

Gait Biomechanics Among Female Endurance Runners: Comparing Days With and Without Menstrual Cycle–Related Symptoms

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Objective: Determine differences in running biomechanics in female endurance runners between days when they did and did not report menstrual cycle–related symptoms.

Methods: Observational study. Participants were provided RunScribe sensors to attach to their shoes to collect biomechanical data when running. Daily during the study period, participants were sent a text message to complete a survey asking about their wellness, menstrual status, and training status. Descriptive measures (mean $\pm$ SD) were generated for whether runners reported being asymptomatic or symptomatic during runs and run work out details. Paired-samples *t* tests were executed to identify differences in impact force, braking force, pronation excursion, maximum pronation velocity, foot-strike type, and gait speed between runs on days participants reported having menstrual cycle–related symptoms (symptomatic) or not (asymptomatic). Participants needed to have recorded runs spanning the entire data collection window to be included for comparative analyses.

Results: Twenty-seven university club runners (age = 20.5 ± 1.5 years) participated in the study. All runners ($N = 27$)

experienced at least 1 menstrual cycle–related symptom during data collection. The average number of asymptomatic runs was 22.3 ± 17.1 , and the average number of symptomatic runs was 9.1 ± 7.5 . Daily distance ran averaged 6.9 ± 3.1 km, and total distance ran was 248.2 ± 185.7 km. Fourteen runners had run data viable for pairwise sampling. There was no significant difference in biomechanical measures between symptomatic and asymptomatic days ($P > .05$).

Conclusions: This study prospectively monitored distance runners' activity while simultaneously recording symptoms related to the menstrual cycle. Although runners reported fewer days running when symptomatic, we did not identify a difference in objective biomechanical measures between asymptomatic and symptomatic runs. Perceived symptom burden was present in this sport population and may warrant further exploration of perceived expectations of the menstrual cycle to athletic performance.

Key Words: wearable technology, menses, symptomology

Key Points

- Menstrual cycle–related symptoms were reported by all participants regardless of if they were or were not taking a hormonal contraceptive.
- There were no differences in running-related biomechanical measures when participants reported having or not having menstrual cycle–related symptoms.

Running is a popular sport due to its known positive health benefits.¹ Recently, sport science literature has been reviewed to identify if there was a difference in study participation by sex.² It was determined that prominent sport science journals had a low volume of female study participants, even when studies were not addressing male-specific physiology.² When female participants are not represented in research, assumptions can manifest that they will respond and perform the same as their male counterparts. Yet how an athlete moves during activity is one of many sex differences that have been identified between male and female athletes.³

Within running, there are known biomechanical differences between males and females.³ Females can present

with increased frontal plane hip adduction and knee adduction.⁴ The majority of biomechanical running studies have been conducted in a controlled lab setting.³ This may not accurately represent potential biomechanical changes, such as those related to musculoskeletal pain or other symptoms exclusive to females, observed during their routine outdoor runs. Wearable technology can allow the scientist to track biomechanical measures over time in a natural environment for the female runner.

The commercial availability of wearable technology has made it feasible to acquire a multitude of training variables with ease.⁵ In sport science literature, training variables are often quantified as workloads that can be separated into

internal and external components.⁶ Common internal workload measures include heart rate and rating of perceived exertion, whereas external workload measures include metrics such as distance run, gait speed, and biomechanical measures quantifying accelerations, decelerations, and other movement parameters.

