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Effects of Menstrual Cycle Phases on Selected Fitness Variable: In Case of Female Volleyball Players of Azazo Dimaza High School, Gondar City, Amhara Region, Ethiopia

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ABSTRACT

This study sought to determine the effects of the menstrual cycle phases (follicular, menstrual, and luteal) on strength and explosive power performance in a cohort of 25 female volleyball players from Azezo Dimaza secondary school. The research employed a longitudinal, prospective design, focusing on ninth-grade students who were selected purposively. Data was collected across the three cycle phases using three fitness tests: push-ups and sit-ups (assessing strength/endurance) and the standing long jump (assessing explosive power). Each performance measurement involved two familiarization sessions and one actual test per menstrual phase. The athletes, with a mean age of 15.76±1.25 yrs, and an average cycle length of 28.32±1.69 days, had an average height of 1.64±.049 meter, weight of 47.72±5.07kg, and a BMI of 17.73±1.98 kg/m2. Statistical analysis using a Repeated Measures ANOVA followed by a Bonferroni post hoc test revealed a statistically significant difference in mean performance scores across the follicular, menstrual, and luteal phases for all tests. Specifically, push-up scores showed a significant difference ($F(1.063, 25.501) = 4.780, p < 0.05$), sit-up scores were significantly different ($F(1.433, 34.386) = 5.651, p < 0.05$), and standing long jump scores also demonstrated a highly significant difference ($F(1.991, 47.779) = 17.947, p = 0.00$). These findings collectively indicate that the menstrual cycle phase measurably impacts the physical performance, both strength endurance and explosive power, of these female volleyball players.

Keywords: Menstrual cycle phase, female, volleyball, muscular endurance, muscular strength, power.

INTRODUCTION

Volleyball stands as one of the world's major international sports, boasting an estimated 800 million weekly players across 220 affiliated national federations (Kilic et al., 2017). Recognized for its exhilarating, fast, and dynamic nature (Desalegn, 2016), it is unique as a ball game featured in both the modern Olympic and Paralympic competitions, with variations including the six-player indoor version and the two-player beach format (Desalegn, 2016). Beyond its global appeal, participation in volleyball contributes significantly to physical, mental, and social well-being.

A common biological process for healthy women, the menstrual cycle averages 28 days and is fundamentally characterized by fluctuating ovarian hormones that govern its proper function (Ramos et al., 2018). This cycle is typically divided into three phases: the follicular phase, ovulation, and the luteal or premenstrual phase (Silva and Pires, 2021).

The effects of menstruation on female athletes' performance have been a long-debated topic, as many women report physiological difficulties and may try to abstain from training or competition during this period. However, research attempting to establish a conclusive negative or positive relationship between the menstrual cycle and sportive performance remains inconclusive (Kalyon, 2000; Lebrun, 1993; On, 2012; Ön et al., 2014; Sevim, 2002; Tsampoukos et al., 2010).

Some studies suggest athletes perform worse during the actual menstruation period, while others find the best performance at the beginning of this phase, and some evidence points to extraordinary achievements occurring across all phases (Ertas and Ersoz, 2002; Karacan et al., 2013; Karakas, 1987; Ön, 2012; Ön et al., 2014). Conversely, other research concluded there was no change in power output values during sprint tests in the menstrual phase. Further complexity exists regarding strength and endurance, with findings indicating that muscle endurance peaks midway through the follicular phase but is lowest in the mid-luteal phase, and that overall performance may be better in the early luteal phase (Lebrun, 1993; Fomin et al., 1989; Lind and Petrofsky, 1976; Ön, 2012; Ön et al., 2014; Özdemir and Kucukoglu, 1993; Tsampoukos et al., 2010).

Ultimately, a common conclusion from various studies is that the best performance is measured after the ovulation and menstruation phases, with the worst performance often seen during the premenstruation period (Lebrun, 1993; Fomin et al., 1989; Lind and Petrofsky, 1976; Ön, 2012; Ön et al., 2014; Özdemir and Kucukoglu, 1993; Tsampoukos et al., 2010). Given these conflicting results in the literature, the investigators undertook the current study to specifically explore the effect of the menstrual cycle on selected physical fitness components—namely muscular endurance, muscular strength, and power—in their athlete population.

