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Original Research Article

Effect of menstrual phase-wise training versus conventional training on speed, agility, power and psychological well-being in female sprinters: a comparative study

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ABSTRACT

Background: The menstrual cycle phase is increasingly acknowledged as a determinant of female athletic performance; nevertheless, data for phase-tailored training of sprint-specific attributes is still scarce. This study examined the effects of a menstrual phase-wise training (MPWT) program versus conventional training (CT) on speed, agility, power, and psychological well-being in female sprinters.
Methods: This comparative research randomly assigned 60 female sprinters (18-28 years) either MPWT (n=30) or CT (n=30) for six weeks. MPWT suggested phase-specific exercise-rest and breathing exercises during menstruation, strengthening during the follicular phase, resistance range-of-motion exercise during ovulation, and endurance running during the luteal phase; CT maintained normal sport-specific training. Measurements speed (30 m sprint test), agility (Edgren side-step test), power (vertical leap, jump height, Harman average and peak power) and psychological well-being (BBC subjective well-being scale) were examined pre- and post-intervention.
Results: Groups were similar at baseline. After the intervention, MPWT provided considerably bigger gains than CT for lower-limb power (vertical jump/jump height, p=0.009; Harman average power, p=0.001; Harman peak power, p=0.001) with medium to large effect sizes. There were no significant differences between groups in speed or agility. There was a substantial drop in psychological well-being within the MPWT group (p=0.0001) and no significant difference was seen across groups (p=0.05).
Conclusions: A six week menstrual phase-wise training program provided a selective benefit of power-specificity against conventional training in female sprinters. There were no improvements in speed or agility and an unsolved deficit in psychological well-being. Larger trials are needed before menstrual cycle-informed training may be suggested for everyday practice.

Keywords: Female athletes, Menstrual cycle, Phase-based training, Power, Psychological well-being, Sprint performance

INTRODUCTION

The menstrual cycle is regulated by cyclical fluctuations in estrogen and progesterone across four physiological phases - menstrual, follicular, ovulatory, and luteal - that influence neuromuscular, metabolic, and connective-tissue function beyond their reproductive role.[1] Because competitive female athletes train and compete throughout this cycle, understanding how these hormonal phases affect physical performance has become a priority in women's sports science.[2,3]

Evidence on phase-specific performance effects remains inconsistent. A meta-analysis of 22 studies found that maximal strength peaks in the late follicular and ovulatory phases and is lowest in the early follicular phase; follicular phase-based strength training likewise produces greater gains in muscle strength and diameter than luteal phase-based training.[4] The likely mechanism is hormonal: estrogen supports glucose uptake and glycogen storage in skeletal muscle, while progesterone works against these pathways, giving phase-dependent trainability a plausible physiological basis.[5,6] Menstruation is not a passive period either. Prostaglandins involved in uterine vasoconstriction and contraction mediate shedding of the endometrial lining and help explain the lower abdomen and low back discomfort many athletes suffer in the first two days of menses.[7] During ovulation, the spike in estrogen leads to increased laxity of ligaments, which has been associated with altered tibial acceleration profiles and a 2.4-fold greater incidence of anterior cruciate ligament damage during the pre-ovulatory period in female skiers.[8,9] Taken together, these data establish a fair basis for adjusting exercise prescription to cycle phase.

But the situation is less apparent for sprint-specific traits. In female soccer players, endurance capacity was dramatically decreased in the mid-luteal phase but sprint and jump performance were not affected.[10] The luteal-phase endurance decrement coincides with a 0.3-0.5°C increase in resting and exercising core temperature due to elevated progesterone, which increases the cardiovascular strain, oxygen consumption, heart rate, and rating of perceived exertion at a given exercise intensity- an effect most apparent in hot, humid conditions.[11] Two independent assessments, from different perspectives, arrived to a similar conclusion: athletes regularly evaluate their own performance as inferior during the early follicular and late luteal phases, while objectively assessed strength, power and sprint outcomes show no consistent trend across the cycle.[2,3] To start with, there are very few controlled training studies in elite or competitive female athletes. In fact, one systematic review revealed just seven out of 218 qualified studies that explicitly studied a performance metric throughout cycle stages.[2] So whether a fitness program explicitly planned around the menstrual cycle adds anything above ordinary training is still an unresolved subject.

