and during the mid-luteal phase (>7 days following ovulation, T7), compared to other times across the menstrual cycle. Interestingly, recent work featured a similar study design, monitoring training in elite rowers for 3-6 months. The researchers found that self-reported training performance, defined as how athlete perceive the quality of their training session, independent of effort, was lower in the menstruation phase (Antero et al., 2023). Without a clearer idea of how my undefined measure of 'Satisfaction' relates to their measure of 'Self-Reported Training Performance' it is difficult to accurately compare these findings. Regardless, the satisfaction results herein are a particularly fascinating finding due to the varied qualitative reports that may support the quantitative findings. For example, half (n = 8) participants explicitly commented that training was advantageous in relieving symptoms, especially mood related symptoms (feeling stressed, reduced motivation and irritability), which were more prevalent during this time. As previously discussed, the cohort varied with participants who felt strong and genuinely enjoyed training during menstruation and those would work harder in spite of menstruation. Regardless of the incentive, each of these scenarios may

generate high satisfaction with training – the relief of symptoms, the joy of a good training stimulus, or the gratification of enduring a tough session. As highlighted in my literature review, a positive affective response to physical activity is known to generate continued engagement and adherence to exercise (Osorio, 2020). Therefore, I recommend that sport-scientists and coaches consider adopting a training satisfaction scale, as exemplified in my study. Monitoring training satisfaction allows an understanding of affective training response that is not offered by standard measures of internal training load, such as rating of perceived exertion, but provides complementary insight about how an athlete perceives training. Additionally, as evidenced in my study, this unique training response helps illuminate how female athletes respond to, and experience, their MC and its symptoms. It is also worth noting that the highest mean value for SAT among my participants was 6.8 (out of a possible 10), the closest descriptive anchor for this score is 'Satisfied'. This is not a very high score and begs the question: *what drives satisfaction of training in female endurance athletes?* Future research might seek to explore how female athletes arrive at these self-reported perceptual responses and whether this perhaps, differs between individuals as well as across the MC. Within my data, deeper investigation into the individual results would help to identify the distribution of SAT scores (i.e., how many participants self-reported higher or lower SAT) and if these scores correspond with certain workouts.

The experiences across the menstrual cycle varied among the participants revealing an array of positive, negative, or indifferent perceptions at different hormonal time points. However, the exceptional time when most women indicated experiencing their best training was during the mid (T3) to late (T4) follicular times, or as participants described it, between menstruation ending and ovulation occurring; this perception is consistent with existing research. Righi and

Barroso (2022) found that the majority of recreational female athletes indicated the late follicular phase as the best to train in whereas the early follicular (menstruation) and late luteal (pre-menstrual) were the worst to train in. Moreover, McNulty (2022) states that among naturally cycling women who were recreationally active, 67% reported a perceived improvement in exercise performance during phase 2 (late follicular to ovulation) whilst 38% perceived a decrease in exercise performance during phase 1 (early follicular, menstruation). During this point in the cycle (mid to late follicular), most women in this cohort expected to experience higher quality training, more confidence, greater resilience to both fatigue and stress, as well as an increase in energy levels especially toward ovulation. Interestingly, a recent study by de Carvalho et al. (2023) found that during the luteal phase, a perceived influence of the MC on exercise affected total test time in a treadmill graded exercise test whereby among women who did not perceive the MC to influence exercise, total test time was significantly longer. It is possible that women may have held comparable pre-existing perceptions and expected to feel better during the follicular phase, consequentially driving the lived and reported experiences.

Notably, these perceptions appear to align with the athlete monitoring data which presented during the mid-follicular time (T3). The lowest supine resting heart rate (HR) and basal body temperature (BBT) measures; highest total training stress (TTS) and highest motivation (MOT); and among the highest satisfaction (SAT) and muscle feel (MF) measures were observed, at the group level. During the T4 time point, motivation to train (MOT) remained high. First, understanding that a lower HR provides information about the autonomic nervous system and cardiovascular adaptation to endurance training (Schneider et al., 2018; Smith, 2003), it is possible that the women better tolerated the stress imposed by training at this time. Whilst

there are a variety of external factors that can influence HR, because my athlete monitoring and MC tracking stage occurred across three cycles, I am confident these co-variates are distilled.

Second, while T3 revealed the highest TTS, as previously mentioned, further investigation into the determinants of training stress is required. Future analysis of these findings, specifically, evaluating the distribution of training volume across the eight time points would then help clarify differences in intensity (perceived rating of exertion); thus, elucidating how training stress was accumulated across the cycle.

Third, higher measures of MOT (T3 and T4) and SAT (T3) at this time, compared to the other MC time points, further support the athletes' perceptions. As mentioned, interviewees felt more confident at this time and expected to experience higher quality training. As for physical body sensations, greater resilience to fatigue and stress were experienced during the mid-follicular. Increased energy levels were also noted, especially in the mid to late follicular times. Taking into consideration the physiological and psychological perceptions at this time, it is not surprising that women self-reported higher perceptual responses to training during the mid (T3) and late (T4) follicular times.

Finally, while further analyses at the individual level would be required to deduce the specific types of workouts being completed during T3, the higher self-reported MF (mean = 5.2) agrees with existing evidence that found greater responses of creatine kinase (CK) and Interleukin-6 (IL-6), biomarkers of muscle damage and the pro-inflammatory process, after intensive endurance exercise in the mid-follicular phase (Hackney et al., 2019). Lower concentrations of sex hormones during the mid-follicular phase may explain this, mechanistically, because the anti-oxidant effects of estrogen are said to attenuate exercise induced muscle damage (Hackney et al., 2019; Oosthuyse et al., 2023). However, self-reported

MF was even higher (mean = 5.3) during the ovulation time (T5). This is curious, because estrogen levels rise to their highest peak immediately prior to ovulation, lower, and then rise again throughout the luteal phase. If this mechanistic influence of estrogen to attenuate muscle damage is correct, my participants must have observed positive ovulation test results toward the end of the ovulatory window, as estrogen levels are briefly lowered during the early luteal phase.

Aside from these physiological and self-reported perceptual measures, the athlete monitoring data also revealed T3 as the time point where the fewest menstrual symptoms were experienced (see Chapter 4, Tables 8 and 9). At the group level, nearly every symptom, with the exception of headache, bloating and lower back pain, was reported less during the mid-follicular time (T3). At the individual level, also, menstrual related symptoms were less reported during the mid (T3) to late (T4) follicular times (see Table 9). Across the sample of participants whose data were included in quantitative analyses (n = 14), the majority (93%, n = 13) experienced either no symptoms at all, or their lowest percentage of symptoms, during the mid-follicular time point (T3). Less reports of menstrual symptoms were also observed in the late follicular time point (T4), in fact, over half of participants (57%, n = 8) reported no symptoms at all during this time. Certainly, the reduced impact of these symptoms may reasonably lead to perceptions of improved training and/or performance, especially considering a negative correlation between the presence of menstrual symptoms and endurance performance has been reported (Antero et al., 2023).

These combined insights hereby illuminate the deeper understanding that can be gained by listening to the athletes' experiences and perceptions, not just about sport training but also about overall health, in a more profoundly holistic way, such as those shared in the interview results. Merging different types of data (i.e., MC data, physiological and self-report, and

comprehensive athlete feedback) in this way may be instrumental to the successful integration of menstrual health considerations into standard practices of monitoring athlete training. Particular strengths of my research approach included the length of the monitoring stage, the standardized timing of survey delivery, and participant screening and classification to ensure as high quality research as possible. To expand upon the present findings, it may be insightful to examine the training responses at an individual level. Are there certain workouts that feel better, or can be more successfully completed, at different times in the MC or while experiencing different symptoms? How do female athletes define feelings of satisfaction in relation to training, and, does this definition differ throughout the MC? How do measures such as RPE, HR, and motivation to train impact decision-making processes in self-guided and coached athletes? Future investigations could consider case studies approaches to facilitate such inquiries.

Chapter 6: Conclusion

The extensive exploration into the subjective perceptions of and objective responses to training across the menstrual cycle (MC) presented in this study offers novel considerations for the practical and scholastic realms of female sport science. In my research, I used an eight-time point approach to quantitatively investigate women's responses to training across the menstrual cycle. This process offers a new understanding of how the MC influences athlete training status because it illuminates how physiological and perceptual responses to training, as well as menstrual related symptoms, are temporally localized. These insights would not have otherwise been attained through exclusive analysis of changes across phases, hereby, illustrating that the transitions between phases should also be considered in MC research and when planning training for female athletes.