MATERIALS AND METHODS

Study design

The researchers chose a prospective research design for this study because it required repeated observation of the same sample of female volleyball players over an extended period. Specifically, the study spanned two months (eight weeks), allowing the investigators to assess performance across the participants' various menstrual cycle phases. This design was ideal because prospective studies repeatedly examine the same individuals, enabling researchers to accurately detect and track any performance changes that might occur over time in correlation with the shifting menstrual phases (Bookwala, Hussain and Bhandari, 2011). Consequently, this method provided the necessary framework for a descriptive and observational analysis.

Sample

Out of the 145 female ninth-grade students initially considered, only 25 met the strict inclusion criteria and were purposively selected for the current study. These criteria ensured the selection of participants who were eumenorrheic (having a normal menstrual cycle), were 17 years of age, were actively involved as Volleyball sport project trainees, had no major injury history for the past two weeks, and were not currently using hormonal contraceptives. This highly selective process resulted in a focused sample best suited for investigating the effects of the natural menstrual cycle on physical performance.

Data collection instruments and procedures

The researchers detailed the procedures for administering the performance tests used in the study. Three performance tests—push-ups, sit-ups, and the standing long jump—were selected to measure muscular strength, muscular endurance, and leg power, respectively. Before the testing commenced, the participants' basic demographic information (age, height, and body weight) was recorded. The actual testing protocol was rigorous: participants were exposed to three separate occasions during each menstrual cycle phase, which included two familiarization sessions and one actual testing session for each performance measurement. All tests followed the scientific functional test procedures outlined by Mackenzie (2015). Prior to the administration of the tests, the nature and procedures were clearly explained to the participants, and a 15-minute standard warm-up was conducted by a coach.

Ethical consideration

Given the experimental nature of this study, which involved human subjects, the researchers prioritized ethical compliance. Formal approval to conduct the research was first secured from the Sport Science Department's postgraduate coordinator. Following this institutional clearance, a crucial step was obtaining informed permission from the participants; thus, both a parent consent form and a child assent form were prepared and distributed to the students to ensure their voluntary participation.

Determination of the Menstrual Cycle Phase

The precise timing and duration of each menstrual cycle phase were meticulously determined over two consecutive cycles prior to the main data collection, utilizing LH (Luteinizing Hormone) urine kits based on established protocols (Bambaeichi et al., 2004; Tenan et al., 2013; Tenan et al., 2016).

Ovulation was detected by testing urine samples collected after 2:30 AM for three days, starting two days before the estimated ovulation date, with the 24-hour period following a positive LH test accepted as the day of ovulation (Oğul et al., 2021). Health professionals from Azezo Health Center assisted with this detection process. Although the ovulation phase itself was too brief (lasting about 24 hours) for performance testing, it was designated as the starting point for the data collection.

The first actual performance tests were administered during the luteal phase, specifically on the 7th day after ovulation, placing it in the middle of this phase which typically lasts between 11 and 17 days (or 14 days on average). Following this, tests were conducted during the menstrual phase—which generally lasts 3 to 7 days for the participants—with testing occurring in the middle of each student's period.

The testing concluded during the follicular phase, which was defined as the period from the end of menstruation (to avoid overlap) up until the day of ovulation, averaging about 16 days. The tests were administered in the middle of this follicular phase (Oğul et al., 2021). Thus, testing was strategically timed during the mid-luteal, mid-menstrual, and mid-follicular phases to accurately assess performance variations across the cycle.

Statistical procedures

To analyze the collected data, the statistical software SPSS version 26 was utilized. Descriptive statistics, specifically the mean ± SD, were calculated to report the central tendency and dispersion of the results. The core analysis relied on a Repeated Measures ANOVA to assess differences in the athletes' performance scores across the various menstrual cycle phases. This model was chosen to determine if the mean performance varied significantly between phases. Following the ANOVA, a Bonferroni post hoc test was applied to pinpoint exactly which specific phase comparisons were statistically different. For all analyses, the level of significance was set at $p < 0.05$.

