

ISOMETRIC MID-THIGH PULL AND COUNTERMOVEMENT JUMP PERFORMANCE ACROSS THE MENSTRUAL CYCLE IN NCAA DIVISION I BEACH VOLLEYBALL PLAYERS

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ABSTRACT

BACKGROUND: Regularly monitoring athletes is essential for optimizing training, recovery, and overall readiness. In beach volleyball, lower-body power and maximal strength are key indicators of athletic performance and readiness, but research is limited as to the influence of the menstrual cycle. **PURPOSE:** This study aimed to explore strength and power changes over a seven-week off-season period and determine the influence of menstrual cycle phase on performance. **METHODS:** Eighteen NCAA Division I beach volleyball athletes (age=20.7±1.3 years; height=177.4±4.0 cm; weight=72.3±6.3 kg) underwent seven weeks of performance testing during the fall off-season period. Isometric mid-thigh pulls (IMTPs) and countermovement jumps (CMJs) were assessed two days apart using a force plate (VALD Performance, Brisbane, Australia). After completing a progressive warm-up, athletes performed a maximal IMTP to assess peak isometric force production. For the CMJ assessment, athletes performed a standardized dynamic warm-up followed by two maximal CMJs with hands on hips to assess maximal jump height and peak power. Menstruation was self-reported to determine menstrual cycle phase. Menstrual cycle phases were categorized as menstrual (Phase 1), non-menstrual (Phase 2), early luteal (Phase 3), and late luteal (Phase 4). Linear mixed-effects models were used to determine differences between each week while accounting for menstrual cycle phase on each variable ($\alpha=0.05$). **RESULTS:** IMTP peak force production increased at weeks 3 ($P<0.01$) and 7 ($P<0.01$) compared to week 1. Moreover, IMTP peak force production was greater overall during the early luteal phase (Phase 3) ($P<0.01$). Week 3 ($P<0.01$), week 4 ($P=0.01$), and week 7 ($P=0.01$) interactions with Phase 3 were significant, indicating that IMTP changes over time were influenced by menstrual cycle phase. In contrast, there were no changes in maximal jump height or peak power over seven weeks even when accounting for menstrual cycle phase ($P>0.05$). **CONCLUSIONS:** IMTP peak isometric force production increased over the course of the training program and was also highest during the early luteal phase of the menstrual cycle while maximal jump height and peak power did not change throughout the off-season. Our findings suggest that strength can be influenced by menstrual cycle phase and that coaches and athletes may benefit from including this as a tracking variable, particularly when assessing strength performance. Future research should explore the physiological mechanisms underlying hormone-based strength fluctuations and the potential impact on performance across various athletic disciplines and phases of a training year. **PRACTICAL APPLICATIONS:** Menstrual cycle phase did not influence peak power production or maximal jump height but did affect peak isometric force production in beach volleyball players. Integrating menstrual cycle phase tracking into training programs may provide context for interpretation of fluctuations in strength and overall performance as well as allow coaches to make more informed programming decisions. Importantly, data were collected during an off-season period in which training and other stressors were limited. It is conceivable that the observed effects of menstrual cycle phase would differ due to the impact of other influential variables that have been shown to impact performance and recovery while in-season, which should be explored in future research.

INTRODUCTION

- Regular **athlete monitoring** supports individualized training, recovery, and performance optimization.
- In beach volleyball, **lower-body power and maximal strength** are essential for performance.
- However, the extent to which the **menstrual cycle** affects these parameters is not well established.
- Incorporating **menstrual cycle tracking** into athlete monitoring may enhance performance interpretation and training decisions by accounting for how hormonal fluctuations can influence strength, power, readiness and recovery.

Purpose: To explore lower-body strength and power changes over a seven-week off-season period and determine the influence of menstrual cycle phase on performance.

MAIN FINDINGS

- IMTP peak force increased significantly over the 7-week training period, peaking during the early luteal phase.
- Menstrual cycle phase did not influence peak power production or maximal jump height but did affect peak isometric force production in beach volleyball players.
- Future research should investigate the role of other influential variables that have been shown to affect performance in the context of menstrual cycle phase changes to assess the relative impact of menstrual cycle phase on performance across different sports and training phases.

METHODS

Participants:

Eighteen NCAA Division I female beach volleyball players participated in this study.