I hypothesized higher ratings of perceived exertion (sRPE), higher ratings of muscle feel (MF), lower ratings of satisfaction (SAT), lower ratings of motivation (MOT), and more menstrual symptoms would be reported during the final, pre-menstrual, days of the MC (T8) and early days (onset of menstruation, T1) of the MC. Additionally, I hypothesized that resting heart rate (HR) and basal body temperature (BBT) would be highest during Phase 4 (T7) of the MC when progesterone levels are most elevated. My data revealed otherwise: MF was highest in the ovulation time (T5); SAT was lowest in the early luteal time (T6); MOT was lowest in the ovulation time (T5); HR was highest during the onset of menstruation (T1) and ovulation (T5). My hypothesis of BBT proved correct as highest BBT was observed in the mid-luteal time (T7) and, also, the late luteal time (pre-menstrual, T8). Instead of completing statistical analysis on ratings of perceived exertion (sRPE), I explored analysis of total training stress (TTS), a measure partly determined by sRPE. Menstrual symptoms were, in fact, more reported during T1 and T8:

most women 86% (n = 12) experienced more symptoms in T1 (n = 10) and T8 (n = 2). I further hypothesized that the highest measures of SAT and MOT, and lowest measures of *both* subjective (sRPE and MF) and objective measures (HR and BBT) would be reported during Phase 2 (T4) of the menstrual cycle when estrogen is highest in isolation of progesterone. Again, my data revealed otherwise: highest reports of SAT were seen in T1; highest reports of MOT were seen in T2 and T3; equally, lowest reports of MF were seen in T2, T7 and T8; and lowest HR measures were seen in T3. Anticipated measures of BBT were correctly hypothesized with the lowest BBT seen in T4 and, also, T3.

My additional qualitative exploration revealed how MC experiences varied across the group. Through interviews, I aimed to answer the following research questions: a) *What impact will women perceive the MC as having on their training?* and b) *How will women feel about tracking their MC when training?* Women spoke about the challenges or ease of exercising while experiencing menstrual symptoms and these insights helped answer my first research question. Regardless of their individual MC experience, women felt a desire to continue with their training regardless of their MC and they perceived little impact of the MC on their execution of endurance training. Further, women shared how the process of MC tracking improved their self-awareness and confirmed pre-existing knowledge about their cycle. Ultimately, women felt that the experience of cycle tracking was valuable. Notably, women identified the importance of menstruation for endurance athletes.

A particular strength to this study is its integration of empirical data generated through physiological measures. Evidently, there are not many new materialist scholars who produce biological data as part of their own projects or work alongside scientists to facilitate more comprehensive understanding of biological or physiological processes (Thorpe & Clark, 2020).

As such, engaging directly with physiological data produced within this study can be considered novel even among new materialists. Further, sport science research is most often completed in controlled laboratory environments, which may limit the extent to which sport practitioners can translate findings into pragmatic applications for practice. By using a survey that was designed to simulate an athlete training log typically used in practice as my data collection tool, this study shows how menstrual health monitoring can be readily applied and interpreted by sport scientists. Additionally, by supplementing the above strategy with qualitative interview and focus groups to explore athletes' perceptions clearly facilitate a thorough exploration into how women endurance athletes perceive and respond to training throughout the menstrual cycle. These insights offer a starting point for which sport scientists can continue to build to enrich our knowledge of female athlete health.

Considerations for Applied Practice

Through the research process and findings shared herein, I can suggest applications for practice that may facilitate improved support in female endurance athletes. First, coaches and sport-scientists should consider incorporating MC tracking into their processes of monitoring athlete health. While there is a general consensus suggesting that monitoring the MC is valuable within sport contexts (Antero et al., 2023; Bergström et al., 2023; Cristina-Souza et al., 2019; Elliott-Sale et al., 2020; Pitchers & Elliot-Sale, 2019; Solli et al., 2020), I will explore how this can be incorporated mindfully and used to inform training. As previously cautioned, monitoring the MC must be implemented in a way that ensures athletes feel safe and confident sharing such information – this data should be embraced without judgment or paternalistic direction and rather, with sufficient knowledge of female physiology (Elliott-Sale et al., 2020). Indeed, a key benefit of MC tracking is its ability to enable a proactive approach to athlete health. Yet, despite

the best of intentions, coaches can still fail to critically examine how this surveillance "may further work to normalize and discipline female athletes in new ways" (Schofield et al., 2022, p. 341). This is a real threat, but athletes may also be subject to threats of insufficient or false information when they are left to independently engage with their biodata through MC tracking. Endurance athletes are currently inundated with the ability to produce data (i.e., through wearable technology) with little to no real guidance for how to interpret and apply it. Furthermore, an excess of pseudoscientific information exists on social media – a platform where athletes might seek such guidance. This can be particularly overwhelming, and potentially damaging, for recreational athletes who are self-guided and not supported by well-informed coaches or sport-scientists. Female physiology presents a fascinating, and frustrating, example of this: a plethora of "cycle-syncing" (i.e., specific training for specific times in the cycle) rhetoric has spread rapidly across social media platforms in recent years. This ill-informed strategy has caught the attention of many female athletes but clearly fails to recognize or convey how tentative, and not to mention individual, the sport science knowledge of female physiology remains. Thus, despite potential risks outlined above, I advocate that MC tracking should be employed, provided the athlete and practitioner have given meaningful consent for how, and when, data will be collected and used.

Integrating MC tracking into an applied practice of athlete monitoring can be achieved with relative ease using a calendar and ovulation test kits, as well as noting menstrual-related symptoms such as physical and emotional changes that may occur throughout the cycle (Elliott-Sale et al., 2020). Undoubtedly, the MC is not a singular determinant of physiology and psychosocial status, other factors such as illness, nutrition, lifestyle and external stressors must be considered. Thus, when integrating MC tracking into athlete health monitoring processes it is

critical to monitor for > 3 months for any meaningful conclusions about cycle patterns to be made (Elliott-Sale et al., 2020). The present study design serves as an example for how practitioners might employ simple questions to collect MC data into a traditional athlete training log (i.e., noting cycle day, ovulation confirmation, symptoms) over consecutive cycles. In doing so, individual MC data can provide useful information that may improve how testing and training data are interpreted, inform program design, anticipate physiological and perceptual responses in training or competition, and ultimately, make appropriate adaptations, if needed (Antero et al., 2023; Clarke et al., 2021; Cristina-Souza et al., 2019; Solli et al., 2020). At certain times in the cycle for some women, bodily confidence might be the critical component to develop their "enduring consciousness" (Hockey & Allen-Collinson, 2016, p. 236). Some athletes may be able to pinpoint specific workouts that are more effectively executed at certain times of their MC or while experiencing particular symptoms – where possible, this insight should be used to inform successful training design that can inspire confidence *and* move athletes towards their performance goals. Additionally, MC related insights can be used in relation to the training principle of specificity where training is designed to be specific to the demands of competition (Smith, 2003). For instance, many athletes and coaches would evaluate competition day factors such as incline, course terrain and weather, planning accordingly to specify training to these factors. Similarly, cycle tracking can allow an athlete to predict, approximately, where within their MC a competition will occur. With such advance planning, this information can be integrated into pre-competitive training to ensure MC symptoms, fuel/fluid preferences, expected sleep disturbances, leg feel and overall psychosocial status are then approached in training, thus mitigating the additional and unnecessary stress of the unknown. As participants in this study noted, MC tracking made menstrual related discomforts

predictable and often, more manageable as a result. Whilst this might not impact how an athlete chooses to organize their race schedule, it can certainly help them to feel more prepared and ready to perform.

Assuming a positive coach-athlete relationship and meaningful consent, menstrual cycle tracking, with ovulation testing when appropriate (i.e., to establish cycle regularity, endocrine health, monitor energy availability status), should be implemented. As evidenced in the athlete monitoring stage of this study, ovulation testing can help with identification of menstrual dysfunction. In fact, menstrual bleeding does not guarantee that ovulation has occurred, therefore confirmed ovulation (by use of urinary ovulation tests or hormonal measurements) is now regarded among experts as the gold-standard methods for identifying and preventing low energy availability (O'Donnell et al., 2022). Therefore, it may be beneficial to specifically include ovulation testing as a method to confirm endocrine health during particularly stressful training blocks. As an alternate to long-term, coach-led MC monitoring, coaches and sport scientists may suggest that their athletes autonomously pursue cycle tracking processes for the sake of heightened personal awareness, offering to support and guide them as needed. Then, consider periodizing formal MC tracking as an additional measure during specific high volume or intensity training builds, or pre-competitive phases, when generated insights may be most meaningfully applied.