Beyond physical performance, the menstrual cycle carries a psychological and communicative burden that is frequently overlooked in training design. Elite athletes report that menstrual symptoms affect training and competition but are rarely discussed openly with coaches.[12,13] Large cross-sectional surveys of more than 1,000 female athletes found that most perceive their fitness and performance as worst during the bleeding phase, yet few factor menstrual cycle awareness into training or competition planning, and few communicate about it with coaching staff.[14,15]

Sprinting places specific demands on speed, agility, explosive power, and psychological readiness, but no controlled study has examined a menstrual phase-wise training program targeting all four of these domains together in competitive female sprinters. The present study addressed this gap by comparing a menstrual phase-wise training program against conventional training on speed, agility, power, and psychological well-being in female sprinters.

METHODS

Study design and reporting

This was a two-arm, parallel group comparative interventional study conducted at Chimanbagh sports ground and Physiotherapy OPD, M. Y. Hospital, Indore, Madhya Pradesh, India with institutional ethical permission (EC/MGM/Dec-22/09, dated 20 August 2022). Reporting followed the CONSORT methodology for parallel-group studies when appropriate.[16] This study was not prospectively documented in a clinical trials registry, which is noted here for transparency and not left implicit.

Sample size

During the recruiting period, 80 female sprinters from a single competitive training cohort were screened. The sample size (n=60) was not decided a priori by a power calculation but was based on the availability of suitable, consenting volunteers during the research duration. This is recognized as a methodological restriction (see limitations) and should affect sample size design in future confirmatory experiments.

Participants

Inclusion criteria were, age 18-28 years, regular menstrual cycle (21-35 days), sprint distance up to 200 m, at least one year of competitive experience and musculoskeletal problems influencing performance. Those who were sprinters, had amenorrhea, menstrual cycle irregularity over the preceding year, gynecological problems (PCOD/PCOS), those who were on contraception, or had a previous severe musculoskeletal injury were excluded.

Randomization, allocation, and blinding

Sixty eligible subjects were randomly assigned to the MPWT or CT group (30 each) in a 1:1 ratio and requested to keep a monthly diary for the duration of the trial. The mechanism of random sequence generation was not described apart from basic random allocation and formal allocation concealment was not performed. Outcome assessors were not blinded from group allocation. These points are conveyed clearly and unambiguously so that the reader may judge their influence on the findings.

Intervention

Both groups trained for 6 weeks. The MPWT group followed a protocol tailored to the physiological needs of each cycle phase: rest, breathing exercises and positioning techniques during menstruation; lower-limb strengthening (squats, lunges, step-ups, gluteal bridges) during the follicular phase; resistance range-of-motion exercises with 1 kg weight cuffs during the ovulatory phase; and jogging/long-run workouts during the luteal phase. The CT group maintained their regular sport-specific training (i.e. skipping, stretching, sprint drills). Supplemental content includes complete workout prescriptions (frequency, intensity, time, kind)

Outcome measures

Speed was assessed using the 30 m sprint test, agility using the Edgren side-step test, based on established principles of classification and testing of change-of-direction performance, lower-limb power through the vertical jump test, jump height and Harman average and peak power, and psychological well-being through the modified BBC subjective well-being scale, a validated 24-item, 5-point Likert scale of psychological, physical and relational well-being, with higher scores indicative of greater well-being.[17,18] All outcomes were measured by the same assessor pre- and post- the six week intervention.

Statistical analysis

Data were analysed using SPSS (v23.0). Normality was assessed with the Shapiro-Wilk test. Normally distributed outcomes (BBC-SWB, Harman average and peak power) were compared using unpaired t-tests (between-group) and paired t-tests (within-group); non-normally distributed outcomes (30 m sprint, Edgren agility, vertical jump, jump height) were compared using the Mann-Whitney U test (between-group) and Wilcoxon signed-rank test (within-group). Statistical significance was set at $p<0.05$. Because statistical significance alone does not convey the magnitude of an observed difference, effect sizes (Cohen's d for t-tests; r for Mann-Whitney/Wilcoxon tests) were additionally calculated and interpreted using conventional small/medium/large thresholds.[19,20]

RESULTS

Of 80 female sprinters screened, 60 met the inclusion and exclusion criteria and were randomly allocated to the menstrual phase-wise training (MPWT) group (n=30) or the conventional training (CT) group (n=30) (Figure 1). Baseline demographic characteristics did not differ between groups (Table 1).

