



Evaluation of Progesterone Levels during the Luteal Phase in Athletes and Sedentary Individuals

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ABSTRACT The aim of this study is to investigate the effect of regular exercise on progesterone levels during the luteal phase among basketball players and sedentary women. The study included a total of 34 individuals. Venous blood samples (4 cc) were collected from subjects on days 20 and 21 of the menstrual cycle. Based on the test results, a statistically significant difference was observed between active basketball players and sedentary individuals ($p < 0.05$). The average progesterone levels of the players and sedentary women were 3.84 ng/ml and 7.88 ng/ml, respectively. In accordance with the Pearson's correlation analysis that was applied to determine the relationship between progesterone levels and age, height, and weight of the subjects, a slight positive correlation was observed between the age and progesterone levels of the subjects ($p = 0.015$). Despite significant differences between the groups with respect to progesterone levels, these values in both groups were within normal limits.

INTRODUCTION

The increasing participation of women in different branches of sports has brought to light many important and previously unknown data concerning women and their physiology (Woodward et al. 2015; McGuire et al. 2016). In this context, previously held negative theses and beliefs concerning women were disproven by their success in sports. This unexpected success has led scientists in countries of different levels of development to conduct further research on this subject. As a result of these studies, "Women and Sports" has become a separate and important field within sports sciences (Sevim 1997; Karacan et al. 2013). There are many physiological differences between women and men. One of the most important of these physiological differences is menstruation, which begins between the ages of 11 and 13, and occurs periodically once every 28 days.

Menstruation represents frequent physiological changes that occur in the genital organ and the entire body throughout a woman's entire fertile period, from menarche and menopause. Ovulatory cycles in women generally last for 28-30 days, although regular cycles varying between 21 to 35 days are also observed in certain cases (Turkmen 1994; Laux-Biehlmann et al. 2015; Ikhsan et al. 2016). Each menstruation cycle consists of the follicular, ovulation and luteal phases. Following ovulation, the endometrium will become more vascularized and slightly edematous due to the effects of estrogen and progesterone, which are both secreted by the corpus luteum. These glands will also acquire a more convoluted appearance, and begin to secrete a transparent fluid. For this reason, this phase of menstruation is also called the secretory or luteal phase (Ganong 1995; Weis et al. 2016).

The female sex steroid hormones estrogen and progesterone potentially affect numerous different mechanisms such as exercise capacity, cardioreceptor function during performance, thermoregulation, psychological factors, and injury. For this reason, variations in the level of these hormones throughout the menstrual cycle can, at different times, have either a performance enhancing or a performance reducing ef-

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fect (Redman and Weatherby 2004; Constantini et al. 2005; Sato and Iemitsu 2015).

Sex hormones in women are not constant during the monthly menstrual cycle, and are secreted at highly variable rates during different periods of this cycle (Guyton 1986). The level of luteinizing hormone (LH), on the other hand, remains fairly stable except for its fluctuation during the pre-ovulatory period. The level of follicular stimulating hormone (FSH) begins to increase before menstruation, drops slightly during the first half of the cycle, and then undergoes a transient increase immediately before ovulation. The menstrual cycle ends with a drop in estrogen and progesterone concentrations (Clayton et al. 1985; Kunduk et al. 2016). Of these hormones, estrogen is secreted during the 14 days preceding ovulation, while progesterone is secreted for 14 days following ovulation (Hatiboglu 1989). The combined presence of progesterone and estrogen has the effect of increasing alveolar respiration and chemical sensitivity (Guenette et al. 2007). The absence of LH and FSH hormones prevents the onset of puberty and the occurrence of menstrual cycles (Hasbay 2005).

Menstruation is a significant problem for women athletes. Menstruation can lead to a various difficulties both during training and competitions (Kalyon 2000; Takeda et al. 2016). Women generally avoid athletic activities during this period. While doing so may theoretically seem reasonable, there are cases where the opposite sometimes holds true in practice (Sevim 1997).

The participation of women in physical activities has been gradually increasing in recent times, along with their performance and the results they achieve in competitions. In fact, they even demonstrate better performance than men in certain branches of sports. Parallel to this, physiological, endocrinological, and psychological studies on the subject of women in sports are becoming increasingly more important.

The aim of this study is to investigate progesterone levels during the luteal phase of the menstrual cycle among professional basketball player women and sedentary women.

MATERIAL AND METHODS

The study protocol as legally was approved by the Clinical Trials Ethics Committee of Ondokuz Mayıs University (25.04.2014 and 2014/614). The study was conducted with the participation of 34 female subjects, 17 of which were sedentary women, while the other 17 were ath-

letes playing in the 55 Gençlik Spor and the Tekkeköy Belediye Spor Clubs, which are two basketball teams in the Turkish Women's Second Basketball League from the 2013-2014 season. Inclusion criteria for the exercise group of the study included participation in basketball training at least three times a week, not having any serious disease or disability, no surgery in the past six months, no polycystic ovaries or ovary cysts, and no pathologies affecting the uterus, endometrium, and ovaries. The sedentary group had the same criteria except for participation basketball training at least three times a week.

