The motor performance and some physical characteristics of the sportswomen and sedentary lifestyle women during menstrual cycle

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- A Study Design
- B Data Collection
- C Statistical Analysis
- D Manuscript Preparation
- E Funds Collection

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Abstract

Background and Study Aim: The aim of this study were the effects of the menstrual cycle in sportswomen and sedentary lifestyle women, before menstruation (BM), during menstruation (DM) and after menstruation (AM) cycle, related to their motor performance and some physical characteristics during these three periods.

Material/Methods: A total of 60 women, including 30 sportswomen and 30 sedentary women (control group) between the ages of 18–24 years, took voluntary part in the study as subjects. For two months, some motor performance features and the circumferences and skin-fold thickness of some body parts were measured between the 26th–28th (BM), 1st–6th (DM), and 7th–12th (AM) days of the subjects' monthly cycles. The BM, DM and AM measurements of the sportswomen and control groups were analyzed together using repeated measures variance analysis.

Results: The menstrual cycle showed differences in some motor performance, especially a significant capacity rise in the dominant hand grip capacity was observed in sportswomen during the AM period. Increased anaerobic capacity was also apparent in the DM and AM periods for the sportswomen group, compared to the BM period. Over the two month measuring span, body weight was the highest in the BM period. Speed of reaction to light decreased significantly in the AM period in sportswomen, and a similar, but not statistically significant, decrease in response to sound was observed. However, these differences did not shed sufficient light on the effects of menstruation on motor performance.

Conclusions: The results of this study reveal that some motor performance show differences during the menstruation cycle. There is a significant capacity increase, especially in dominant hand grip capacity, in the AM period. On the other hand, DM and AM periods show a significant increase in anaerobic capacity when compared with BM period.

Key words: menstrual cycle • motor performance • sportswoman

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Background

More women are engaged in sports nowadays and their athletic performance is becoming increasingly more remarkable. One of the many important factors that may alter athletic performance is hormonal changes in the body [1]. Women's hormone levels are known to fluctuate during menstruation and reproduction periods, affecting the autonomic nervous system and metabolic functions [2]. Therefore, a number of physiological variables and overall athletic performance could also change along with the menstrual cycle phases [3]. However, the influence of the menstrual cycle phase on exercise performance, particularly muscle strength, is unclear [4].

Menstrual cycle – is a series of physiological changes that can occur in fertile females. It is commonly divided into three phases: the follicular phase, ovulation, and the luteal phase. Average menstrual cycle is 28 days.

Motor performance – is the physiological, biomechanical and psychological factors that a physical activity requires. The elements that constitute motor performance can be listed as energy produce (aerobic-anaerobic), neuro-muscular message and psychological factors (motivation).

Sportswoman – a woman who is active in sports.

Previous studies on the effects of menstrual cycle phase on athletic performance have produced ambiguous and conflicting results [4–6]. For example, Friden was unable to detect any differences in muscle torque of the knee flexors and extensors during the menstrual cycle [7]. Friden concluded that muscle strength and endurance were not influenced by the hormonal variation during the menstrual cycle. Similarly, de Jonge et al. found no significant changes in any of the muscle function variables tested throughout the menstrual cycle [4]. In contrast, other studies have indicated that the strength of the adductor policies and quadriceps muscles increased 11% in the first half of the menstruation cycle [5,8]. Davies et al. stated that athletic performance was higher during the menstruation period than on other days [9].

Because of these inconsistent results, the aim of the present study was the effects of the menstrual cycle in sportswomen and sedentary lifestyle women, before menstruation (BM, days 26–28 of the cycle), during menstruation (DM, days 1–6 of the cycle) and after menstruation (AM, days 7–12 of the cycle) cycle, related to their motor performance and some physical characteristics (anthropometric variables) during these three periods.

Material and Methods

Sixty female voluntary subjects, aged 18–24, participated in the study. Of these, 30 were sportswomen (the sportswomen were intermediate level and they were actively engaged in basketball, judo, and football) while 30 were sedentary (control group). The subjects' menstrual histories were obtained by information forms. With the help of the data from these forms, the scope of the study was narrowed and the limits were defined, to include: those who had their menarche at least three years ago; those who had no chronic illness; those who had not conceived and did not use any oral contraceptives in the recent year; and those who were between 18–25 years of age, 160–170 cm tall and weighing 46–76 kg. For inclusion in the sportswomen group, the criterion was being engaged in sports for the last two years. The age and height average were, respectively, 18±3.2 years and 1.65±0.06 cm for the sportswomen group and 18.05±0.8 years and 1.62±0.03 cm for the sedentary group.