When considering new technology for data collection use, it is important that the device be able to measure what it is intended to measure. RunScribe (Scribe Labs) is a shoe-mounted wearable sensor that can collect spatiotemporal, kinetic, and kinematic data when an individual is running. It has been demonstrated to be valid in the measurement of spatiotemporal⁷ (ie, cadence, stride length, contact time), kinematic⁸ (ie, pronation excursion, maximum pronation velocity), and kinetic⁹ (ie, impact force, braking force) outcomes during running. The RunScribe sensors are designed and marketed to measure select biomechanical variables during outdoor running. Because it is not feasible to directly compare simultaneous measures from the sensors with gold standard 3-dimensional (3D) motion analysis and force plate measures during continuous outdoor running, our research group has systematically developed a portfolio of validity evidence to justify use of the RunScribe sensor measures in applied settings. These include correlation of simultaneous measures during treadmill running with a gold standard 3D motion capture system^{8,10}; demonstrating expected changes in measures when running on different surfaces and different speeds⁹; demonstrating changes in measures when running under different conditions, such as ankle taping, bracing, and control conditions¹¹; demonstrating differences in measures between healthy runners and those with pathological conditions including chronic ankle instability¹² and exercise-related lower leg pain^{13,14}; and the ability to change measures after targeted clinical interventions in runners with exercise-related lower leg pain.¹⁴ Collectively, this evidence demonstrates a portfolio of validity for the RunScribe sensors to justify use in the measurement of gait biomechanics during outdoor running. Wearable sensors such as the RunScribe can allow clinicians to obtain objective data within the natural environment the athlete is running in.

Specific to female physiology is the menstrual cycle. On average, a menstrual cycle can last from 21 to 35 days. Female athletes have reported a perceived negative impact on their performance from menstrual cycle symptoms.^{15,16} The term *performance* can be applied to when athletes are engaging in training or competition situations for their respective sport. When a negative perception is tied to their symptoms, it is common for athletes to consider modifying or discontinuing their training plans when experiencing menstrual cycle-related symptoms.¹⁷ Studies focused on auditing hormonal contraceptive use among female athletes have reported that 41%¹⁸ to 68%¹⁹ of their respective study samples were taking a hormonal contraceptive. Reasons for taking a hormonal contraceptive could be to manage when an athlete is bleeding or to mitigate menstrual cycle-related symptoms.²⁰ Although taking a hormonal contraceptive may be a common strategy among athletes to address these concerns, menstrual cycle-related symptoms are still being reported.²¹ It is not known if there are differences in symptoms experienced between female athletes who are and are not taking a hormonal contraceptive.

Endurance runners are a unique sport population due to the high volume of training that is accrued relative to the number of races completed.²² Perceived changes in performance due to menstrual cycle-related symptoms have been reported regardless of whether the athlete is participating in a team or individual sport.²³ Biomechanical measures have not been recorded in a natural environment in conjunction with recording menstrual cycle-related symptoms. Whether or not runners experience changes in their sport performance due to menstrual cycle-related symptoms is unclear.

When attempting to measure sport performance, an objective metric should be included (eg, time to complete a 5-km race or impact force when running on concrete). Qualitative literature supports that females perceive that symptoms related to their menstrual cycle yield a negative sport performance.^{15,23} When assessing an athlete's workload, it is indicated to capture internal and external variables so there is a robust representation of the athlete's response to the training stimulus.⁶ To the author's knowledge, no researchers have yet prospectively tracked menstrual cycle-related symptoms in conjunction with collecting objective biomechanical measures in distance runners. The purpose of this study was to measure biomechanical outcomes during training over time in relation to reported menstrual cycle symptoms in a female endurance running population to better understand the impact of perceived menstrual cycle-related symptoms on running biomechanics. We expected to observe changes in the runner's biomechanical performance variables when the athlete reported menstrual cycle-related symptoms.

METHODS

Participants

Participants were recruited through the University of Virginia Club Running Listserv. An email was sent detailing the purpose of the study and inclusion criteria. To be considered for participation, participants had to be aged 18 to 45 years, be of the female sex, have had at least 1 period, exercise vigorously at least 75 minutes a week,²⁴ and compete in races of 1500 m or greater distance. Interested prospective participants who met inclusion criteria could reply via the recruitment email to the primary investigator to schedule their baseline visit. All prospective participants who met for a baseline visit were included in the study. Two cohorts were recruited. The first was recruited January 2023 for data collection to run through April 2023. The second cohort was recruited from June 2023 to August 2023, and participants were in active data collection for 90 days total. Twenty-seven participants were included between the 2 cohorts. Although all 27 participants were included for descriptive measures, only 14 had viable run data for comparison analyses. Some athletes discontinued reporting run data within 1 month of being enrolled ($n = 7$) or did not consistently record runs spanning 3 months ($n = 6$).