Table 1: Demographic characteristics of the intervention and control groups (Mean±SD).

Characteristic	Intervention (n=30)	Control (n=30)
Age (years)	21.43±3.08	21.03±3.41
Sports age (years)	1.18±0.46	1.28±0.78
Weight (kg)	49.10±6.26	46.33±4.82
Height (cm)	151.53±6.33	145.83±3.22

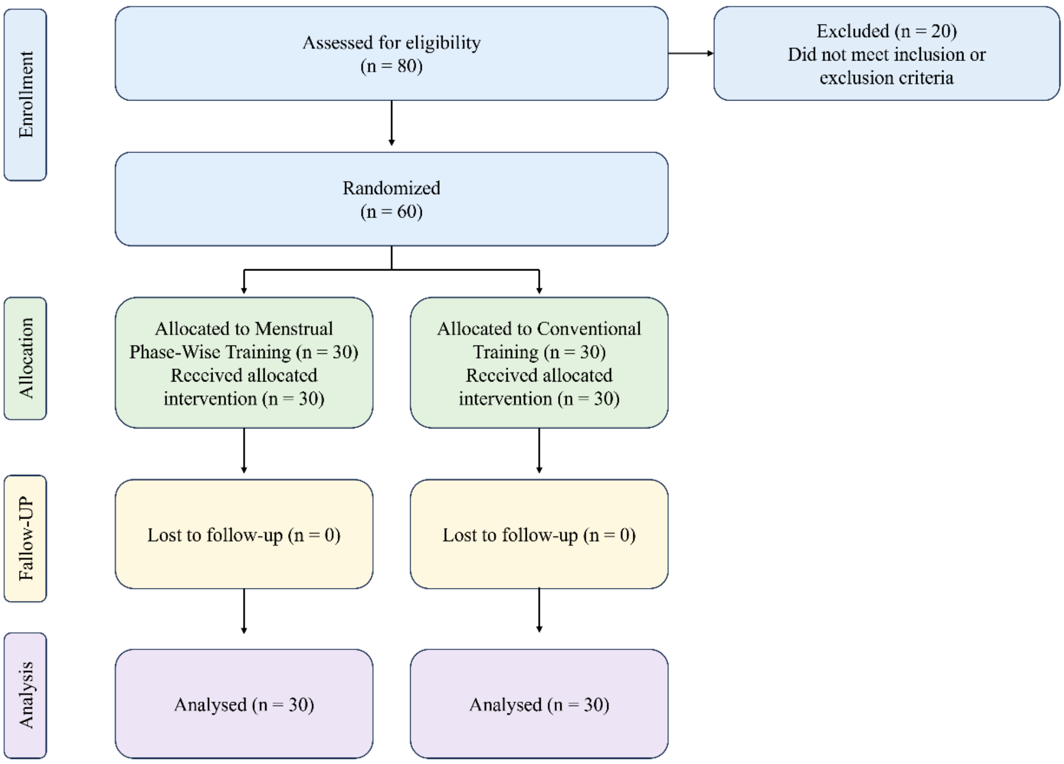

Figure 1: CONSORT flow diagram of participant recruitment, allocation, and follow-up.