For two months, motor performance features [anaerobic capacity (vertical jump), hand reaction to light and sound, hand grip strength and 20 m sprint] were measured with tests during the BM, DM and AM periods of the subjects' monthly cycle and also anthropometric variables (weight and body height, subdermal fat thickness).

Measurement and Test Procedures

Motor performance

a. For the vertical jump test, one of the anaerobic capacity measurement methods, a Takei Physical Fitness Test Jumping device was used. The anaerobic power (*P*) was measured as kg-m/sec by the following formula, using the vertical jump test results:

$$P\,(\text{kg - m/sec}) = \sqrt{4.9\,(\text{Weight})}\,.\,\sqrt{\text{Jump Research Score}}$$

b. The subjects' audio and visual reaction time measurements were detected by a Newtest 1000 device. The measurements were done between 17.00–18.00 hours every day, in a quiet and appropriately lit setting. The device was placed opposite the subject, 10 cm away from the desk, and the subject was asked to place her dominant hand on the desk. On hearing the instruction "ready," the subject was asked to press the buttons according to the stimuli in the shortest time possible when one of the stimuli, light or sound, was given. The results were recorded on previously prepared result papers. A total of 10 assays were run with each subject for the light and sound stimuli. The first 5 assays were regarded as adaptation and the average of the last 5 assays were assessed as the reaction time.
c. 20 m sprint. A sprint running test was carried out at 23°C ambient temperature on a synthetic non-slip floor. A photo-cell (Digital electronic chronometer) was used to detect the running time. Two repetitions were made and the best result was recorded.
d. Handgrip strength was measured in kilograms with a Takei hand dynamometer. Two measurements were taken for each hand when the subject was standing with arms unbent at both sides of the body and the highest values were recorded.

Weight and body height

Subjects were weighed with bare feet and light casual clothing (shorts and t-shirt) using an Angel scale with a precision of up to 20 g. The heights were measured with bare feet during deep inspiration by a Holtain floating caliper with a precision of 1 mm.

Subdermal fat thickness

Subdermal fat thickness (skinfold) measurements were made on 6 parts of the body (biceps, triceps, iliac, sub scapula, abdomen, chest).

Statistical analysis

The data were analyzed with the Shapiro-Wilk's test for normality. Because the data were normally distributed

Table 1. Sports parameters measurements.

Measurements	Groups	Menstrual cycle Mean ±SD Before (BM)	During (DM)	After (AM)	P*
Vertical jump	Sportswoman	39.20 ± 5.21^{B}	39.67 ± 5.10^{B}	39.91 ± 4.81^{B}	>0.05
	Control	$29.69\pm4.03^{a,A}$	30.00 ± 4.15^{abA}	$30.24\pm3.87^{b,A}$	<0.05
	P	<0.001	<0.001	<0.001	
Anaerobic Capacity	Sportswoman	$106.09\pm9.76^{b,B}$	$106.72\pm9.76^{a,B}$	$106.49\pm9.62^{a,b,B}$	<0.05
	Control	$89.67\pm8.52^{b,A}$	$90.26\pm8.66^{a,A}$	$90.49\pm8.65^{a,A}$	<0.05
	P	<0.001	<0.001	<0.001	
Reaction time (sound)	Sportswoman	14.68 ± 1.22^{A}	14.53 ± 1.38^{A}	14.35 ± 1.10^{A}	>0.05
	Control	16.95 ± 2.35^{B}	17.20 ± 2.63^{B}	17.01 ± 2.15^{B}	>0.05
	P	<0.001	<0.001	<0.001	
Reaction time (light)	Sportswoman	15.16 ± 1.72^{bA}	15.00 ± 1.27^{bA}	$14.66\pm1.02^{a,A}$	<0.05
	Control	17.73 ± 2.56^{B}	17.91 ± 2.27^{B}	17.72 ± 2.32^{B}	>0.05
	P	<0.001	<0.001	<0.001	
20 meter sprint running	Sportswoman	$4.13\pm0.18^{b,A}$	4.12 ± 0.18^{aA}	$4.12\pm0.19^{a,A}$	<0.05
	Control	$4.70\pm0.69^{b,B}$	4.73 ± 0.65^{bB}	$4.55\pm0.58^{a,B}$	<0.05
	p	<0.001	<0.001	<0.001	
Right hand grip strength	Sportswoman	$30.92\pm4.62^{a,B}$	$30.87\pm4.66^{a,B}$	$31.35\pm4.40^{b,B}$	<0.05
	Control	$27.04\pm3.58^{a,b,A}$	$26.92\pm3.40^{a,A}$	$27.24\pm3.40^{b,A}$	<0.05
	p	0.001	<0.001	<0.001	
Left hand grip strength	Sportswoman	29.42 ± 4.78^{B}	29.32 ± 4.80^{B}	29.32 ± 4.80^{B}	>0.05
	Control	26.03 ± 3.53^{A}	25.75 ± 3.76^{A}	25.75 ± 3.76^{A}	>0.05
	p	0.003	0.002	0.002	