RESULTS

The demographic characteristics of participants, Age, Height, Weight, BMI and menstrual cycle days are reflected in Table 1 below.

Table 1. Demographic characteristics of the study.

Variables	N	Mean	Std. Deviation
Age (year)	25	15.76	0.436
Height (meter)	25	1.6412	0.04961
Body Weight (kg)	25	47.72	5.071
Body Mass Index (kg/m2)	25	17.7312	1.98535
Menstrual cycle (day)	25	28.32	1.069

In the present study the average age, stature, weight, BMI and menstrual cycle days of the study subjects were 15.76 ± .436, 1.64 ± .049 meter, 47.72 ± 5.07, 17.73 ± 1.98 and 28.32 ± 1.69 days respectively.

Table 2. Tests of within-subjects effects on pushup test.

Physical fitness test: Push ups

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Menstrual Phase	Sphericity Assumed	28.347	2	14.173	4.78	0.013*	0.166
	Greenhouse-Geisser	28.347	1.063	26.678	4.78	0.036*	0.166
	Huynh-Feldt	28.347	1.071	26.47	4.78	0.036*	0.166
	Lower-bound	28.347	1	28.347	4.78	0.039*	0.166
Error(Menstrual Phase)	Sphericity Assumed	142.32	48	2.965			
	Greenhouse-Geisser	142.32	25.501	5.581			
	Huynh-Feldt	142.32	25.701	5.537			
	Lower-bound	142.32	24	5.93			

*The mean difference is significant at the .05 level.

The statistical analysis using Repeated Measures ANOVA with a Greenhouse-Geisser correction revealed a significant overall difference in the mean push-up scores across the three menstrual cycle phases (follicular, menstrual, and luteal). Specifically, the results indicated a statistically significant effect of the menstrual cycle phase on push-up performance, as shown by the value ($F(1.063, 25.501) = 4.780$, $p < 0.05$). Furthermore, the Partial Eta Squared ($F = 1.063$, $p < 0.05$) suggested a large effect size ($\mu = 0.166$) of the independent variable (menstrual cycle phase) on the dependent variable (push-up performance) within the repeated measures model.

Table 3. Pair wise Comparisons of Push up tests (N=25)

Physical fitness test: Sit ups

(I) Menstrual cycle Phase	(J) Menstrual cycle Phase	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference [a]	
					Lower Bound	Upper Bound
Follicular	Menstrual	1.320*	0.39	.007*	0.315	2.325
	Luteal	0.52	0.494	0.908	-0.751	1.791
Menstrual	Follicular	-1.320*	0.39	.007*	-2.325	-0.315
	Luteal	-.800*	0.271	.021*	-1.497	-0.103
Luteal	Follicular	-0.52	0.494	0.908	-1.791	0.751
	Menstrual	.800*	0.271	.021*	0.103	1.497

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

*The mean difference is significant at the 0.05 level. A Adjustment for multiple comparisons: Bonferroni.

The Bonferroni post hoc test was used to identify the specific menstrual cycle phases where push-up performance significantly differed, following the overall significant finding from the ANOVA. The results showed that the follicular phase performance was statistically significantly different from the menstrual phase ($p < 0.05$). The mean difference (I-J = 1.32) indicates that push-up scores were significantly reduced during the menstrual phase compared to the follicular phase. Conversely, there was no significant difference found when comparing the follicular phase to the luteal phase ($p = 0.138$), with a mean difference of (I-J = -1.240). Furthermore, the test revealed a second statistically significant difference between the menstrual phase and the luteal phase ($p < 0.05$), with a mean difference of (I-J = -1.360). In summary, the most notable difference was the significant drop in push-up scores during the menstrual phase when compared to both the follicular and luteal phases.

Table 4. Tests of within-subjects effects on Sit up test.