Procedures

During their baseline visit, participants reviewed and signed a consent form, completed a baseline questionnaire, downloaded the RunScribe application to their phone, and went through a calibration process for the RunScribe

Table 1. Definitions of Performance Outcome Measures

Category	Variable	Definition
Kinetic	Impact force	Vertical component of peak force. Correlates to ground impact force at foot strike.
	Braking force	Horizontal component of peak force. Correlates to braking forces at foot strike.
Kinematic	Max pronation velocity	Maximum angular rate the foot pronates between foot strike and point of maximum pronation.
	Pronation excursion	Total range of angular movement when foot pronates from foot strike to maximum pronation.
	Foot-strike type	Categories are based on the sagittal plane angle of the foot at initial contact ¹⁰ : heel (value: 1–5), midfoot (value: 6–10), or forefoot (value: 11–15).

sensors. Thereafter, they were instructed to wear the sensors whenever they went running regardless of surface type or workout plan. Every day during the data collection period a text message was sent with a link directing participants to complete an online daily survey. Active data collection lasted 90 days per participant. The baseline and daily survey were both administered using Qualtrics. Participants needed to consistently record runs spanning the 3-month collection window to be considered for comparison analyses. This study was approved by the university institutional review board.

Daily Survey Instrument

The daily survey was delivered to participants via text message every evening at 6:30 PM local time. If the survey was not completed within 30 minutes, a reminder message was sent at 7:00 PM. The text message contained a link that redirected the participant to a Qualtrics web page with a mobile version of the survey to complete. Items in the survey included recording their RunScribe sensor number, questions about their training details for the day (eg, participants could select if they *ran*, *cross-trained*, or if it was a *rest day/withheld from activity*), menstrual cycle symptoms experienced (derived from preexisting work), and responses to wellness questions via the Short Recovery and Stress Scale.¹⁶ If 1 or more symptoms were selected on the daily survey, this was considered a *symptomatic day*. When no menstrual cycle–related symptoms were selected, this was categorized as an *asymptomatic day*.

RunScribe Sensors

The RunScribe sensors house a triaxial accelerometer and gyroscope with a sampling rate of 200 Hz.¹⁰ We used these devices to collect kinetic and kinematic data (Table 1). The RunScribe has yielded successful concurrent validity when compared with the gold standard 3D motion capture

system.^{7,8} Upon completion of the baseline survey, participants downloaded the RunScribe application onto their mobile phone to allow for tracking of their running data. Thereafter they went through a sensor-calibration procedure including a quiet-stance task and a predetermined distance run to calibrate their sensors for participant use. The predetermined run was an out-and-back route from the testing site with total distance of 1.4 km. Participants were instructed to run at a self-selected comfortable run pace. During the baseline visit, participants were provided a PDF document detailing how to position the sensors on their shoes and login information to access the RunScribe application via their phones. Upon successful fitting of the sensors to the participants' running shoes, they were instructed to stand and be still during the quiet-stance calibration. Thereafter, the participant and investigator went outside to complete the calibration run. Participants were shown a map of the run route before departure and shown how to start a "run" on the RunScribe app. Participants did not have to run with their phones as the sensors had data storing capabilities. Once the participant returned from the run, the "run" was stopped on the app and synced to the phone application via Bluetooth. The distance recorded on the app was manually updated if it did not match the predetermined distance. This was the only time the run distance was manually manipulated. Participants were discouraged from changing any data collected on the phone application. Run data were transferred via a wireless network from the phone application to RunScribe's website for storage. Each sensor had an individual account that could be accessed by a master account through RunScribe's website.