Second, coaches and sport-scientists should consider further inclusion of qualitative feedback into training logs. It is well established that lengthy surveys can induce questionnaire fatigues whereas space for personal comments in training diaries can provide more valuable feedback (Halson, 2014; Roos, 2013). However, throughout the athlete monitoring stage of this study, different athletes demonstrated vastly different response styles within the open-ended

comment box where space for general subjective insight was offered. The qualitive interviews, however, offered the opportunity to learn about each athlete's lived experience and established context for their athlete monitoring data. In this way, I was afforded an understanding of the individual, learning how she situates herself in the broader sport landscape and how her positionality informs her engagement with the embodied experience of training and the MC. Certainly, including lengthy qualitative interviews is not practical in an applied setting. Still, sport practitioners ought to consider including regular one-on-one conversations with their athletes which would likely help to build trust, improve individual understanding, and invite open communication. Based on my research, I would recommend the following questions that might be used to initiative a dialogue and establish deeper communication between a coach, or sport scientist, and their athlete:

1. How do you feel your menstrual cycle and athlete training experiences are related and how has this changed throughout your time as an athlete?
2. Please describe any menstrual cycle symptoms that you experience.
    a. How do certain symptoms rate in severity?
    b. How do certain symptoms impact your training?
    c. How does your training impact certain symptoms?
3. Consider how you experience specific training throughout your menstrual cycle.
    a. How do you experience certain modes of training differently across the cycle?
    b. How do you experience specific workouts, within a mode of training, differently across the cycle?

Finally, there is an urgent need for more education about the MC and sport among both athletes and coaches, as well as among health care practitioners. Often, a physician or health care

practitioner is the first point of contact from whom female athletes seek advice. Thus, this research serves as a stepping stone, guiding how menstrual cycle tracking might be approached in clinic settings. This call for education is not new, suggestions for improved knowledge in this area among coaches and athletes alike have been repeatedly recommended within research literature (Armour et al., 2020; Bergström et al., 2023; Brown et al., 2021; Clarke et al., 2021; Hook et al., 2021; Pitchers & Elliot-Sale, 2019; Solli et al., 2020). In fact, a structure for the development and execution of coach education on the MC and sport has been proposed (i.e., Clarke et al., 2021). Beyond the implicit needs for more coach education, a module that is provided as continued medical education or in resident training for physicians would also be important, given this point of contact for many female athletes. Within the present cohort, many participants shared how they developed a heightened awareness and improved knowledge of their body while tracking their MC through the athlete monitoring stage. This further confirms the need for more education, even among female athletes. Yet, given the tentative state of the science in this area (Casto, 2022), I understand that it would be challenging to develop evidence-informed educational programs at this time. Still, a basic overview of the menstrual cycle including: hormone function and fluctuations, cycle phases, menstrual irregularities and dysfunction, hormonal contraceptives, and possible menstrual-related symptoms would be a reasonable starting place that would undoubtedly expand the existing knowledge in many sport-scientists, coaches, and athletes.

The above recommendations provide guidance for how practitioners can mindfully incorporate menstrual health into standard practices of athlete monitoring and offer concrete examples for how this data may be used to inform training design. As intended, the present study design exemplifies how sport-scientists and coaches might reasonably include MC factors into

traditional athlete training logs. I also encourage sport practitioners to invite more extensive subjective feedback from athletes and reiterate the calls for more educational opportunities to enrich knowledge in this area among athletes and practitioners.

Study Limitations

It is important to acknowledge that the present study and findings herein are not without limitations, described as follows. First, a particular limitation of my quantitative research is the inability to perform blood samples to confirm serum estrogen and progesterone as method of verifying menstrual cycle phase and thus, conduct research of the highest quality (McNulty et al., 2020). This limits the confidence of hormonal milieu in certain MC time points: confirmation of menstruation and ovulation determined T1, T2 and T5, but the remaining time points were informed estimates based on when menstruation and ovulation occurred in each cycle, per individual. Therefore, readers should interpret the findings accordingly, understanding that precise hormonal measures were not possible for all time points. A small and heterogenous sample size is a second limitation, underpowering the ability to detect significant differences within the quantitative analysis. Whilst I attempted to limit the variability between individuals by recruiting women with homogenous menstrual status (i.e., naturally cycling with confirmed ovulation) and of comparable training level within the same sport, minimal variability in hormonal status remains, as my athlete monitoring stage revealed one participant with menstrual irregularity. Also, women completed their own training with distinct types, intensities and volumes of training that caused variability in the cohort. Third, the statistical analysis of physiological and self-report measures, as well as menstrual cycle symptoms, was completed at the group level. There is still value provided by such analysis but the insight gained into individual experience is limited and warrants further investigation. Fourth, the participants self-

selected their training and no participant trained every single day during all 3 cycles. As such, the insights gained are limited to the data from training days since no data pertaining to training response was obtained on rest days.

For the qualitative interviews, the structure (i.e., group or individual) and environment of the interviews may have impacted the depth of conversation that was achieved with participants. Although the group interviews still generated rich discussion, the individual speaking time for each participant was limited by the nature of the interview structure. Additionally, conducting interviews virtually (as opposed to in-person) limited the extent to which I could accurately gauge facial cues and read body language which may have influenced my ability to interact with participants. Virtual interviews were necessary due to the ongoing COVID-19 pandemic and they proved advantageous in facilitating broader geographic reach of my sample which helped increase recruitment potential. Finally, researchers engaging with new materialism would not necessarily use conventional methods to collect and analyze data (Smith & Monforte, 2020). Using interviews as my only method for qualitative data generation, hence, limited the depth to which I engaged with women athletes' training experiences.

Future Research Directions

Recent growth in female specific sport science, including contributions from the present research, continues to improve our understanding of the interactions between the menstrual cycle, exercise training and athlete health. However, I see several possible directions for future research. First, more studies devoted to exploring single athlete case studies can help to advance knowledge by generating insight about the individual variability in female endurance athletes and their training as well as exemplify the recommendation of taking a personalized approach to understanding exercise across the menstrual cycle in an individual (McNulty et al., 2020).

Second, continued research into menstrual cycle symptoms is required. Echoing the recommendation of (Bruinvels et al., 2022), insight into symptoms clusters (i.e., which symptoms frequently occur together) may better inform how symptoms influence training and vice versa, as well as how symptoms may be managed. In addition, investigating menstrual symptoms alongside markers of overtraining syndrome (OTS) and relative energy deficiency in sport (RED-S) would be a worthwhile line of inquiry. Current knowledge in sport medicine surrounding OTS and RED-S, similarly, continues to grow. The potential symptoms to demarcate overtraining syndrome are plentiful (Fry, 1991). Recent work highlights how the symptoms associated with both OTS and RED-S overlap significantly, making it challenging to accurately and definitively diagnose either condition (Stellingwerff et al., 2021). Some of these symptoms may further overlap with commonly experienced menstrual cycle symptoms. Yet, if practitioners and athletes alike are not familiar with the typical menstrual cycle symptoms experienced by an athlete, recognizing what may or may not be a true symptom and "red flag" of OTS and/or RED-S could become increasingly difficult. Thus, future research to investigate the overlap in symptoms between the menstrual cycle, OTS, and RED-S may offer useful insight for sport-scientists and coaches as well as sport medicine practitioners.

Final Thoughts

Using data collected with both qualitative and quantitative methods, the purpose of this study was to explore how female endurance athletes, specifically distance runners, perceived and responded to athletic training throughout the menstrual cycle. The aims of this study were to generate an improved understanding of how female endurance athletes perceive their menstrual cycle to impact their training; and second, to determine what objective insight can be achieved from consistent monitoring of athlete training and menstrual cycle data. I believe I was able to

achieve these aims: a) a better understanding of *who* the female athlete is then informs a better understanding of *how* the female athlete experiences the menstrual cycle alongside athletic training; and b) meaningful patterns within objective data *can* be achieved with consistent monitoring but *should* be investigated across multiple time points (such as the eight-time point approach used herein) to accurately capture menstrual cycle phases and the transitions between.

The effective design and execution of this study was a complex and extensive task. The quantitative research process involved administration of daily surveys to collect data over the course of five months; the analysis of these data was experimental, with an absence of comparable literature, at the time, to support a specific analysis strategy. The qualitative research process comprised of ten qualitative interviews and amounted to nearly thirteen hours of data – this added substantial value, helping me uncover the stories behind the numbers. Indeed, I owe a great deal of gratitude to my supervisory committee who could have easily recommended that I "scale back" and limit the study design to a singular method. Rather, I was met with enthusiasm and graciously supported by experts from vastly different and unique disciplines, uniting with the common goal of advancing female athlete health in sport science. In closing, I would challenge more researchers to extend their boundaries and attempt to work across disciplines – I suspect the future of sport science would be undeniably benefitted.