Physical fitness test: Sit ups							
Source		**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Menstrual Phase	Sphericity Assumed	22.107	2	11.053	5.651	0.006*	0.191
	Greenhouse-Geisser	22.107	1.433	15.429	5.651	0.014*	0.191
	Huynh-Feldt	22.107	1.499	14.752	5.651	0.013*	0.191
	Lower-bound	22.107	1.000	22.107	5.651	0.026*	0.191
Error (Menstrual Phase)	Sphericity Assumed	93.893	48	1.956			
	Greenhouse-Geisser	93.893	34.386	2.731			
	Huynh-Feldt	93.893	35.966	2.611			
	Lower-bound	93.893	24.000	3.912			

*The mean difference is significant at the .05 level.

The results from the Repeated Measures ANOVA, which included a Greenhouse-Geisser correction, indicated a statistically significant overall difference in the mean sit-up performance scores among the three menstrual cycle phases: follicular, menstrual, and luteal. This significant effect of the menstrual cycle phase on the dependent variable (sit-up performance) was confirmed by the F-value of $F(1.433, 34.386) = 5.651$, $p < 0.05$. Furthermore, the analysis revealed a large effect size ($\mu = 0.191$), as shown by the Partial Eta Squared, suggesting that the differences in sit-up scores between the menstrual cycle phases have substantial practical importance in these repeated measures model.

Table-5: Pair wise Comparisons of Sit up tests (N=25)

Physical fitness test: Sit ups						
(I) Menstrual cycle Phase	**(J) Menstrual cycle Phase**	**Mean Difference (I-J)**	**Std. Error**	**Sig.[a]**	**95% Confidence Interval for Difference [a]**	
					Lower Bound	**Upper Bound**
Follicular	Menstrual	1.320*	0.39	.007*	0.315	2.325
	Luteal	0.52	0.494	0.908	-0.751	1.791
Menstrual	Follicular	-1.320*	0.39	.007*	-2.325	-0.315
	Luteal	-.800*	0.271	.021*	-1.497	-0.103
Luteal	Follicular	-0.52	0.494	0.908	-1.791	0.751
	Menstrual	.800*	0.271	.021*	0.103	1.497

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

The Bonferroni post hoc test was conducted following the overall significant finding from the ANOVA to specifically identify differences in mean sit-up test scores among the three menstrual cycle phases. The analysis showed a statistically significant difference between the follicular phase and the menstrual phase ($p < 0.05$). The mean difference (I-J = 1.32) indicates that sit-up performance was significantly reduced during the menstrual phase. A second significant difference was observed when comparing the menstrual phase to the luteal phase ($p < 0.05$), with a mean difference of (I-J = -0.800). However, the comparison between the follicular phase and the luteal phase showed no statistically significant difference ($p = 0.908$), with a mean difference of (I-J = 0.520). In summary, the findings confirm that sit-up performance, a measure of muscular endurance, is significantly lower during the menstrual phase compared to both the follicular and luteal phases.

Table 6: Tests of Within-Subjects effects on Standing long jump test.

Physical fitness test: Standing long jump							
Source		**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Menstrual Phase	Sphericity Assumed	259.280	2	129.640	17.947	.000*	.428
	Greenhouse-Geisser	259.280	1.991	130.239	17.947	.000*	.428
	Huynh-Feldt	259.280	2.000	129.640	17.947	.000*	.428
	Lower-bound	259.280	1.000	259.280	17.947	.000*	.428
Error (Menstrual Phase)	Sphericity Assumed	346.720	48	7.223			
	Greenhouse-Geisser	346.720	47.779	7.257			
	Huynh-Feldt	346.720	48.000	7.223			
	Lower-bound	346.720	24.000	14.447			

*. The mean difference is significant at the .05 level.

As indicated in the above table the F value for the "menstrual cycle phase" factor, is associated with its significance level and effect size ("Partial Eta Squared"). The results presented in this table showed that the overall significant difference obtained in means. As the values in the "Greenhouse-Geisser" row indicated when using an ANOVA with repeated measures with a Greenhouse-Geisser correction, the Standing Long Jump test mean scores for during follicular phase, menstrual phase and luteal phase were statistically significantly different ($F(1.991, 47.779) = 17.947$, $p = 0.00$).