* Different letters indicate significant differences among time; ^{a,b,c} letters indicate differences in time within the same group; ^{A,B} letters indicate differences within groups in the same time period.

according to the groups, they were further assessed using parametric statistics. The BM, DM, and AM measurements of the sportswomen and the sedentary control groups were analyzed by one-way ANOVA with repeated measures. When differences in time were significant, these differences were reanalyzed by the same analysis method for each group. For each time cycle, sportswomen and control group comparisons were made by the Student *t*-test.

Results

The motor performance and anthropometric variables measurements of the groups are given in Tables 1 and 2.

In the vertical jump test, the sportswomen's results were significantly greater ($p<0.001$) than the controls for all three cycle periods (BM, DM and AM). However, no significant difference was seen between the BM, DM or AM periods in the sportswomen group. In contrast, for the control group, there was a significant difference between the BM and the AM periods ($p<0.05$). The results were greater in the AM period (BM: 29.69±4.03, DM: 30.00±4.15, AM: 30.24±3.87).

The anaerobic capacity variables, assessed by the vertical jump, showed a statistically significant difference between the menstrual periods both within the groups (<0.05) and between the groups (<0.001). The sportswomen's results were greater than the controls'. As for the periods, in the sportswomen group, there was a significant difference between the BM and DM periods, with DM having greater values (BM: 106.09±9.76, DM: 106.72±9.76, AM: 106.49±9.62). No difference was observed in the control group between the DM and AM groups. However, BM period was significantly different than the DM and AM periods with lower results (BM: 89.67±8.52, DM: 90.26±8.66, AM: 90.49±8.65).

No significant differences were observed for the sound reaction test between BM, DM or AM periods in either

Table 2. Antropometric measurements.