On the day of the study, all subjects were specifically requested not to use any medications prior to the study measurements (carried out between 08:00am and 12:00pm), and also not to perform any additional exercises other than their routine activities. Approximately 4 cc of venous blood was collected from women in both the exercise and control groups of the study on days 20 and 21 of their menstrual cycle, and the samples were collected at the central laboratory of the Ondokuz Mayıs University, Samsun.

The collected blood samples were centrifuged following coagulation in order to separate their serum. The obtain sera were transferred into eppendorf tubes, and were stored at -80°C until the day of the study tests and assessments. Before commencing the study tests, the serum samples were warmed to room temperature (25°C). Serum progesterone levels were determined using an immunological assay method (ECLIA). The results were provided in ng/mL. Progesterone levels were then compared between exercise and control groups.

A personal information form developed by the researchers was used to determine and record the age, smoking and alcohol using status, weight, and height parameters of the study participants. The criteria of World Health Organization's (WHO) used to determine the smoking and alcohol dependency of the participants (www.who.int). Concerning smoking, individuals who smoked at least one cigarette a day were considered as having smoking dependency. On the other hand, individuals who consumed alcohol at least twice a week were considered to have alcohol dependency.

The SPSS 21 statistical package program was used for the calculation of the data. As descriptive statistics, the arithmetic means ($\bar{X}$) and standard deviations (SD) of the data were calculated. P values less than 0.05 were considered signifi-

Table 1: The age, weight, height, and body mass index (BMI) of the study subjects

Groups	n	Age (years)	Weight (kg)	Height (cm)	BMI (kg/m ²)
Athletes	17	21.35±2.80	65.82±8.29	174.35±6.79	21.61±2.17
Sedentary individuals	17	22.94±3.32	64.64±12.96	165.05±5.56	22.49±3.68

cant. The normality test was applied to determine the statistical method to be employed for the obtained data. The differences between the groups were then evaluated using the Mann-Whitney-U tests, which is a non-parametric test. Pearson's correlation was employed to evaluate the age, alcohol, smoking, weight, and height parameters.

RESULTS

The study was conducted with the participation of a total of 34 women who were not contraceptive users. Seventeen of these women were athletes playing in the 55 *Gençlik Spor* and the *Tekkeköy Belediye Spor Clubs*, which are two basketball teams in the Turkish Women's Second Basketball League from the 2013-2014 season (mean age: 21.35±2.80 years; mean weight: 65.82±8.29 kg, mean height: 174.35±6.79 cm; body mass index (BMI): 21.61±2.17 kg/m²). The remaining 17 of the study participants were sedentary women (mean age: 22.94±3.32 years; mean weight: 64.64±12.96 kg; mean height: 165.05±5.56 cm; BMI: 22.49±3.68 kg/m²) (Table 1).

An evaluation of smoking and alcohol using among the study participants revealed that seventeen percent of the athletes were smokers and thirty-five percent were alcohol users, while forty-seven percent of the sedentary individuals were smokers and thirty-five percent were alcohol users (Table 2).

Table 2: The percentage of smoking and alcohol-using athletes and sedentary individuals

Groups	Smoking %	Alcohol %
Athletes	17	35
Sedentary individuals	47	35

Table 3: Distribution of progesterone levels among athletes and sedentary individuals

Variable	Groups	n	Mean	Max.	Min.	SD	p
Progesterone ng/ml	Athlete	17	3.84	12.45	0.22	3.95	0.040*
	Sedentary individual	17	7.88	21.57	0.84	6.37	

*p<0.05

The mean progesterone level of the athletes was 3.84 ng/ml, while the mean progesterone level of the sedentary individuals was 7.88 ng/ml. A statistically significant relationship was identified between the athletes and the sedentary individuals (p<0.05) (Table 3).

Among the study participants, a positive relationship was identified between age and progesterone levels (p=0.015), while a negative relationship was identified between weight and progesterone levels (p=0.019) (Table 4).

Table 4: The relationship of progesterone levels with certain variables among the study participants

n	Variables	Progesterone level (ng/mL)
34	Age	0.015*
	Alcohol	0.105
	Smoking	0.733
	Weight	0.019*
	Height	0.132

*p<0.05

The normality test was used to determine the statistical method to be applied on the obtained data. Based on the Shapiro-Wilk test, it was determined that the data did not show normal distribution (p<0.05) (Table 5).