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Appendix A –Menstrual Cycle Phases

Menstrual phase definitions based on hormonal profiles (Retrieved from Elliott-Sale et al., 2021)

Recommendation	Rationale (intended to…)	Pro	Con
Phase 1: indicated by the onset of bleeding until day 5. Oestrogen and progesterone levels are low.	Capture the lowest concentrations of oestrogen and progesterone	Easy to determine due to obvious physical cue (i.e., bloody discharge)	Can be difficult to predict in those with variable cycle length therefore requiring reactive testing session (i.e., participant alerting the researcher on day 1 of bleeding and then both parties having availability for testing within the next 4 days)
Phase 2: occurs in the 14-26 h prior to ovulation and the LH surge. Oestrogen higher than during phase 1, 3 and 4 and progesterone higher than during phase 1, but lower than 6.36 nmol-L^{-1}	Capture the highest oestrogen concentration while progesterone remains low	Enables the biggest difference between oestrogen and progesterone to be investigated	Difficult to predict without daily blood samples for the determination of oestrogen and progesterone
Phase 3: indicated by a positive urinary ovulation kit and lasts 24-36 h. Oestrogen higher than phase 1 but lower than phase 2 and 4 and progesterone higher than phase 1 but lower than 6.4nmol-L^{-1}	Capture a medium oestrogen concentration while progesterone remains low	Easy to establish due to positive LH* surge captured by the ovulation kit	Relies on having multiple ovulation kits available for each participant (cost) and requires reactive testing (i.e., participant alerting researcher to the positive result and then both parties having availability for testing within the next 24-36 h)
Phase 4: +7 days after ovulation has been confirmed. Oestrogen higher than phase 1 and 3 but lower than phase 2 and progesterone >16 nmol-L^{-1}	Capture the highest concentration of progesterone and a high concentration of oestrogen	Easy to establish in those with eumenorrheic cycles as it typically occurs within 7 days of confirmed ovulation	Relies on the confirmation of ovulation

**LH = luteinizing hormone*

This table is retrieved from the following article: Elliott-Sale, K. J., Minahan, C. L., de Jonge, X., Ackerman, K. E., Sipila, S., Constantini, N. W., Lebrun, C. M., & Hackney, A. C. (2021). Methodological Considerations for Studies in Sport and Exercise Science with Women as Participants: A Working Guide for Standards of Practice for Research on Women. *Sports Medicine*, *51*(5), 843-861. https://doi.org/10.1007/s40279-021-01435-8

Appendix B – Ethics Approval Letter

Notification of Approval

Date:	January 17, 2022
Study ID:	Pro00115475
Principal Investigator:	Sara Szabo
Study Supervisor:	Michael Kennedy
Study Title:	Exploring the subjective perceptions and objective responses to training stress throughout the menstrual cycle in women endurance athletes
Approval Expiry Date:	January 16, 2023

Thank you for submitting the above study to the Research Ethics Board 2. Your application has been reviewed and approved on behalf of the committee.

Approved Documents:

Recruitment Materials
Recruitment Letter (Clean)
Social Media Recruitment Post (Revised)
Recruitment Email (Clean)
Letter of Initial Contact
Revised Email Script (Clean)
Consent Forms
Information & Consent Form (Clean)
Questionnaires, Cover Letters, Surveys, Tests, Interview Scripts, etc.
Interview Guide (Clean)
Revised Daily Check-In Questionnaire (Survey Monkey)
Revised Intake Questionnaire (Survey Monkey)
Other Documents
Athlete Monitoring Instructions

Any proposed changes to the study must be submitted to the REB for approval prior to implementation. A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the REB does not constitute authorization to initiate the conduct of this research. The Principal Investigator is responsible for ensuring required approvals from other involved organizations (e.g., Alberta Health Services, Covenant Health, community organizations, school boards) are obtained, before the research begins.

Sincerely,

Carol Boliek, PhD
Associate Chair, Research Ethics Board 2

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix C – Study Eligibility Form

Menstrual Cycle & Training Stress: Study Eligibility Form

Please fill out the following questions to determine if you are eligible to participate in this study.
The Research Ethics Board at the University of Alberta has reviewed the plan for this study. If you have questions about your rights as a research participant, you may email reoffice@ualberta.ca and quote Ethics ID Pro00115475.

Please enter your name (first & last):

Do you currently reside in Canada?
Yes
No

Are you between the ages of 18-40?
Yes
No

Have you used any form of hormonal contraceptive within the last 3 months?
Yes
No

If applicable, are you at least 12 months postpartum?
Yes
No
Not Applicable

Is running your primary sport?
Yes
No

Are you actively preparing for a running specific event/competition occurring in the next 4-6 months?
Yes
No

Are you currently experiencing any injuries?
Yes
No

Thank you for completing this form. You will be contact directly to confirm whether or not you are eligible to participate in this study.

Appendix D – Information and Consent Form

Initial ICF:

INFORMATION LETTER & CONSENT FORM

Study Title: Exploring the subjective perceptions and objective responses to training stress throughout the menstrual cycle in women endurance athletes

Principal Investigator:
Sara Szabo
4-245 Van Vliet Complex
University of Alberta
Edmonton, AB T6G 2H9
sszabo@ualberta.ca

Co-Investigator:
Dr. Michael Kennedy
4-230 Van Vliet Complex
University of Alberta
Edmonton, AB T6G 2H9
kennedy@ualberta.ca

Background & Purpose:
You are being asked to participate in a research study. This study explores the objective and subjective responses to athletic training throughout the menstrual cycle in women endurance athletes. The menstrual cycle is an important biological process in women. Changes in female hormones support reproductive function but also impact many other systems. As such, sport performance and the menstrual cycle is a growing area of research. Still, we need more research to better understand athletes' experiences, perceptions, and responses. We want to learn how endurance athletes perceive and respond to training stress throughout the menstrual cycle. It is important to consider women-specific physiology when monitoring athlete training. For instance, by tracking the cycle with common measures of exercise effort and athlete fatigue. Doing so will lead to a better understanding of the training response in women athletes.

Participation:
There are two phases to participation in this study. The first phase is a 12-week monitoring phase. The second phase involves a one-on-one interview. The monitoring phase includes an intake survey and 12-weeks of daily check-ins. The intake survey will take approximately 5 minutes to complete. Questions will ask about your menstrual cycle history and your athletic history. The daily check-in will be a brief survey sent to you by e-mail at 8PM each day. Daily check-in surveys will ask for menstrual and training information for that day. You will need to take your resting heart rate each morning immediately upon waking. You will need to verify your cycle day using a urinary ovulation detection test. You will also need to take your basal body temperature each morning. Urinary ovulation tests and basal body thermometers are provided. Each daily check-in will take approximately 5-10 minutes to complete. The one-on-one interview will occur after the monitoring phase ends. Interview questions will ask about your experiences with your menstrual cycle and training. This will allow an opportunity to share more detailed information. Interviews will occur over Zoom and will take place at a time that is convenient for you. The interviewer will keep an audio-recording of the interview conversation. The interview will take approximately 60 minutes.

Approximately 20 individuals will be studied for this research study. Participation in this study is ***completely voluntary.*** You can withdraw your participation in this study, without consequence. You may decline to answer any questions at any time during the interview. You may withdraw your data up to 2 weeks following the completion of the monitoring phase and/or the interview. If you do, researchers will delete any data collected from you from the study. If you wish to withdraw, please inform the research assistant or principal investigator.

Benefits:

There is no direct benefit to study participants, however each participant will receive a summary of their monitoring phase. This will highlight any available patterns between training and the menstrual cycle. Participants can use this information to better understand their menstrual cycle and training. Athletes can then share this information with coaches or sport practitioners. In turn, this may help inform and guide future decision making.

Risks:
There are no foreseeable risks to participation in the study.

Confidentiality & Anonymity:
Any personal identifying information will remain confidential. Data might appear in journal publications or conference presentations. In this case, researchers will remove any personal identifiers to maintain participant anonymity. All survey data will be stored on servers located in the United States and is subject to the USA privacy legislation, so we cannot guarantee absolute privacy. Participants must know that no voice or video calling software is completely secure. We will only be using Zoom Video Conference software. This software uses encryption and meets the University of Alberta's security requirements. Researchers will collect interview data through audio-recordings. Researchers will keep all audio and transcribed files in a folder. The folder will be password protection and encrypted to ensure confidentiality. The computer is only accessible to the research assistant. Researchers will immediately destroy written field notes after transcription. Researchers will keep study information for 5 years after publication. Researchers will destroy all study information after this duration. Presented data (written or verbal) will not link to you by name or any other personal identifiers. Researchers will change any identifiable information to guarantee anonymity.

Contact Information:
If you have any more questions about the research study, please contact either of the researchers. You can find their contact information at the top of this letter. The Research Ethics Board at the University of Alberta has reviewed the plan for this study. If you have questions about your rights as a research participant, please email reoffice@ualberta.ca and quote Ethics ID Pro00115475. This office is independent of the researchers.

Consent Statement:
I have read this form and received an explanation of the proposed research study. I have had the opportunity to ask questions. I have received answered to all questions. If I have more questions, I understand who to contact. I agree to take part in this survey for the research study described above. After reading and signing this document, please return by email to Sara Szabo (sszabo@ualberta.ca).