Data Processing

The primary investigator accessed runs via the RunScribe website for each runner. Runs were reviewed by date and were considered for analysis if recorded distance equaled or exceeded 1 mile and there were data for both limbs. Data were exported as .csv files and converted to

Table 2. Participant Demographics

Characteristic	Value
Race/Ethnicity, No. (%) (N = 27)	
White/Caucasian	22 (81.5)
Multiracial/biracial	3 (11.11)
Hispanic or Latino	1 (3.7)
Asian or Pacific Islander	1 (3.7)
Age, mean $\pm$ SD, y	20.5 $\pm$ 2.5
BMI, mean $\pm$ SD, kg/m ²	21.7 $\pm$ 1.8
Stress reaction history (N = 27)	
Yes	6 (22.2)
No	21 (77.8)

Abbreviation: BMI, body mass index.

Table 3. Self-Reported Menstrual Cycle Characteristics

Characteristic	Value
Age at menarche, mean $\pm$ SD, y	13 $\pm$ 1.5
Natural cycle (every 21–35 days), No. (%) (n = 25)	
Yes	17 (68)
No	8 (32)
Taking birth control, No. (%) (n = 27)	
Yes	10 (37)
No	17 (63)
Birth control hormonal, No. (%) (n = 10)	
Yes	9 (90)
No	1 (10)

Table 4. Running Participation Details (N = 27)

Detail	Value
Age started running, mean $\pm$ SD, y	14 $\pm$ 2.1
Self-reported competition level, No. (%) (N = 27)	
Club running team	11 (40.7)
Competitive recreational	8 (29.6)
For fun	8 (29.6)
Days running per week, No. (%) (N = 27)	
2	1 (3.7)
3	7 (26)
4	5 (18.5)
5	4 (14.8)
6	9 (33.3)
7	1 (3.7)
Weekly distance, No. (%), km (N = 27)	
10–24	8 (29.6)
26–40	9 (33.3)
42–56	6 (22.2)
58–81	3 (11.1)
81+	1 (3.7)
Running events, No. (%) (N = 27)	
1 mile	8 (29.6)
2 miles	5 (18.5)
2-km steeplechase	1 (3.7)
3 km	6 (22.2)
5 km	19 (70.4)
4 miles	1 (3.7)
6 km	6 (22.2)
10 km	4 (14.8)
10 miles	1 (3.7)
Half marathon	11 (40.7)
Marathon	4 (14.8)

Table 5. Distribution of Runs by Surface Type

Surface Type	Total Runners, No. (%) (N = 27)	Total Runs Logged, No. (%) (N = 850)
Concrete	26 (96.3)	433 (50.9)
Asphalt	24 (88.9)	292 (34.4)
Trail	14 (51.9)	44 (5.2)
Rubber track	9 (33.3)	41 (4.8)
Treadmill	11 (40.7)	33 (3.9)
Grass	5 (18.5)	6 (0.7)
Wooden track	1 (3.7)	1 (0.1)

Excel files (Microsoft) for cleaning. Flight time was used to ensure data collected for each run did not include time when the runner was walking or standing. Any rows of data in which flight time equaled zero (ie, when the sensor recorded the participant not running) were removed for each file. Biomechanical variables of interest were exported in a new file version in which average values for each foot were then consolidated to obtain a mean value for each metric by run. The new mean values for each variable were then averaged to yield a single score for each participant to include for statistical analysis.