DISCUSSION

An evaluation of studies in the literature comparing exercising women with sedentary women reveals many contradictory findings. The intensity and duration of exercise, as well as age group and environmental factors, can all affect hormonal levels in different ways. For example, it was pre-

Table 5: Relationship between demographic characteristics and the study variables

Variables	n		Age	Alcohol	Smoking	Weight	Height
Age	34	Pearson Correlation	1	0.095	-0.028	-0.101	-0.101
		Sig		0.593	0.874	0.568	0.57
Alcohol	34	Pearson Correlation	0.095	1	0.279	-0.178	-0.077
		Sig	0.593		0.111	0.313	0.665
Smoking	34	Pearson Correlation	-0.028	0.279	1	-0.058	0.304
		Sig	0.874	0.111		0.745	0.081
Weight	34	Pearson Correlation	-0.101	-0.178	-0.058	1	0.614**
		Sig	0.568	0.313	0.745		0
Height	34	Pearson Correlation	-0.101	-0.077	0.304	0.614**	1
		Sig	0.57	0.665	0.081	0	

viously determined that women performing long jumps tests showed lower performance during menstruation, and higher performance prior to menstruation (Wearing et al. 1972). Menstruation was similarly associated with decreased performance in 50 meters swimming (Dawson and Rilly 2009) and reduced peak torque production of the extensors in well-trained athletes (Gordon et al. 2013). In another study, Ahrens et al. (2014) investigated in 259 women the effect of exercise performed on different weeks on serum leptin, estradiol, progesterone, luteinizing hormone, follicle stimulating hormone, and testosterone. They determined a relationship between physical exercise and the reproductive hormones in question, and that, among healthy and premenopausal women, physical activities during the menstrual period lowered the concentrations of leptin and luteal progesterone.

In a study performed by Janse de Jonge et al. (2001) on 19 women, it was determined that LH and estrogen levels were not affected by the muscle contractions performed during exercise in 15 of the participating women. Otag et al. (2016) evaluated the progesterone activity after the exercise (shuttle run test) and they obtained significantly decreased progesterone levels in their study, which they applied to 12 healthy female footballers. Other studies on physical activity and hormone levels in reproductive age women identified similar results with regards to progesterone and leptin. Two interrelated studies determined that compared to sedentary individuals, recreational runners (20 hours/week), and exercising women had significantly lower urine levels of progesterone during the luteal phase (De Souza et al. 1998; De Souza et al. 2010). The endocrine response to acute exercise tests can also differ between regularly exercising women and sedentary women. In a study encompassing

the luteal and follicular phases, eight non-athlete women were asked to perform maximum-level exercise during certain phases for the purpose of determining the differences in their respiratory responses, and the progesterone level of these women were measured during these phases. Following the assigned exercises, no differences were observed in the obtained MaxVO_2 , heart rate (HR), partial carbon dioxide (PaCO_2), and work efficiency values, and none of these parameters were associated with serum progesterone (Dombovy and Bonekat 1987). In another study on the mid-luteal phase and the early and late follicular phase, the blood lactate response and respiration values were evaluated, and no relationship was identified during the assessments between the phases of the menstrual cycle and the response to exercise (Bemben et al. 1995).

In this study, the mean progesterone levels of the athletes and sedentary individuals were 3.84 ng/ml and 7.88 ng/ml, respectively. A statistically significant relation was identified between the groups with respect to progesterone values ($p < 0.05$, $p = 0.040$).

In a study performed by Janse de Jonge et al. (2001), an acute contraction model was used by having the study participants only exert maximum isometric quadriceps force as exercise. In this study, the researchers selected basketball as the type of exercise, and team members from clubs in Samsun playing in the Turkish Women's Second Basketball League as the study's athlete group. Basketball is a sport and exercise that requires the active use of many muscle groups. The researchers believe that the disagreement between this study's results and the results of Janse de Jonge et al. (2001) might have stemmed from differences in the relevant muscle groups, in the type of exercise, and in the in-

tensity and duration of exercise. The effect of physical activity on hormones has been the subject of numerous studies, and it is generally accepted that hormonal changes have an effect on physical activity as well as metabolic and endocrine adaptation (Galbo 1981; Schaumberg et al. 2016). Data from such studies is parallel to the findings of this study.

Erboga (2012) previously performed a study in which he investigated the effect of changing sex hormone levels (estradiol, FSH, LH and progesterone) caused by the menstrual cycle on chromosomal sensitivity and cytotoxicity in smoking and non-smoking reproductive age women who were not using contraceptives. The study assessments were performed by Sister Chromatid Change and Chromosomal Abnormality tests, while cytotoxicity was determined using proliferation and the mitotic index. Following the evaluation of the progesterone levels, it was determined that both the smoking and non-smoking groups had lower hormone concentration during the follicular phase, while the luteal phase was associated with higher hormone concentration for both groups. In addition, it was also determined that progesterone levels showed sharper decreases in progesterone level during all three of the menstrual phases. Nishino et al. (2014) determined that cigarette smoke affects estrogen and progesterone levels, while Kawai et al. (2014) similarly determined in their study performed on 938 women between the ages of 20-44 that cigarette smoke has an effect on progesterone receptors.