_____	_____
Participant Name (Printed)	**Date**
_____	_____
Participant Name (Signed)	**Date**
_____	_____
Researcher Name (Printed)	Date
_____	_____
Researcher Name (Signed)	Date

Revised ICF:

INFORMATION LETTER & CONSENT FORM

Study Title: Exploring the subjective perceptions and objective responses to training stress throughout the menstrual cycle in women endurance athletes

Principal Investigator:
Sara Szabo
4-245 Van Vliet Complex
University of Alberta
Edmonton, AB T6G 2H9
sszabo@ualberta.ca

Co-Investigator:
Dr. Michael Kennedy
4-230 Van Vliet Complex
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Edmonton, AB T6G 2H9
kennedy@ualberta.ca

Background & Purpose:
You are being asked to participate in a research study. This study explores the objective and subjective responses to athletic training throughout the menstrual cycle in women endurance athletes. The menstrual cycle is an important biological process in women. Changes in female hormones support reproductive function but also impact many other systems. As such, sport performance and the menstrual cycle is a growing area of research. Still, we need more research to better understand athletes' experiences, perceptions, and responses. We want to learn how endurance athletes perceive and respond to training stress throughout the menstrual cycle. It is important to consider women-specific physiology when monitoring athlete training. For instance, by tracking the cycle with common measures of exercise effort and athlete fatigue. Doing so will lead to a better understanding of the training response in women athletes.

Participation:
There are two phases to participation in this study. The first phase is a 12-week monitoring phase. The second phase involves a one-on-one interview. The monitoring phase includes an intake survey and 12-weeks of daily check-ins. The intake survey will take approximately 5 minutes to complete. Questions will ask about your menstrual cycle history and your athletic history. The daily check-in will be a brief survey sent to you by e-mail at 8PM each day. Daily check-in surveys will ask for menstrual and training information for that day. You will need to take your resting heart rate each morning immediately upon waking. You will need to verify your cycle day using a urinary ovulation detection test. You will also need to take your basal body temperature each morning. Urinary ovulation tests and basal body thermometers are provided. Each daily check-in will take approximately 5-10 minutes to complete. The one-on-one interview or group interview will occur after the monitoring phase ends. Group interviews will consist of 3 to 4 participants per group. You may choose to participate in a group or one-on-one interview, whichever you feel comfortable with. Interview questions will ask about your experiences with your menstrual cycle and training. This will allow an opportunity to share more detailed information and in the case of group interviews, engage in discussion with other women athletes. Interviews will occur over Zoom and will take place at a time that is convenient for you or for the group. The interviewer will keep an audio-recording of the interview conversation. The interview will take approximately 60 minutes.

Approximately 20 individuals will be studied for this research study. Participation in this study is ***completely voluntary.*** You can withdraw your participation in this study, without consequence. You may decline to answer any questions at any time during the interview. You may withdraw your data up to 2 weeks following the completion of the monitoring phase and/or the interview. If you decide to withdraw, researchers will delete any data collected from you from the study. Data cannot be withdrawn from group interview

transcripts, however, if a participant withdraws, their data will not be quoted or used in publication. If you wish to withdraw, please inform the research assistant or principal investigator.

Benefits:
There is no direct benefit to study participants, however each participant will receive a summary of their monitoring phase. This will highlight any available patterns between training and the menstrual cycle. Participants can use this information to better understand their menstrual cycle and training. Athletes can then share this information with coaches or sport practitioners. In turn, this may help inform and guide future decision making.

Risks:
There are no foreseeable risks to participation in the study.

Confidentiality & Anonymity:
Any personal identifying information will remain confidential. In the case of group interviews, confidentiality and anonymity cannot be guaranteed. The interview can guarantee responses will be kept private to protect your identity, but in a group interview, your identity and responses may be known to other interviewees present. All interviewees will be asked to respect the anonymity and confidentiality of the interview. All interviewees will be asked to agree to this statement prior to beginning the interview. Data might appear in journal publications or conference presentations. In this case, researchers will remove any personal identifiers to maintain participant anonymity. All survey data will be stored on servers located in the United States and is subject to the USA privacy legislation, so we cannot guarantee absolute privacy. Participants must know that no voice or video calling software is completely secure. We will only be using Zoom Video Conference software. This software uses encryption and meets the University of Alberta's security requirements. Researchers will collect interview data through audio-recordings. Researchers will keep all audio and transcribed files in a folder. The folder will be password protection and encrypted to ensure confidentiality. The computer is only accessible to the research assistant. Researchers will immediately destroy written field notes after transcription. Researchers will keep study information for 5 years after publication. Researchers will destroy all study information after this duration. Presented data (written or verbal) will not link to you by name or any other personal identifiers. Researchers will change any identifiable information to guarantee anonymity.

Contact Information:
If you have any more questions about the research study, please contact either of the researchers. You can find their contact information at the top of this letter. The Research Ethics Board at the University of Alberta has reviewed the plan for this study. If you have questions about your rights as a research participant, please email reoffice@ualberta.ca and quote Ethics ID Pro00115475. This office is independent of the researchers.

Consent Statement:
I have read this form and received an explanation of the proposed research study. I have had the opportunity to ask questions. I have received answered to all questions. If I have more questions, I understand who to contact. I agree to take part in this survey for the research study described above. After reading and signing this document, please return by email to Sara Szabo (sszabo@ualberta.ca).

_____	_____
Participant Name (Printed)	**Date**
_____	_____
Participant Name (Signed)	**Date**

_____	_____
Researcher Name (Printed)	Date
_____	_____
Researcher Name (Signed)	Date

Appendix E – Menstrual Cycle and Training Stress: Intake Questionnaire

Menstrual Cycle and Training Stress: Intake Questionnaire (Informed Consent)
Please read the following information carefully before proceeding.

Background & Purpose: The menstrual cycle is an important biological process in women. Changes in female hormones support reproductive function but also impact many other systems. As such, sport performance and the menstrual cycle is a growing area of research. We want to learn how endurance athletes perceive and respond to training stress throughout the menstrual cycle. It is important to consider women-specific physiology when monitoring athlete training. For instance, by tracking the cycle with common measures of exercise effort and athlete fatigue. Doing so will lead to a better understanding of the training response in women athletes.
Participation: There are two phases to participation in this study. The first phase is a 12-week monitoring phase. The second phase involves a one-on-one interview; however, this consent form will highlight only the athlete monitoring (survey collection) phase. The monitoring phase includes an intake survey and 12-weeks of daily (AM & PM) check-ins. The intake survey will take approximately 5 minutes to complete. Questions will ask about your menstrual cycle history and your athletic history. The daily check-ins will be brief surveys sent to you by e-mail at 8AM and 8PM each day. Daily check-in surveys will ask for menstrual and training information for that day. You will need to verify your cycle day using a urinary ovulation detection test. You will also need to take your basal body temperature each morning. Urinary ovulation tests and basal body thermometers are provided. Each daily check-in will take approximately 5-10 minutes to complete. Participation in this study is completely voluntary. You can withdraw your participation in this study, without consequence. You may decline to answer any questions at any time during the interview. You may withdraw up to 2 weeks following the completion of the monitoring phase and/or the interview. If you do, researchers will delete any data collected from you from the study. If you wish to withdraw, please inform the research assistant or principal investigator.
Benefits: There is no direct benefit to study participants. There is an indirect benefit to participation. Each participant will receive a summary of their monitoring phase. This will highlight any available patterns between training and the menstrual cycle. Participants can use this information to better understand their menstrual cycle and training. Athletes can then share this information with coaches or sport practitioners. In turn, this may help inform and guide future decision making.
Risks: There are no foreseeable risks to participation in the study.
Confidentiality & Anonymity: Any personal identifying information will remain confidential. All survey data will be stored on servers located in the United States and is subject to the USA privacy legislation. Researchers will keep study information for 5 years information for 5 years after publication. Researchers will destroy all study information after this duration. Presented data (written or verbal) will not link to you by name or any other personal identifiers. Researchers will change any identifiable information to guarantee anonymity.
Contact Information: If you have any more questions about the research study, please contact Sara Szabo (sszabo@ualberta.ca). The Research Ethics Board at the University of Alberta has reviewed the plan for this study. If you have questions about your rights as a research participant, you may call (780) 492-2615. This office is independent of the researchers.

*** Consent Statement:** I have read this form and received an explanation of the proposed research study. I have had the opportunity to ask questions. I have received answered to all questions. If I have more questions, I understand who to contact. I agree to take part in this survey for the research study described above.

Yes, I consent to participate in this survey.
No, I do not consent to participate in this survey.