Statistical Analyses

Descriptive measures (mean $\pm$ SD) for all study participants included the following: total symptomatic and asymptomatic days reported when running, cross-training, or resting/withheld; average daily run distance when symptomatic and asymptomatic; total distance ran; running

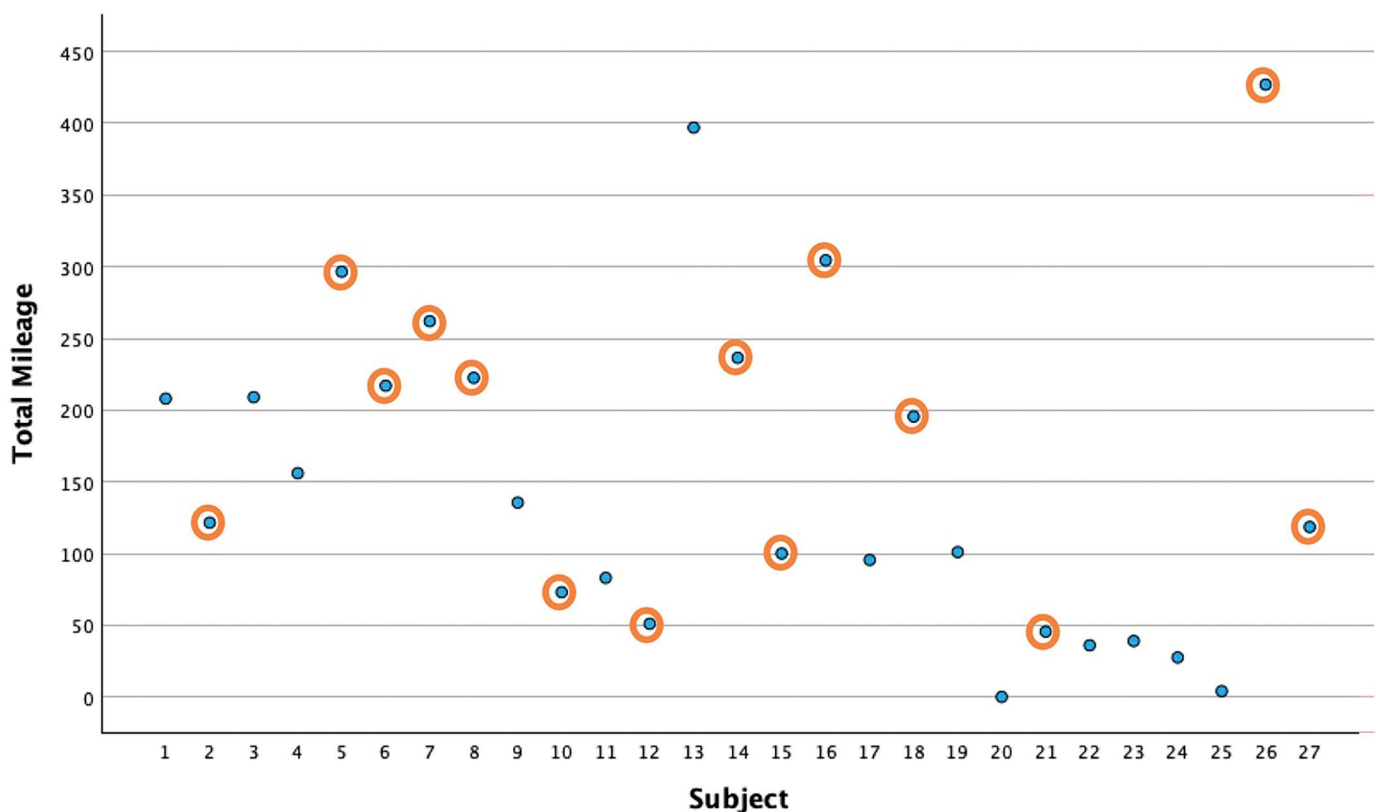


Figure. Total distance covered by each participant. Those circled in orange were included for comparison analyses.