A repeated measure ANOVA was also performed to compare the effect of the menstrual phases, such as on the dependent variables (leg power performance). As shown on the above table, there was statistically significant difference in Standing Long Jump scores between three different menstrual cycle phases (F = 17.947, $p < 0.05$). As well as, as shown on the above table, partial eta squared showed that large effect size (μ = 0.428) of the independent variable in the repeated measure ANOVA model.

Table-7: Pair wise Comparisons of Standing long jump tests (N=25)

Physical fitness test: Standing long jump						
(I) Menstrual cycle Phase	**(J) Menstrual cycle Phase**	**Mean Difference (I-J)**	**Std. Error**	**Sig.[a]**	**95% Confidence Interval for Difference[a]**	
					Lower Bound	**Upper Bound**
Follicular	Menstrual	3.320*	0.78	.001*	1.311	5.329
	Luteal	-1.04	0.736	0.511	-2.934	0.854
Menstrual	Follicular	-3.320*	0.78	.001*	-5.329	-1.311
	Luteal	-4.360*	0.764	.000*	-6.325	-2.395
Luteal	Follicular	1.04	0.736	0.511	-0.854	2.934
	Menstrual	4.360*	0.764	.000*	2.395	6.325

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

In the above table the significance level for differences between the individual time points (menstrual cycle phases) have been illustrated. Consequently, there was a statistically significant difference in Standing Long Jumps test scores of follicular phases compared with menstrual phase ($p < 0.05$), and luteal phase ($p = 0.511$). The table revealed that there was significant difference between follicular phase and menstrual phase ($p < 0.05$), while no significant difference between follicular phase and luteal phase ($p = 0.511$). As indicated on table 4 above ("Mean Difference (I-J)" column), Standing Long Jump test scores was significantly reduced at menstrual phase. Therefore, the mean difference between Standing Long Jump scores at follicular phase and menstrual phase was (I-J = 3.320, $p < 0.05$); the mean difference between Standing Long Jump scores at follicular phase and luteal phase was (I-J = -1.040, p = 0.511); whereas the mean difference between menstrual phase and luteal phase was (I-J = - 4.360, $p < 0.05$).

DISCUSSION

The present study investigated the effect of menstrual cycle phases on strength, endurance, and power in female volleyball players at Azezo Dimaza secondary school, finding a significant difference in upper-body muscular endurance and power performance across the phases ($P < 0.05$). This result aligns with the complex and often contradictory findings in existing literature. While some studies, like those by Ön (2012) and Dibrezzo et al. (1988), found no significant effect of the menstrual cycle on various performance parameters, including anaerobic power, jumping, and dynamic power, other research similarly concluded that speed and endurance were unaffected in women with non-painful menstruation (Özdemir and Kucukoglu, 1993), and no differences were found in repetitive sprint performance (Hazir et al., 2011) or anaerobic performance (Cakmakci et al., 2005) between follicular and luteal phases. These studies often reflect the known variability in women's experiences, where many feel sensitive and stressed during menstruation, while others experience no physical or psychological difficulties (Özdemir and Kucukoglu, 1993). In contrast to the "no effect" findings, a line of research, which the present study corroborates, found significant differences influenced by the cycle. For instance, wearing et al. (1972) noted the worst performance in the menstrual phase, while Lebrun and Rumball (2001) suggested the best performances occur after ovulation and menstruation, with the worst during the premenstrual period. Other studies have found that performance parameters like general coordination, anaerobic power, and vertical jump scores improved significantly after the menstruation period compared to premenstrual and menstrual phases (Karacan and Gunay, 2003). Furthermore, some research indicates the best performance at the beginning of the menstrual period (Ertas and Ersoz, 2002), and Masterson (1999) reported significant differences in anaerobic power between the follicular and luteal phases in exercising women. Ultimately, this body of research, including the current study, confirms a significant interaction between the menstrual cycle and sportive performance, though the direction and specific impact vary widely across individual athletes and different measures of fitness.

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