Measurements	Groups	Menstrual cycle Mean ±SD			P*
		Before (BM)	During (DM)	After (AM)	
Body weight	Sportswoman	58.97 ± 6.98^{a}	58.95 ± 6.82^{a}	58.38 ± 6.84^{b}	<0.05
	Control	56.05 ± 6.51^{b}	56.00 ± 6.42^{ab}	55.80 ± 6.53^{a}	<0.05
	p	0.099	0.090	0.138	
Abdominal circumference	Sportswoman	76.80 ± 6.19^{bB}	76.97 ± 6.28^{c}	76.08 ± 6.08^{a}	<0.05
	Control	72.21 ± 7.42^{aA}	72.48 ± 7.29^{b}	72.00 ± 7.42^{a}	<0.05
	p	0.012	0.13	0.23	
Hip circumference	Sportswoman	96.00 ± 4.33^{b}	95.87 ± 4.42^{ab}	95.67 ± 4.25^{a}	<0.05
	Control	94.22±6.00	94.25±5.90	94.20±6.00	>0.05
	p	0.192	0.234	0.023	
Chest circumference	Sportswoman	88.60 ± 5.22^{b}	89.00 ± 5.33^{b}	88.15 ± 5.32^{a}	<0.05
	Control	87.45 ± 5.60^{a}	87.70 ± 5.45^{b}	87.25 ± 5.48^{a}	<0.05
	P	0.414	0.386	0.522	
Chest skinfold	Sportswoman	6.33±1.85	6.33±1.85	6.34±1.86	>0.05
	Control	6.76 ± 1.05^{b}	6.67 ± 1.03^{a}	6.75 ± 1.04^{b}	<0.05
	P	0.414	0.386	0.522	
Abdominal skinfold	Sportswoman	12.10 ± 2.99^{a}	12.18 ± 2.95^{b}	12.18 ± 2.96^{bA}	<0.05
	Control	13.68 ± 3.36^{a}	13.77 ± 3.46^{b}	13.85 ± 3.42^{cB}	<0.05
	p	0.053	0.061	0.049	
Thigh skinfold	Sportswoman	17.03±4.70	17.02±4.70	17.04±4.66	>0.05
	Control	17.43 ± 3.69^{b}	17.31 ± 3.67^{a}	17.43 ± 3.70^{b}	<0.05
	p	0.711	0.791	0.724	
Triceps skinfold	Sportswoman	13.30±4.59	13.32±4.58	13.35±4.63	>0.05
	Control	11.98±4.00	12.00±4.10	12.02±4.10	>0.05
	p	0.242	0.243	0.243	
Biceps skinfold	Sportswoman	5.30±1.64	5.29±1.64	5.28±1.65	>0.05
	Control	4.67 ± 1.24^{b}	4.62 ± 1.24^{a}	4.65 ± 1.24^{b}	<0.05
	P	0.093	0.079	0.106	
Subscapula skinfold	Sportswoman	11.89±3.54	11.86±3.51	12.05±4.07	>0.05
	Control	12.09 ± 3.84^{b}	12.03 ± 3.89^{a}	12.07 ± 3.83^{a}	<0.05
	P	0.826	0.856	0.990	
Iliac skinfold	Sportswoman	13.10±4.41	13.23±4.35	13.19±4.36	>0.05
	Control	13.82±3.74	13.42±3.70	13.81±3.74	>0.05
	P	0.476	0.855	0.551	

* Different letters indicates significant differences among time; ^{a,b,c} letters indicate differences in time within the same group; ^{A,B} letters indicate differences within groups in the same time period.

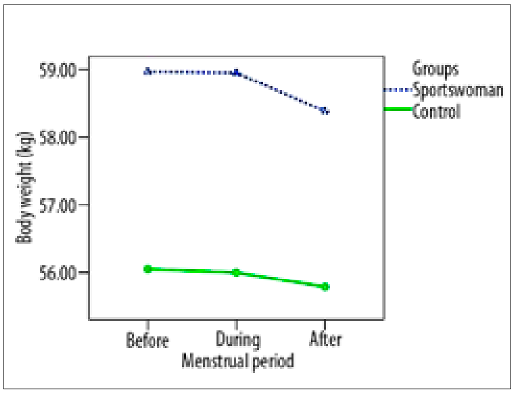

Figure 1. Body weight.

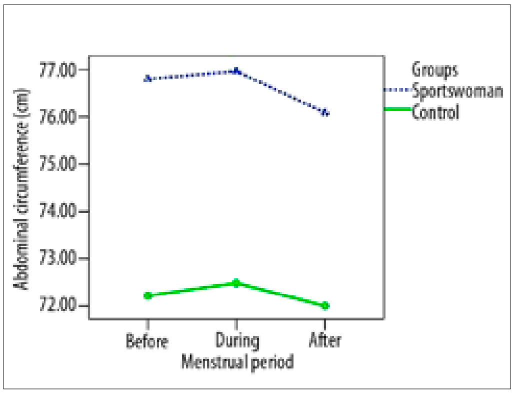

Figure 2. Abdominal circumference.

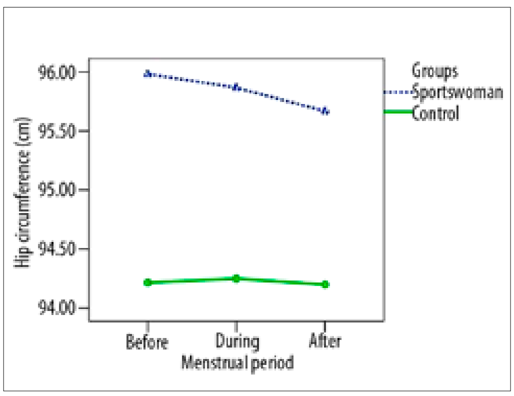

Figure 3. Hip circumference.