Table 1. Baseline Characteristics

| | |
|-------------|-------------|
| Age (yrs) | 20.7 ± 1.3 |
| Height (cm) | 177.4 ± 4.0 |
| Weight (kg) | 72.3 ± 6.3 |
| Freshman | n = 2 |
| Sophomore | n = 5 |
| Junior | n = 4 |
| Senior | n = 6 |
| Graduate | n = 1 |

Data shown as mean ± SD

Statistical Analysis:

Linear mixed-effects models were used to determine differences between weeks while accounting for menstrual cycle phase on each variable ($\alpha=0.05$).

Experimental Protocol:

- Participants underwent seven weeks of performance testing during the fall off-season period.
- Isometric mid-thigh pull (IMTP) and countermovement jump (CMJ) were assessed two days apart using force plates (VALD Performance, Brisbane, Australia).
- After completing a progressive warm-up, athletes performed a maximal IMTP to assess peak isometric force production
- For the CMJ assessment, athletes performed a standardized dynamic warm-up followed by two maximal CMJs with hands on hips to assess maximal jump height and peak power.
- Menstruation was self-reported to determine menstrual cycle phase. Menstrual cycle phases were categorized as menstrual (Phase 1), non-menstrual (Phase 2), early luteal (Phase 3), and late luteal (Phase 4).

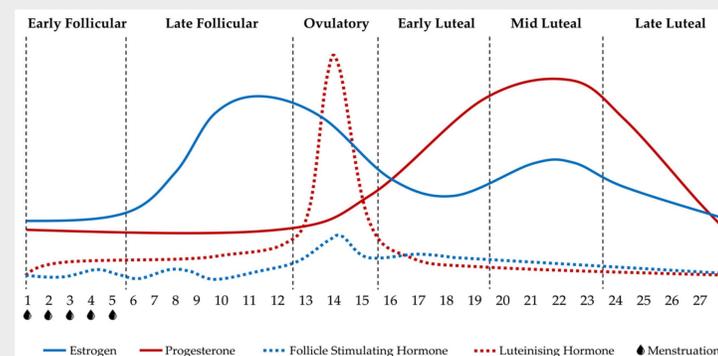


Figure 1. Menstrual Cycle

RESULTS

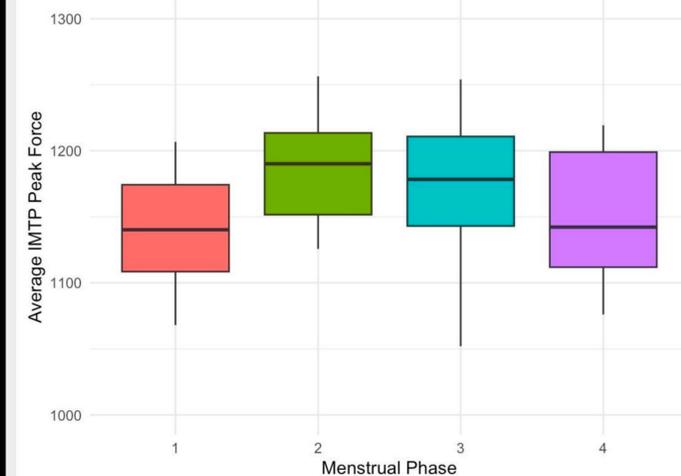


Figure 2. Average IMTP Peak Force Across Menstrual Cycle Phases

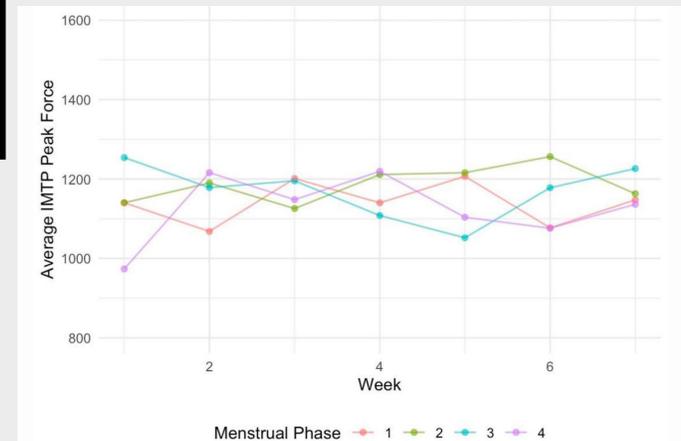


Figure 3. Average IMTP Peak Force Across Menstrual Cycle Phases by Week

PRACTICAL APPLICATIONS

Menstrual cycle phase did not affect peak power or jump height but did influence peak isometric force in beach volleyball players. Tracking cycle phases may help coaches interpret strength fluctuations and optimize training. Since data were collected in the off-season with limited stressors, future research should examine whether in-season factors alter these effects.

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