Table 6. Mean Activity Frequency

Activity	Asymptomatic Days, Mean $\pm$ SD	Symptomatic Days, Mean $\pm$ SD
Running	22.3 $\pm$ 17.1	9.1 $\pm$ 7.5
Cross-training	5.3 $\pm$ 9.4	2.4 $\pm$ 3.9
Rest/withheld	15.4 $\pm$ 13.9	5.5 $\pm$ 5.5

frequency; and running surface types. Paired-samples *t* tests were conducted (version 29.0.2.0; SPSS) to compare the biomechanical measures on symptomatic and asymptomatic days. Three groups of *t* tests were completed on (1) the total sample, (2) only runners cycling naturally, and (3) only runners taking a hormonal contraceptive. Outcome variables of interest were gait speed, braking force, impact force, maximum pronation velocity, pronation excursion, and foot-strike type. RunScribe's predetermined foot-strike type was categorized as *forefoot* (value = 11–16), *mid-foot* (value = 6–10), and *rearfoot* (value = 1–5).¹⁰ Data are reported as mean $\pm$ SD, mean differences, Cohen *d* effect sizes, and *P* values. Effect size was calculated using the following interpretation: ≥ 0.8 = *large*; 0.5–0.79 = *moderate*; 0.2–0.49 = *small*; ≤ 0.19 = *trivial*.²⁵ A priori statistical significance was set to $P < .05$.

RESULTS

Twenty-seven runners (age = 20.5 $\pm$ 1.5 years) were enrolled for study participation; the average age at which participants started running was 14 $\pm$ 2.1 years. Demographics are summarized in Table 2, self-reported menstrual cycle characteristics are summarized in Table 3, and running participation details are summarized in Table 4. The number of days run during the study period while asymptomatic was 22.3 $\pm$ 17.1 and while symptomatic was 9.1 $\pm$ 7.5. The average daily distance ran was 6.9 $\pm$ 3.1 km for asymptomatic days and 6.8 $\pm$ 3.2 km for symptomatic days. Average total distance ran was 248.2 $\pm$ 185.7 km (Figure). The most common running surface was concrete ($n = 433$, 50.9%); see Table 5 for additional surface types. Table 6 provides details on activity frequency during the study period.

There were no significant differences in biomechanical measures when comparing symptomatic and asymptomatic run days within the entire sample, within those taking a hormonal contraceptive, or within those who reported a natural cycle ($P > .05$; Tables 7 through 9). Effect sizes across all comparisons were considered trivial or small (*d* ranging from -0.1 to 0.46).

DISCUSSION

The purpose of this study was to identify if running gait biomechanics differed on days when female runners did or did not report menstrual cycle–related symptoms. We did not identify significant differences in any biomechanical measures collected on runs performed on symptomatic versus asymptomatic days. Importantly, average gait speed was nearly identical between runs that occurred on symptomatic and asymptomatic days, indicating that systematic performance deficits were unlikely to be related to the presence of menstrual cycle–related symptoms. Daily distance ran was also similar between asymptomatic and symptomatic days; however, more days were logged running when participants reported being asymptomatic versus symptomatic. Daily distance mileage was also similar between asymptomatic and symptomatic days. To the author's knowledge, this is the first study that has prospectively tracked running biomechanical measures in conjunction with collecting menstrual cycle–related symptoms in an endurance running population.

Our study did not identify significant differences for running biomechanical outcomes on days runners reported being asymptomatic versus symptomatic (regardless of contraceptive use). Additionally, the effect size estimates between kinematic and kinetic measures indicated small differences between symptomatic and asymptomatic days. Most literature that has previously explored the effects of the menstrual cycle in female athletes has attempted to identify differences in sport performance across the different menstrual cycle phases.²⁶ Authors of one study looked at changes in aerobic capacity via peak oxygen uptake, maximal heart rate, and blood lactate levels during a submaximal test on a treadmill or bicycle.²⁷ Testing was conducted at 3 different time points to represent different phases of the menstrual cycle, yet did not identify any significant changes in these outcome measures of internal workload.²⁷ Authors of another study, which included only naturally cycling females ($n = 8$), looked at kinetic variables during running across menstrual cycle phases at 3 separate visits in a lab setting.²⁸ They did not identify any differences in external workload measures, specifically impact force and braking force, across different menstrual cycle phases.²⁸ This is somewhat similar to our finding that we did not identify a significant difference in biomechanical variables measured during outdoor running on days when participants reported having or not having menstrual cycle–related symptoms. Sprinting (repeat 20-m sprint test) and jumping capacity (countermovement jump height) have also been assessed in female soccer players at 4 different time points across the menstrual cycle (2 testing sessions in the follicular phase and 2 testing sessions during ovulation),