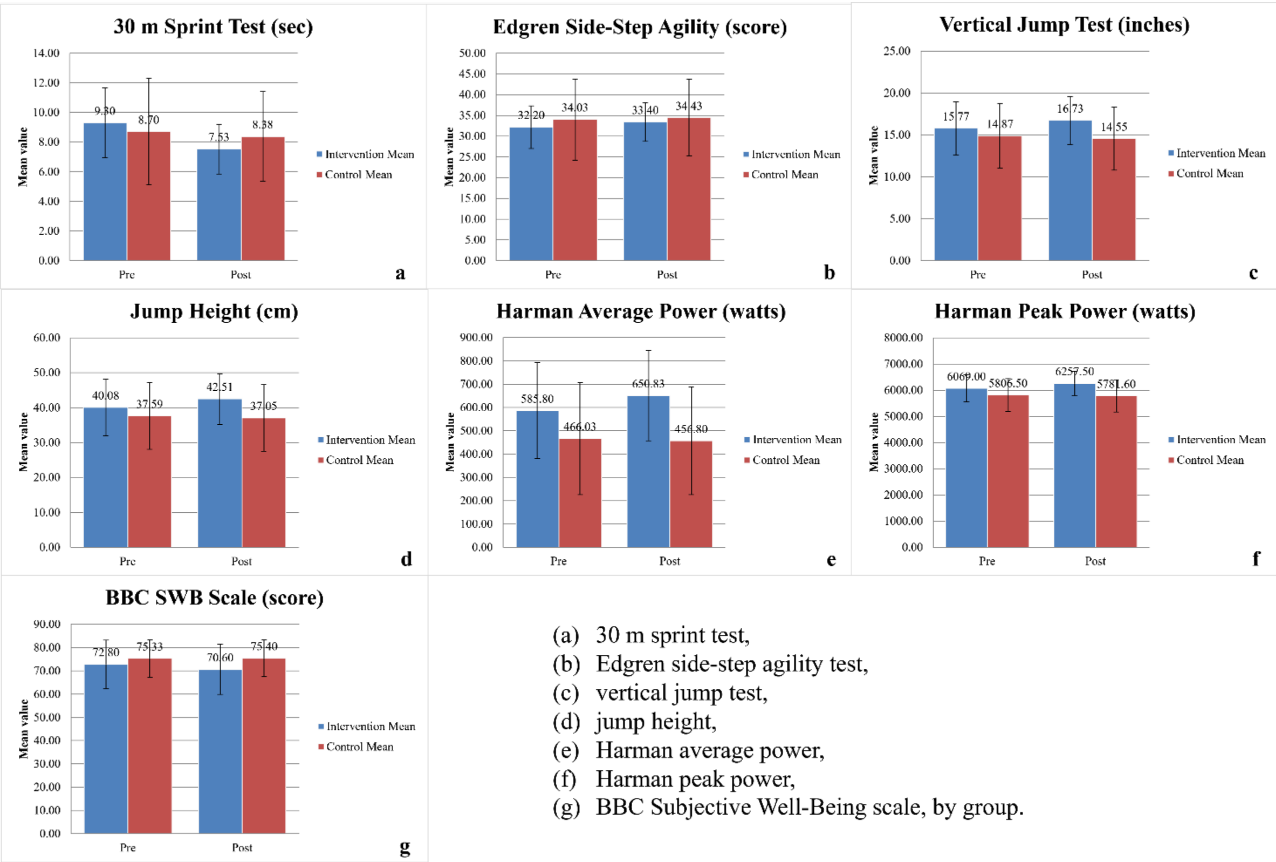

Figure 2: Pre- and post-intervention mean ± SD for (a) 30 m sprint test, (b) Edgren side-step agility test, (c) vertical jump test, (d) jump height, (e) Harman average power, (f) Harman peak power, and (g) BBC Subjective Well-Being scale, by group.

Table 2: Between-group comparison of outcome measures before and after the six-week training period.

Outcome measure	Intervention pre (M±SD)	Intervention post (M±SD)	Control pre (M±SD)	Control post (M±SD)	P value (post)	Effect size (post)
30 m sprint test (sec)	9.30±2.35	7.53±1.67	8.70±3.58	8.38±3.03	0.90	r=-0.04
Edgren side-step agility test (score)	32.20±5.15	33.40±4.69	34.03±9.75	34.43±9.25	0.81	r=-0.03
Vertical jump test (inches)	15.77±3.21	16.73±2.85	14.87±3.85	14.55±3.78	0.009*	r=-0.34
Jump height (cm)	40.08±8.18	42.51±7.24	37.59±9.55	37.05±9.52	0.009*	r=-0.34
Harman average power (watts)	585.80±206.25	650.83±193.03	466.03±240.01	456.80±230.88	0.001*	d=0.91
Harman peak power (watts)	6069.00±518.83	6257.50±458.57	5806.50±626.91	5781.60±615.72	0.001*	d=0.88
BBC SWB scale (score)	72.80±10.39	70.60±10.72	75.33±8.08	75.40±7.89	0.05	d=0.51

*p<0.05, statistically significant.