In this study, no statistically significant relation was identified in both groups between the effect of smoking and alcohol use and the menstrual hormone levels (alcohol use level: $p=0.105$; smoking level: $p=0.733$). An evaluation of other studies in the literature reveals that smoking and cigarette smoke affect reproductive hormones and their receptors (Erboga 2012; Kawai et al. 2014). In this study, the ratio of smoking and alcohol-using patients was relatively low, and the researchers believe that this might have partly affected the results.

In a study performed on 107 women, Sarkola et al. (1999) determined that contraceptives and the oral intake of alcohol affected estrogen, progesterone, prolactin, cortisol and LH hormone levels, and that alcohol administered at a 0.5 g/kg dose reduced the level of the progesterone hormone ($p<0.05$). It is known that reproductive

age women with alcohol addiction tend to develop various reproductive function disorders such as menstrual irregularities, interruption of periods, an ovulatory cycles, infertility, and early menopause. It is believed that alcohol can lead to such effects independently of the amount of the consumed, and that alcohol might lead to temporary infertility by affecting hormonal balance even when taken in quantities that will not cause organ damage (Emanuele et al. 2002).

This study demonstrated that although the progesterone levels were different between the groups, and although none of the groups showed a statistically significant relation with alcohol use and smoking ($p>0.05$), the levels of progesterone were not affected by alcohol use or smoking.

In this study, an evaluation of the effect of age on menstrual hormones indicated a positive relation between age and progesterone levels in both groups' subjects ($p=0.015$). Thus, both groups exhibited increased progesterone levels during the luteal phase in parallel to increasing age.

Progesterone is the most important hormone that ensures the continuation of pregnancy, and the level of this hormone increases immediately following ovulation. It is therefore expected that women with high fecundability will also have high levels of progesterone (Berlin et al. 2016). In this study, the sedentary group had a higher mean age than the athlete group, and thus, the age factor might have affected the two groups in a significantly different way. However, beyond the age of 40, age and progesterone levels begin to display a negative relation.

An evaluation of the effect of the body mass index on menstrual hormones indicates that the progesterone hormone is directly associated with the mechanisms that directly affect the body mass index. Various studies have determined that estrogen and progesterone have a positive effect on glycogen retention and fat metabolism (Janse de Jonge 2003). In the presence of sufficient energy, the release of LH takes place in fluctuating waves. In the current study, a negative relation was identified between the weight of the subject and their progesterone levels ($p=0.019$).

Di Brezzo et al. (1991) previously conducted a study investigating the relation between body weight, body fat percentage, dynamic strength, and muscle resistance among 21 women subject between the ages of 18-36 who had normal men-

strual cycles and no function disorders. The said parameters were evaluated in these women at different phases of the menstrual cycle. During this study, a high correlation was identified between the cycles with respect to the strength measurements performed at three different test speeds (three different speeds for each factor: 60 degrees/sec, 180 degrees/sec and 240 degrees/sec). Based on their study findings, Di Brezzo et al. concluded that the different phases of the menstrual cycle had little or no effect on body weight, body fat percentage, knee extension strength/resistance, and flexion strength/resistance.

In the current study, a negative relationship was identified between weight and progesterone levels. Thus, higher progesterone levels were observed among subjects who had lower body weights. This observation is in agreement with the findings and information described in the literature (Janse de Jonge 2003; Evliyaoglu et al. 2010). In a study performed with the participation of 40 athletes and 40 sedentary individuals with an age average of 17, Kishali et al. (2010) identified a statistically significant relation between menarche age and heart rate ($p < 0.05$). On the other hand, no statistically significant relation was identified between the menarche age and the body fat ratio and blood pressure of the subjects ($p > 0.05$).

CONCLUSION

In conclusion, the researchers have determined that as a sport, basketball causes physical stress by straining homeostasis, and that it affects the neuroendocrine system by causing differences in the progesterone levels of athletes (basketball players) and sedentary individuals. Based on the findings of the current study, the researchers believe that this effect is not pathological, and that hormonal changes actually represent a metabolic and endocrine adaptation to physical activity.

RECOMMENDATIONS

The influence of performance sports on the hormonal system in men and women can be characterized as a physiological adaptation of metabolism. Hence, the intensity of physical exercise should not affect the hormonal system and it must adjust in that way during the exercise. All athletes and sedentaries should have regular medical checkups to determine the effects of

physical activities on the endocrine system. For future studies, other team sports' (handball, volleyball) players may be included in the studies. Thus, researchers can design new ideas with other athletes from other sports about women's reproductive hormones.

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