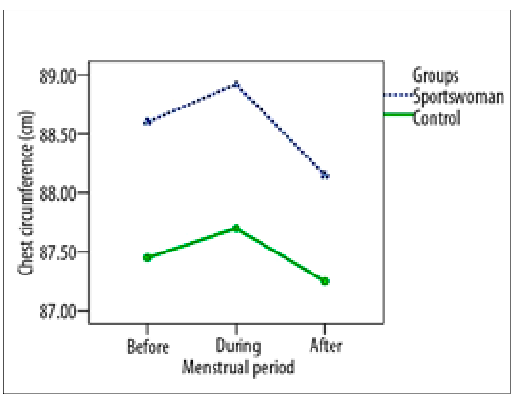

Figure 4. Chest circumference.

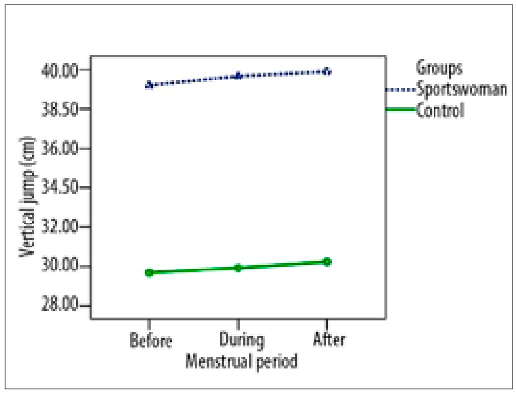

Figure 5. Vertical jump.

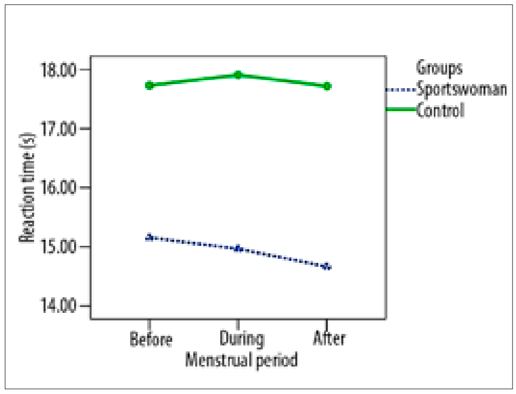

Figure 6. Reaction time (light).

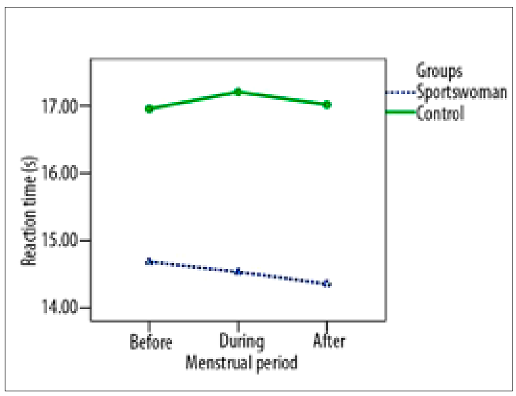

Figure 7. Reaction time (sound).

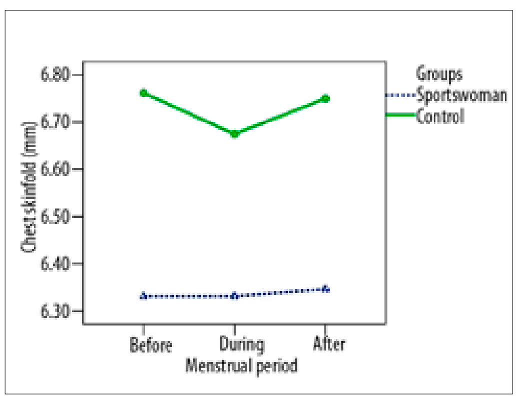

Figure 8. Chest skinfold.