Menstrual Cycle and Training Stress: Intake Questionnaire
Demographic Information (Page 1)

1.1 Please enter your contact information below. A shipping address is only required to deliver necessary study equipment that will be used during the athlete monitoring phase (urinary ovulation test kit & basal body thermometer) and will not be used for any other purposes.
Name:
Address:
Address 2:
City/Town:
State/Province:
Zip/Postal Code:
Country:
Email Address:

1.2 Please enter your height (cm) and weight (kg) in the boxes below.
Height (cm)
Weight (kg)

1.3 Enter your age at the time of the study:

1.4 I identify as:
Female
Non-Binary / Gender-Queer
Prefer not to disclose
Other (please specify)

Menstrual Cycle and Training Stress: Intake Questionnaire
Menstrual Cycle Questions (Page 2)

2.1 At what age did you begin menstruating?

2.2 Have you experienced any of the following irregularities throughout your menstrual history?
Amenorrhea (absent period for at least 3 months without pregnancy)
Oligomenorrhea or Infrequent Periods (occurring >35 days apart)
Menorrhagia (excessive menstrual bleeding)
Prolonged Menstrual Bleeding (regularly exceeding 8 days)
None of the above
Other (please specify)

2.3 Have you used any forms of birth control in the past? Please check all that apply.
Oral Contraceptive Pill
Hormonal Intrauterine Device
Cooper Intrauterine Device
Implant
Injectable Birth Control
Vaginal Ring
Contraceptive Patch
None of the above

2.4 Are there any menstrual symptoms that you experience frequently (i.e., most menstrual cycles)? Please check all that apply.
Fatigue/Reduced Energy Levels
Weakness
Tender/Painful Breasts
Increased Body Temperature
Increased Breathing
Feeling Stressed
Poor Concentration
Stomach Cramps
Muscle Aches
Nausea
Irritability
Heavy Legs
Headache
Disturbed Sleep
Diarrhea
Constipation
Food Cravings
Bloating
Lower Back Pain
Anxiousness
Reduced Motivation
Other (please specify)

2.5 In general, how knowledgeable do you feel about the menstrual cycle?
Not at all knowledgeable
Slightly knowledgeable
Somewhat knowledgeable
Moderately knowledgeable
Very knowledgeable

Menstrual Cycle and Training Stress: Intake Questionnaire
Athlete/Training Related Questions (Page 3)

3.1 How long have you been training as an endurance athlete in the sport of running?
Less than 1 year
1-3 years
3-5 years
5-10 years
10-15 years
More than 15 years

3.2 Specifically, how many years have you been training as a runner?

3.3 Which of the following athlete categories do you identify within?
Tier 5: World Class (Olympic and/or world medalists; world record holders and athlete achieving within 2% of world-record and/or world leading performance; top 3-20 in world rankings and/or 3-10 at an Olympics/World Championships)
Tier 4: Elite/International (competing at the international level; top 4-300 in world rankings; athletes achieving within 7% of world-record and/or world leading performance)

Tier 3: Highly Trained/National Level (competing at the national level; achievement within 20% of world-record and/or world leading performance; completing structured & periodized training and developing to be within 20% of maximal norms in the given sport)
Tier 2: Trained/Development (local level representation; identify with a specific sport and regularly training ~3 times/week; training with a purpose to compete)
Tier 1: Recreationally Active (meet the physical activity guidelines of 150-300 mins of moderate-intensity activity or 75-150 mins of vigorous activity per week, plus a minimum of 2 days/week of muscle strengthening activities; may participate in multiple sports/activity)
Tier 0: Sedentary (do not meet physical activity guidelines)

Performance standards for classifications of female athletes in middle distance and long-distance endurance sport

	Tier 5	**Tier 5**	**Tier 5**	**Tier 5**	**Tier 4**	**Tier 4**	**Tier 3**	**Tier 3**
Distance	World Record (WR) Time	World Leading (WL) Time	2% of WR	2% of WL	7% WR	7% WL	20% WR	20% WL
5000m (min:s)	14:06.62	14:13.32	14:23.60	14:30.40	15:05.90	15:13.10	16:55.90	17:04:00
10,000m (min:s)	29:01.03	29:01.03	29:35.90	29:35.90	31:02.9	31:02.9	34:49.20	34:49.20
Marathon (h:min:s)	2:14:04	2:19:35	2:16:45	2:22:22	2:232:27	2:29:21	2:40:53	2:47:30

Retrieved from: Mckay, A., Stellingwerff, T., Smith, E. S., Martin, D. T., Mujika, I., Goosey-Tolfrey, V. L., Sheppard, J., & Burke, L. M. (2021). Defining training and performance caliber: A participant classification framework. *International Journal of Sports Physiology and Performance.*

3.4 Do you currently work with a coach to guide your training?
Yes
No
If no, please explain.

3.5 If yes, do you discuss your menstrual cycle with your coach?
Yes, I frequently discuss my menstrual cycle with my coach.
Yes, I occasionally discuss my menstrual cycle with my coach.
No, I do not discuss my menstrual cycle with my coach.

3.6 Do you track your menstrual cycle?
Yes
No
If yes, how do you track your cycle? (i.e., specific app, calendar counting)

Your athlete monitoring phase will begin on the first day of your next menstrual cycle. To help determine a timeline, please identify the first day of your last period (bleeding).

You have reached the end of the intake survey. Thank you for your participation.
You will be contacted directly (via email) by the researchers to arrange the beginning of your athlete monitoring phase.

Appendix F – Athlete Monitoring Stage: Instructions Guide

You are being asked to participate in a 12-week athlete monitoring phase as a part of data collection for the research study: '*Exploring the subjective perceptions and objective responses to training stress throughout the menstrual cycle in women endurance athletes.'*

During the athlete monitoring phase, you will receive a daily questionnaire that will ask you questions about your menstrual cycle and training for that day. An individualized start date will have been determined for you by the researcher. You may begin filling out the daily check-in on the first day that you begin menstruating. This document offers instructions for how to answer questions included in the daily questionnaire. Please keep it for your reference over the course of the 12-week monitoring phase. If you have any further questions, please contact Sara Szabo at sszabo@ualberta.ca.

1. **Resting Heart Rate (HR)**
   For the most accurate recording of your resting heart rate, you should measure immediately upon waking while lying in supine position (face up). You can take your resting HR manually by checking your pulse (i.e., radial pulse at wrist) and recording the number of beats over 15 seconds. Multiply this number by 4 to determine your heart rate in beats per minute (bpm).

   Alternately, you may record your heart rate using a HR chest strap or by reading the optical HR measure provided by a sport watch (i.e., Garmin, Apple Watch, Suunto, Polar, Coros) if worn through the night. A benefit of wearing a watch is that AM heart rate recordings for a given day can be retrieved at a later date, if required. However, please note the optical HR measure will be the *least* accurate recording.

2. **Basal Body Temperature**
   For the most accurate recording of your basal body temperature, you should measure immediately upon waking, before getting out of bed. Using a digital thermometer (provided), record your body temperature using 2 decimal places. Note: for an accurate reading, you should have had at least 3 hours of uninterrupted sleep.

It is recommded to record these morning measures in a notebook or on your smart phone (i.e., Notes) so that you may easily recall the numbers when completing your evening check-in for that day.

3. **Cycle Day**
   Record your cycle day based on where you are in your menstrual cycle. The first day of your period (bleeding or spotting) is considered Day 1. The last day of your cycle is the day *before* your next period (i.e., Day 28).

4. **Urinary Ovulation Detection**
   Ovulation can be predicted using a urinary ovulation detection test which identifies the presence of luteinizing hormone (LH) in urine. You have been provided with OVRY Ovulation Test Strips for the purpose of this research study. Please refer to their instructions for reference on how to use the test strips. If at any time you need replacement instructions, please contact the researcher at the email above.

   The best time to complete this test is between 10AM-8PM. You **do not** need to test every day, begin testing on the recommended day within your cycle (see OVRY instructions) – once you

have identified the presence of LH (positive test reading), please continue testing until you receive a negative reading. For example, if you have a 30-day menstrual cycle, begin testing on Day 14. If after 3 days of testing positive you then record a negative ovulation test on the urine strip, you may stop testing.

5. **Type & Duration of Training**
   Select the most appropriate **type** of training that you completed on any given day. Time specifications are provided for most of the options. Below are some examples:

   Example 1: Easy Run (60 minutes, conversational pace): *Select "Aerobic (up to 90 mins)"*

   Example 2: KM Repeat Workout (20 min warm up, 5 x 1km at 4:00/km with 2 min rest, 20 min cool down): *Select "Workout – Aerobic Intervals (2-8 mins work)*

   Identify the **total duration** (in minutes) completed in a given exercise session. For Example 1, you would record "60" and for Example 2, you would record "68".