Table 7. Comparison Between Asymptomatic and Symptomatic Run Days for All Participants (N = 14)

	Asymptomatic, Mean $\pm$ SD	Symptomatic, Mean $\pm$ SD	Mean Difference $\pm$ SD	Effect Size (<i>d</i>)	<i>P</i> Value
Impact Force, N	10.1 $\pm$ 2.1	9.7 $\pm$ 2.0	0.3 $\pm$ 1.3	0.26	.34
Braking Force, N	7.3 $\pm$ 1.2	7.3 $\pm$ 1.3	-0.1 ± 0.6	-0.10	.72
Pronation excursion, °	11.5 $\pm$ 4.7	12.0 $\pm$ 4.9	0.5 $\pm$ 2.1	0.24	.38
Maximum pronation velocity, °/s	562.9 $\pm$ 187.6	515.1 $\pm$ 289.8	47.9 $\pm$ 154	0.31	.27
Gait speed, min/kilometer	15.3 $\pm$ 1.6	15.4 $\pm$ 2.4	-0.2 ± 1.6	-0.11	.70
Foot Strike	7.0 $\pm$ 3.0	6.7 $\pm$ 2.9	0.3 $\pm$ 0.8	0.36	.20

Table 8. Comparison Between Asymptomatic and Symptomatic Run Days for Natural Cycle Participants (N = 8)

	Asymptomatic, Mean $\pm$ SD	Symptomatic, Mean $\pm$ SD	Mean Difference $\pm$ SD	Effect Size (<i>d</i>)	<i>P</i> Value
Impact force, N	10.3 $\pm$ 1.7	10.1 $\pm$ 2.3	0.3 $\pm$ 1.1	0.26	.50
Braking force, N	7.5 $\pm$ 0.8	7.6 $\pm$ 1.0	-0.1 $\pm$ 0.7	-0.10	.85
Pronation excursion, $^{\circ}$	-10.8 $\pm$ 5.5	-11.0 $\pm$ 5.2	0.6 $\pm$ 1.3	0.46	.23
Maximum pronation velocity, $^{\circ}$ /s	550.5 $\pm$ 131.7	498.9 $\pm$ 288.2	51.6 $\pm$ 183.3	0.28	.45
Gait speed, min/kilometer	15.1 $\pm$ 1.8	15.3 $\pm$ 3.1	-0.2 $\pm$ 2.1	-0.1	.76
Foot strike	6.9 $\pm$ 3.2	6.6 $\pm$ 2.9	0.3 $\pm$ 0.3	0.4	.29

and no significant findings related to performance were reported.²⁹

Average foot-strike value minimally changed during asymptomatic and symptomatic runs. Foot-strike changes may occur due to an individual's seeking to improve running economy^{30,31} or to reduce risk of injury.^{30,32} In a distance-race situation, rearfoot strike has been found to be the most common foot-strike type.³³ A systematic review and meta-analysis recently looked at prevalence of foot-strike patterns, changes to foot strike with increased running distance, and potential impact on performance.³⁴ When a runner's foot strike was compared at the start and end of their race, 11% of runners' foot strike trended toward a rearfoot strike. It was not anticipated by these authors that participants' foot-strike type would change (eg, a forefoot runner becoming a midfoot runner); however, all foot-strike types were represented among the study participants.