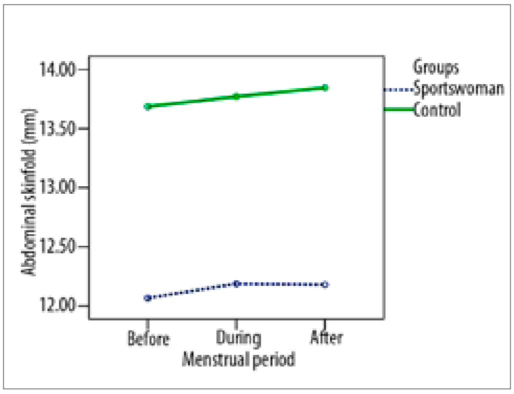

Figure 9. Abdominal skinfold.

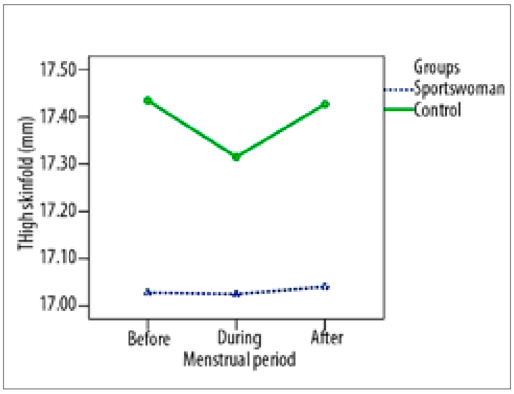

Figure 10. Thigh skinfold.

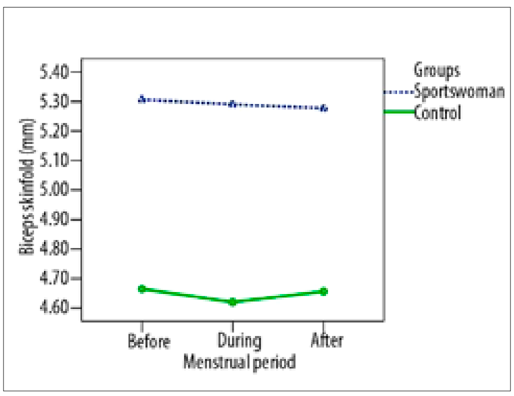

Figure 11. Biceps skinfold.

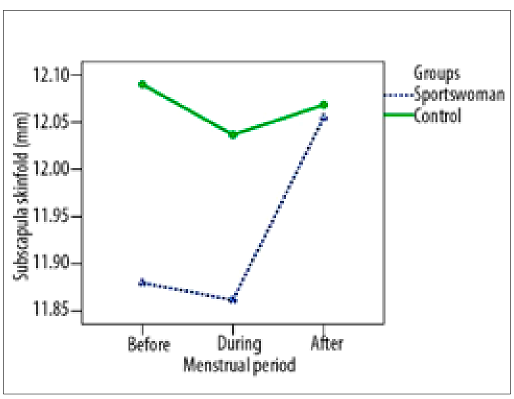

Figure 12. Subscapula skinfold.

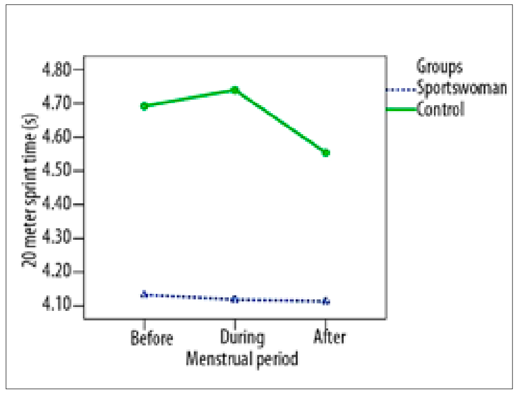

Figure 13. 20 meter sprint time.

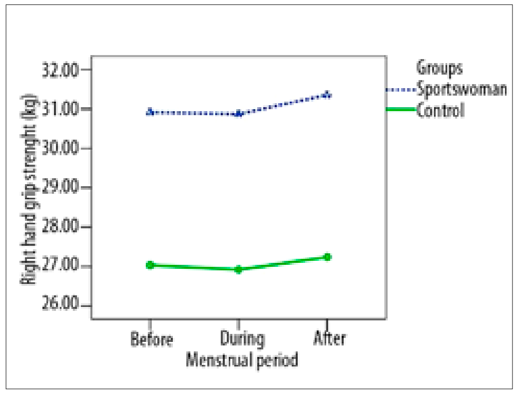

Figure 14. Right hand grip strenght.