6. **Rating of Perceived Exertion (RPE)**
   Your rating of perceived exertion is used to identify the effort you felt you exerted during a given exercise session. Select the most appropriate value from the drop-down list offered in the questionnaire. Please consider the *entire* exercise session, including warm up/work/active rest/cool down.

Some days you may complete more than one training session. If this is the case, please repeat Steps 5 & 6, identifying the type, duration and RPE of your second training session in the available answer fields.

7. **Satisfaction Scale / Motivation Scale / Muscle Feel Scale**
   For each of these scales, please select the most appropriate value for that day from the drop-down list.
   When considering how satisfied you felt about your training that day, please consider your satisfaction *overall*, across all training sessions completed. If you did not complete any training that day, you may select "Not Applicable" for the Satisfaction Scale, but may still answer the subsequent scale questions.

8. **"How are you feeling today?"**
   This open-ended question is meant to offer an opportunity for you to express, generally, how you are feeling on that given day. You can use this box to share any additional life stressors or pleasures that may be contributing to how you feel, physically or emotionally. Please use this space to comment on anything that was not addressed within the questionnaire for that day.

Questions

What happens if I forget to fill out the questionnaire one evening?
It is likely that at some point throughout the 12-week (3 menstrual cycle) monitoring phase, this might happen. Please fill out the survey as soon as you remember the following day. If you use a training app or watch (i.e., Strava, Garmin, Suunto) you should be able to collect most of the information required at a later time.

What happens if I get injured or sick during the monitoring phase?

Minor niggles or irritations are expected to happen throughout the 12-weeks, this is OK. It may even provide some valuable information. If you're having a minor issue but can continue to train, please make a brief note of this in the "How are you feeling today?" comment box. If you sustain a prolonged injury/illness (i.e., requiring ≥1 week off) throughout monitoring phase, please contact the researcher (Sara Szabo) at the email provided above. Each situation will be reviewed on an individual basis, but depending on the severity, you may be required to withdraw from the study.

What if I'm travelling or away from home and cannot complete the questionnaire?
Life happens! If you cannot complete the questionnaire due to travel or lifestyle factors for a brief period of time, that is OK. Extended periods will be evaluated on an individual basis. Please notify the researcher if you know of any circumstances that may impact your ability to complete the questionnaire throughout the 12-week timeline.

Appendix G – Athlete Monitoring Stage: Daily Survey

Menstrual Cycle & Training Stress: Daily Check-In

Please answer each question to the best of your ability. Note: your resting heart rate and basal body temperature values should both be taken first thing in the morning. If you have any questions/concerns, please contact Sara Szabo (sszabo@ualberta.ca).
The Research Ethics Board at the University of Alberta has reviewed the plan for this study. If you have questions about your rights as a research participant, you may email reoffice@ualberta.ca and quote Ethics ID Pro00115475.

1. Please state your resting heart rate, taken upon waking:

2. Please state your basal body temperature, taking upon waking:

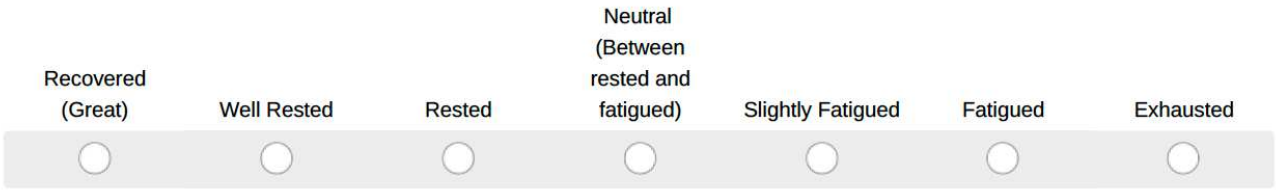
3. Please state your cycle day:

4. Are you experiencing your period today?
   Yes
   No

5. The provided urinary ovulation test kit can be used mid-cycle to determine if you are ovulating. Are you ovulating today?
   Yes
   No

6. Did you experience any menstrual symptoms today? Please check all that apply.
   Fatigue/Reduced Energy Levels
   Weakness
   Tender/Painful Breasts
   Increased Body Temperature
   Increased Breathing
   Feeling Stressed
   Poor Concentration
   Stomach Cramps
   Muscle Aches
   Nausea
   Irritability
   Heavy Legs
   Headache
   Disturbed Sleep
   Diarrhea
   Constipation
   Food Cravings
   Bloating
   Lower Back Pain
   Anxiousness
   Reduced Motivation
   Other (please specify)

7. How do you physically feel today?



8. Please select the **mode** of training you completed today:
   Run
   Cycle
   Swim
   Nordic Ski
   Non-Aerobic Training
   Other (please specify): _____

9. Based on the mode of training selected above, please select the **type** of training you completed today:
   Long Slow Distance (>90 mins)
   Aerobic (up to 90 mins)
   Workout – Tempo (8 to 30 mins work)
   Workout – Aerobic Intervals (2 to 8 mins work)
   Workout – Anaerobic Capacity & VO^2max Intervals (~90 secs to 2 mins work)
   Workout – Anaerobic Power (~0 to 45 secs work)
   Race/Time Trial
   Muscular Strength (i.e., weight lifting)
   Muscular Endurance (i.e., circuit training, CrossFit, Orange Theory)
   Neuromuscular (i.e., yoga, Pilates)
   Off – No Training
   Other (please specify): _____

10. Please enter the total **duration** of your training session (in minutes).
    NOTE: this should include warm up, work, active rest, and cool down.

11. Please select your **overall rating of perceived exertion (RPE)** for your training session today.

Rating	Descriptor
0	Rest
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal

12. If you completed a **SECOND** training session today, please select the **mode** of training you completed today:
    Run
    Cycle
    Swim
    Nordic Ski
    Non-Aerobic Training
    Other (please specify): _____

13. Based on the mode of training selected above, please select the **type** of training you completed today for your **SECOND** session:
    Long Slow Distance (>90 mins)
    Aerobic (up to 90 mins)
    Workout – Tempo (8 to 30 mins work)
    Workout – Aerobic Intervals (2 to 8 mins work)
    Workout – Anaerobic Capacity & VO^2max Intervals (~90 secs to 2 mins work)
    Workout – Anaerobic Power (~0 to 45 secs work)
    Race/Time Trial
    Muscular Strength (i.e., weight lifting)
    Muscular Endurance (i.e., circuit training, CrossFit, Orange Theory)
    Neuromuscular (i.e., yoga, Pilates)
    Off – No Training
    Other (please specify): _____

14. If applicable, please enter the total **duration** of your **SECOND** training session (in minutes):

15. If applicable, please select your **overall rating of perceived exertion (RPE)** for your **SECOND** training session today.

Rating	Descriptor
0	Rest
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal

16. Please rate how satisfied you felt with your training today.

Rating	Descriptor
0	Extremely Unsatisfied
1	
2	Very Unsatisfied
3	
4	Unsatisfied

5	
6	Satisfied
7	
8	Very Satisfied
9	
10	Extremely Satisfied

17. Please rate how motivated you feel for your ***next*** training session.

Rating	Descriptor
0	Extremely Unmotivated
1	
2	Very Unmotivated
3	
4	Unmotivated
5	
6	Motivated
7	
8	Very Motivated
9	
10	Extremely Motivated

18. Please state your overall 'muscle feel' today.

Rating	Feeling
0	Extremely Light
1	Very, Very Light
2	
3	Very Light
4	Light
5	OK
6	Somewhat Heavy
7	Very Heavy
8	
9	Very, Very Heavy
10	Extremely Heavy

19. Overall, how are you feeling today?
Please use this space to provide any additional comments you may have.

Thank you for completing today's check-in.

Appendix H – Rating of Perceived Exertion, Muscle Feel, Motivation & Satisfaction

Session Rating of Perceived Exertion Scale (Retrieved from Foster et al., 2001)

Calculation of exercise score using session-RPE to measure training load:
*Duration of training session (minutes) * Session RPE of training = Training Load (Arbitrary Units)*
*i.e., Easy Aerobic Run (**60 minutes**) * RPE (**3**) = Training Load of **180 au***

Modification of the Category Ratio Rating of Perceived Exertion Scale

Rating	Descriptor
0	Rest
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal

The modified body feeling scale below allows the participant to rate the local feeling in the muscle from “light” to “heavy” (Retrieved from Gustafsson et al., 2008).

Subjective Body Feeling Scale

Rating	Feeling
0	Extremely Light
1	Very, Very Light
2	
3	Very Light
4	Light
5	OK
6	Somewhat Heavy
7	Very Heavy
8	
9	Very, Very Heavy
10	Extremely Heavy

Appendix D (Continued)

0-10 Category Ratio (CR) Scale retrieved from (Borg, 1990)

The following scale will allow participants to rate their session satisfaction.
i.e.: How satisfied did you feel with your training session today?