Participants reported more days running while asymptomatic versus symptomatic. Athletes have previously reported negative perceptions regarding their menstrual cycle.¹⁶ Endurance athletes in India reported improved perception of performance postmenses; however, symptoms were not recorded.³⁵ Another cohort of runners reported a high volume (91%, *n* = 195) of experiencing menstrual cycle-related symptoms yet did not discern if symptoms were experienced on days running or not.³⁶

All participants reported experiencing at least 1 menstrual cycle-related symptom during data collection. The presence of menstrual cycle-related symptoms has been well documented in other studies that have included team- and individual-sport athletes, demonstrating that this is a concern across all female sports and not just for endurance runners.^{16,23} A challenge to addressing this concern is the lack of education athletes and support staff may have.³⁷ When knowledge was tested among professional soccer players and support staff, no group answered correctly on more than half of the questions posed.³⁷ Authors of another study exploring the perceived knowledge among female athletes, coaches, and medical staff reported 40% (*n* = 433) of the athletes agreed that talking about the menstrual cycle in a sport environment is taboo.³⁸ Barriers to

communication around the menstrual cycle can be due to lack of knowledge, interpersonal considerations (eg, a coach avoiding the topic thinking it would invade the athlete's privacy), or structural (eg, no organized discussion or opportunities to educate).³⁹ Educating stakeholders about the menstrual cycle can mitigate taboo around the physiologic process as well as empower athletes to feel in control of their cycle versus being controlled by it.

Limitations

Often runners may have repeated distances they plan to cover during their training window. Due to the heterogeneity of our sample and their training regimens, we were unable to explore interindividual differences for similar run distances that may have been categorized as asymptomatic or symptomatic. Total distance ran recorded from participants in our study varied widely. Although the sample population was recruited from the same university club running team, participation in team workouts was voluntary. Only 14 of our 27 participants had run data eligible for comparative analysis. Because of this, our study was likely underpowered, contributing to our nonsignificant findings comparing performance outcome variables. Lastly, participants chose when they did or did not want to run throughout the data collection window. This may have influenced the biomechanical data rendered.

CONCLUSIONS

Female endurance runners prospectively tracked their training activity in conjunction with reporting menstrual cycle-related symptoms over multiple months. We did not identify significant differences in running gait biomechanics measures captured during runs on symptomatic versus asymptomatic days. Perceived symptom burden was present in this sport population; however, shifting athletes' perception through education may mitigate perceptions around the menstrual cycle and symptoms experienced.

Table 9. Comparison Between Asymptomatic and Symptomatic Run Days for Participants Taking a Hormonal Contraceptive (N = 6)

	Asymptomatic, Mean $\pm$ SD	Symptomatic, Mean $\pm$ SD	Mean Difference $\pm$ SD	Effect Size (<i>d</i>)	<i>P</i> Value
Impact Force, N	9.7 $\pm$ 2.7	9.3 $\pm$ 1.7	0.4 $\pm$ 1.5	0.26	.56
Braking Force, N	6.9 $\pm$ 1.6	6.9 $\pm$ 1.5	-0.1 $\pm$ 0.5	-0.14	.74
Pronation excursion, $^{\circ}$	-12.4 $\pm$ 3.8	-12.8 $\pm$ 4.8	0.4 $\pm$ 3.0	0.12	.78
Maximum pronation velocity, $^{\circ}$ /s	579.94 $\pm$ 258.1	536.7 $\pm$ 318.1	42.9 $\pm$ 120.9	0.36	.43
Gait speed, min/km	15.6 $\pm$ 1.3	15.6 $\pm$ 1.3	-0.08 $\pm$ 0.6	-0.12	.78
Foot strike	7.1 $\pm$ 2.9	6.9 $\pm$ 3.2	0.2 $\pm$ 0.9	0.27	.54

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