At baseline, none of the seven outcome measures differed significantly between groups (p>0.05). After six weeks, MPWT produced significantly greater improvement than CT for lower-limb power- vertical jump/jump height (p=0.009), Harman average power (p=0.001), and Harman peak power (p=0.001)- with medium-to-large between-group effect sizes. Speed (p=0.90) and agility (p=0.81) did not differ significantly between groups post-intervention, and psychological well-being approached but did not reach significance (p=0.05) (Table 2, Figure 2).

Within-group analysis showed that MPWT produced significant pre-post improvement across all seven outcomes (p=0.0001-0.003), with large effect sizes for speed, agility, and jump performance and medium-to-large effect sizes for power and well-being. CT produced a significant within-group change only in agility (p=0.03); speed, power, and well-being remained unchanged (p=0.10-0.98) (Table 3).

Table 3: Within-group (pre–post) comparison of outcome measures for the intervention and control groups.

Outcome measure	Intervention p value	Control p value
30 m sprint test	0.0001*	0.104
Edgren side-step agility test	0.003*	0.03*
Vertical jump test	0.0001*	0.46
Jump height	0.0001*	0.81
Harman average power	0.002*	0.603
Harman peak power	0.001*	0.63
BBC SWB scale	0.0001*	0.977

*p<0.05, statistically significant.

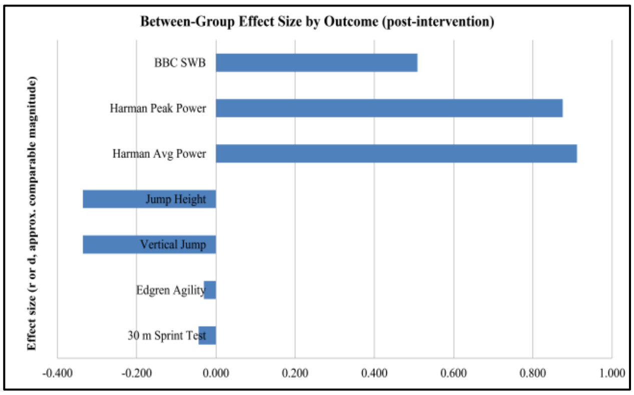

Figure 3: Between-group effect sizes (Cohen's d/r) for all outcome measures at post-intervention.

Overall, the between-group effect-size profile (Figure 3) indicates that the advantage of MPWT over conventional training was specific to power-related outcomes, while both groups showed comparable, non-significant between-group differences for speed and agility.

DISCUSSION

The present study evaluated the effects of a menstrual phase-wise training (MPWT) program with conventional training (CT) on speed, agility, power, and psychological well-being in female sprinters. It was not a benefit for everybody. Selective, yes. Only on power-related outcomes was there a substantial between-group benefit. Speed, agility, and psychological well-being did not show a similar effect.

The MPWT group had substantially bigger post-intervention improvements than the CT group on all three measures of power (vertical jump/jump height, Harman average power, Harman peak power) with medium-to-large effect sizes. This matches the available evidence well. Peak maximal strength occurs in the late follicular and ovulatory phases, and controlled comparisons indicate that strength training in the follicular phase results in higher improvements in muscular strength and cross-sectional area than strength training in the luteal phase.[4,6] The timing corresponds to the intervention design; MPWT focused resistance and strengthening activity during the follicular and ovulatory periods when estrogen-mediated glucose availability and glycogen storage capacity are believed to favor high-intensity, strength-oriented adaptation.[5] This correspondence of training time to hormonal milieu provides a credible physiological explanation for the observed power increase.