Exercise Satisfaction Scale

Rating	Descriptor
0	Extremely Unsatisfied
1	
2	Very Unsatisfied
3	
4	Unsatisfied
5	
6	Satisfied
7	
8	Very Satisfied
9	
10	Extremely Satisfied

Participants will be asked to rate their motivation if they indicate feeling unsatisfied (rating of 5 or less on the above scale) with their exercise session.
i.e.: How motivated do you feel about your next training session?

Exercise Motivation Scale

Rating	Descriptor
0	Extremely Unmotivated
1	
2	Very Unmotivated
3	
4	Unmotivated
5	
6	Motivated
7	
8	Very Motivated
9	
10	Extremely Motivated

Appendix I – Interview Guide

INTERVIEW GUIDE 1.0

"How do women endurance athletes perceive and respond to training stress throughout the menstrual cycle?"

Interview Preface

Thank you for agreeing to participate in this interview with me. I am leading a project which will explore both the subjective and objective responses to training stress throughout the menstrual cycle in women endurance athletes. Sport performance and the menstrual cycle has been a growing area of research in the last few years but there is still very little high-quality research on this topic. This interview will explore how you, as an endurance athlete perceive your menstrual cycle both independently and as it relates to your athletic training.

Our interview today will last approximately one hour during which time I will ask you a number of questions. I will ask you questions that relate exclusively to your menstrual cycle, some exclusively about your athletic training, and some about how your menstrual cycle and training interact. You do not have to answer any questions that you do not wish to answer. You may also choose to decline to answer any question that you do not want to answer. There are no right or wrong answers, I am simply interested in what you have to say. Everything you tell me is confidential and you may stop the interview at any time. I will be recording the interview. If you would like me to stop the recording at any time, please feel free to tell me.

Do you feel confident that you understand the purpose of this study?

If yes, continue.

If no, take some time to review the purpose and ask participants if they feel comfortable moving forward or if they would like to reschedule.

Is there anything that you would like me to clarify?

If no, continue.

CONSENT STATEMENT

1. **Do you consent to participate in this interview?**

If no, ask if participant would like to reschedule for an alternative time.

2. **Do you consent to be audio recorded?**

If no, ask if participant would like to reschedule for an alternative time.

3. **Do you have any further questions?**

If participant consents and does not have any further questions, recording will start at this point.

Main Questions

1. Has your attitude toward menstruation changed throughout your sporting career?
   - Probe around: sport culture and menstruation, potential menstrual irregularities

2. Can you tell me about any notable experiences you have had, either positive or negative, with menstruation and sport?
   - Probe around: reactions to experience, changes in behavior to accommodate experience

3. Are there any times throughout your menstrual cycle where you feel your training is impacted, either positively or negatively?
   - Probe around: physical/emotional symptoms that impact training, physical/emotional symptoms resolved by training, decision making about training

4. Are there certain modes or types of training that feel either better or worse during various phases of your menstrual cycle?
   - Probe around: modes of training, training environment, social training experiences

5. Menstruation as something to endure is a common theme throughout the literature. Please tell me how you relate to this statement.
   - Probe around: coping strategies, social influences

Reflective Questions

1. Has tracking your menstrual cycle alongside your training changed your experiences with or attitudes toward menstruation?
   - Probe around: connection to physical body, self-awareness of physical and psychosocial state

2. After having tracked your training and menstrual cycle for a significant duration, how do you feel about openly discussing menstruation with a coach or sport practitioner?
   - Probe around: changes in comfort level, continued discomforts, specific practitioners

Concluding Question(s)
Do you have anything else to add about your menstrual cycle and training?

INTERVIEW GUIDE 2.0 (UPDATED - FINAL)

"How do women endurance athletes perceive and respond to training stress throughout the menstrual cycle?"

Interview Preface

Thank you for agreeing to participate in this (group) interview with me. I am leading a project which will explore both the subjective and objective responses to training stress throughout the menstrual cycle in women endurance athletes. Sport performance and the menstrual cycle has been a growing area of research in the last few years but there is still very little high-quality research on this topic. This interview will explore how you perceive your menstrual cycle both independently, and as it relates to your athletic training.

Our interview today will last approximately one hour during which time I will ask you a number of questions. I will ask you questions that relate exclusively to your menstrual cycle, some exclusively about your athletic training, and some about how your menstrual cycle and training interact. Many of the questions will follow up on themes from the survey data. You do not need to answer any questions that you do not wish to answer. I will be recording the interview so that I do not miss any responses, and to avoid having to take notes while we are talking.

Individual Interviews: You may choose to end the interview at any time. If you would like me to stop the recording at any time, please feel free to tell me.

Group Interviews: You may choose to exit the interview at any time by leaving the video call. You do not need to announce to the group or provide reason for leaving. It is difficult to ensure anonymity in a group interview. For this reason, I ask that you please respect the privacy of others by not disclosing any information from our interview.

Do you feel confident that you understand the purpose of this study?

If yes, continue.

If no, take some time to review the purpose and ask participants if they feel comfortable moving forward or if they would like to reschedule.

Is there anything that you would like me to clarify?

If no, continue.

CONSENT STATEMENT

4. **Do you consent to participate in this (group) interview?**

If no, ask if participant would like to reschedule for an alternative time.

5. **Do you consent to be audio recorded?**

If no, ask if participant would like to reschedule for an alternative time.

6. **Do you agree to respect the privacy of others in this group interview by keeping the identity of interviewees and information discussed confidential?**

If no, ask if participant would like to reschedule for a one-on-one interview at an alternative time.

7. **Do you have any further questions?**

If participant consents and does not have any further questions, recording will start at this point.

Main Questions (Themes from Surveys)

Theme 1: Menstrual Cycle & Symptoms

Questions:

- Many women commented on specific menstrual symptoms. What types of symptoms did you experience?
- Many women commented about how exercise either relieved certain symptoms, or was more challenging due to certain symptoms. How did you experience this?
- Many women reported on changes of heaviness of their bleeding phase. How did this affect you?
- Many women commented on feeling worse or better during a certain phase of their menstrual cycle? How did this affect you?
- How did your menstrual cycle change your training?
- How did your training change your menstrual cycle?

Theme 2: Body Feel (Physical Sensations)

Questions:

- Many women spoke about how their physical body felt. What types of physical feelings did you notice?
- Many women commented about exercise feeling easier than expected at certain times. How did you experience this?
- Some women spoke about minor injuries or "niggles" they experienced. How did you experience this?
- Many women commented, with increased consciousness, of how their body felt at certain points in their menstrual cycle. How did this impact your approach to training?
- Many women spoke about overcome negative physical sensations during their training sessions. How did you approach this?
- Many women spoke about their energy levels in regard to training. How did your menstrual cycle impact your energy levels?

Theme 3: Mind Feel (Emotional Sensations)

Questions:

- Many women spoke about their mood state or how they were feeling emotionally. How did this affect you?
- Many women experienced changes to their mood or emotional state throughout your menstrual cycle. How does this impact your training?
- Many women commented about feeling irritable, anxious, stressed or cranky. How did this impact your approach to training?
- Many women spoke about their mental state, suggesting they "felt good mentally" or "mentally couldn't deal". How did this affect you?
- Many women commented about how their body felt worse than "headspace". How did this impact you?
- When did your training worsen or improve your mood state throughout your menstrual cycle?

Theme 4: Fatigue

Questions:

- Many women commented that they felt tired or exhausted. How did feelings of fatigue impact your training?
- Some women commented about adjusting their training due to fatigue. How do you adjust your training to accommodate for fatigue?

- How do you tolerate fatigue at certain times in your menstrual cycle? How does this impact your approach to training?
- Many women commented about sleep disturbances at certain times in their menstrual cycle. How did this affect you?

Theme 5: External Life Stressors

Questions:

- Many women commented about managing external stressors alongside training. How do you manage this?
- Many women commented on "a lack of time" as a barrier to completing training. How did this impact you?
- How are certain pressures to train exacerbated throughout the menstrual cycle?
- Many women commented about stress as a menstrual cycle symptom. How did you manage external stressors at certain times in the menstrual cycle?
- Many women commented on feeling less motivated during certain times in their cycle. How motivated did you feel?

Theme 6: Menstruation Tracking

Questions:

- Menstruation as something to endure is a common theme throughout the literature. Please tell me how you relate to this statement.
- How has tracking your menstrual cycle alongside your training changed your experiences with, or attitudes toward, menstruation?
- After having tracked your training and menstrual cycle for a prolonged duration, how do you feel about openly discussing menstruation with a coach or sport practitioner?
- What have you learned about your menstrual cycle and athletic training from the experience of tracking these over the duration of 3 full cycles (approx. 12 weeks)?

Concluding Question(s)

Do you have anything else to add about your menstrual cycle and training?