In contrast, no significant difference was seen in speed or agility across groups after six weeks. However, within the MPWT group both measures greatly improved. There is already evidence to suggest a similar direction: sprint and jump performance appear to be relatively insensitive to menstrual cycle phase compared to endurance or strength measures, and objectively measured performance outcomes tend to be inconsistent rather than clearly phase dependent across the cycle.[2,3,10] Or maybe agility is just less hormone-dependent at the beginning. It is highly dependent on general neuromuscular coordination and reactive, cognitive components that are not obviously related to the cycle phase- which would explain why a general, non-phase specific training stimulus in the CT group resulted in within-group agility gains similar to those achieved by phase-specific training.[17]

The most surprising finding was in psychological well-being. On the BBC subjective well-being scale higher scores represent more well-being, the MPWT group score was significantly reduced between the start and the end of the six-week intervention (72.80 to 70.60, p=0.0001), but the CT group score was virtually unaltered.[18] The between-group difference at post-intervention did not achieve conventional significance (p=0.05). You have had to read that combination carefully. A large within-group fall, in the absence of an established between-group difference, does not provide proof that MPWT damages well-being- but it also does not provide support for a claim of benefit. Nothing in these data allows us to determine one way or the other. There are two explanations to explore and they are not mutually exclusive.

The extra structure, self-monitoring and phase-specific compliance demands of MPWT may simply confer a subtle training and cognitive load of their own. This would be consistent with the broader observation that physical performance gains may be accompanied by transient mood or well-being disturbance during periods of increased training demand.[21] Alternatively, maintaining a daily menstrual cycle diary might have raised participants' awareness of menstrual-related symptoms instead of reducing them, an effect consistent with survey evidence that menstrual symptoms are a common but seldom constructively discussed construct between athletes and coaching staff.[12,14,15] Both interpretations are speculative and need to be directly tested (preferably using concurrent training-load and mood-monitoring methods) in future study.

These findings are set against a background of a wider research that has continually failed to establish reliable, generalizable effects of menstrual cycle phase on sports performance.[2,3] This pattern is domain specific: a true benefit for power, no gain for speed or agility, and an unsolved well-being cost. This argues against the idea of a universally helpful intervention of training menstrual phase-wise. The performance improvement here seems to be outcome-specific, not universal.

Strengths of this study are the head-to-head comparison of a phase-wise program versus active conventional training, rather than control with no treatment, the same assessor and standardized outcome measures for all four constructs, and the combination of physical performance and psychological outcomes. These findings are tempered by many limitations. The sample size was set by participant availability, not by an a priori power estimate, and the study may have been underpowered to identify actual between-group differences in speed, agility and well-being. The menstrual phase was monitored by self-reported diary rather than validated by hormonal test, a shortcoming common to most research in this field.[2] Outcome assessors were not blinded and allocation was not properly concealed. However, the six-week period only represents roughly 1.5 menstrual cycles, thus inferences on longer-term adaptation are limited. Finally, the multiple outcome comparisons were made without any adjustment for multiple testing, therefore the findings relating to power should be regarded as hypothesis-generating requiring replication in a properly powered, registered study.

Future directions

Future studies should validate the menstrual period using hormonal tests, prospectively register trials, include a priori power estimates and blinded evaluation, and increase training length across several cycles. Training load and mood state should be measured simultaneously to see if the decrease in well-being shown here is due to training related strain, greater symptom awareness or some other reason. The current findings would also be tested for generalizability by extending this comparison to strength, endurance and injury-risk outcomes, and to additional sprint lengths.

Clinical relevance

For practitioners contemplating menstrual phase-wise training, the present data imply a reasonable, physiologically-grounded advantage for lower-limb power when strength work is emphasized in the follicular and ovulatory periods. That said, the lack of clear advantage in speed or agility, together with an unresolved deterioration in psychological well-being, argues against the wholesale replacement of well-structured conventional programs with phase-wise training until larger trials establish both the performance benefit and its psychological cost.

CONCLUSION

A selected 6-week menstrual phase-wise training was superior to conventional training in female sprinters: it resulted in better lower-limb power but not speed or agility than conventional training. Well-being, however, did the opposite: it fell dramatically in the intervention group, a finding that deserves careful analysis, not to be dismissed as a benefit or a footnote. These findings need to be confirmed in subsequent appropriately powered and hormonally validated experiments before menstrual phase-wise training may be suggested for routine usage in female sprinters.

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