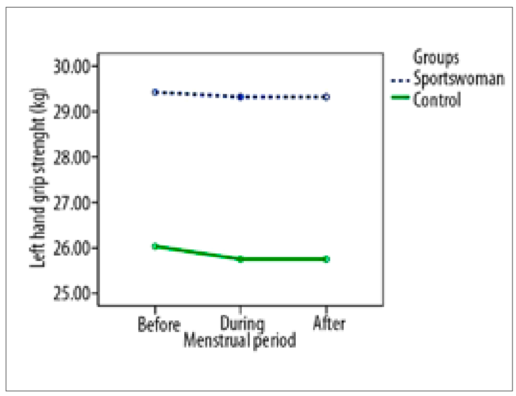

Figure 15. Left hand grip strenght.

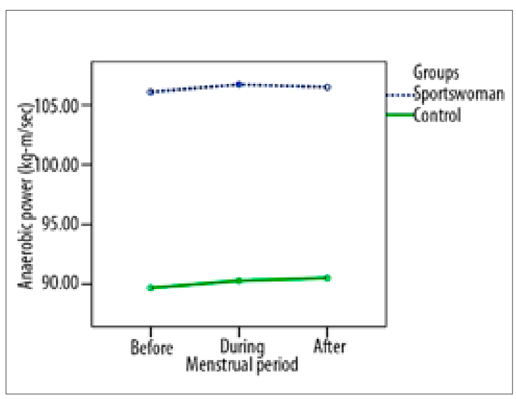

Figure 16. Anaerobic power

group. However, a difference of $p<0.001$ has been found between the sportswomen and control groups, with sportswomen reacting to sound in a shorter time than the controls.

The light reaction test showed a significance of $p<0.05$ level between the periods in the sportswomen group. This difference was between the AM period and the other two groups. The AM period showed shorter results (14.66±1.02). There was no similar difference observed in the control group. However, a comparison of the two groups, between the periods, showed a significant difference ($p<0.001$), with the sportswomen having shorter time values than the controls.

In the 20 m sprint test, the sportswomen group had average values of 4.13±0.18 seconds for BM, 4.12±0.18 seconds for DM, 4.12±0.19 seconds for AM; these values were not statistically different. The control group's values were 4.70±0.69 seconds for BM, 4.73±0.65 seconds for DM and 4.55±0.58 seconds for AM, which also were not statistically different. However, the differences between the two groups were statistically significant ($p<0.05$), with the sedentary women taking a longer time to complete the sprint.

For the right hand grip test, statistically significant differences were observed between groups ($p<0.001$), with the sportswomen group having higher values. Again, statistically significant differences were observed between the three menstrual cycle periods within each group (<0.05). In the sportswomen group, the values were higher for the AM period; there was no significant difference between the BM and DM periods. In the control group, the values were lower for the DM period; there was no significant difference between the AM and BM periods.

For the left hand grip test, there was a significant difference between the menstrual periods (BM: <0.003; DM: <0.002; AM: <0.002). The values were higher for the sportswomen group. However, no significance was found within the sportswomen and control groups between the periods.

While no significant difference was found between the groups in body weight, there was $p<0.05$ statistical difference in the sportswomen group between the BM and DM periods and AM period. The weight was significantly lower in the AM period; however, there was no significant difference between the DM and BM periods. A similar result was seen between the BM and AM periods of the control group. The weight was significantly lower in the AM period; however, there was no significant difference between the DM and BM periods.

No statistical difference was seen for abdominal circumference measurements between the sportswomen and control group. However, there was a significant difference in all the periods (BM, DM and AM) of the sportswomen group ($p<0.05$); the AM group had the lowest value, and the DM period had the highest value. There was also a significant difference between the DM period and other periods of the control group ($p<0.05$). The DM period had the highest values.

No statistically significant difference was found between the two groups in hip circumference measurements, but significant differences ($p<0.05$) were seen in the sportswomen groups between BM and AM periods. The AM period had lower values than the BM period. No significant difference was found between the periods in the control group.

Chest circumference measurements showed no differences between the two groups; however, there was a significant difference ($p<0.05$) between the AM period and the other two periods in the sportswomen group, with the AM period having significantly lower values. There was also a significant difference between the DM period and the other two periods in the control group, with the DM period having significantly higher values.

For the chest skinfold measurements, no significant difference was found between the two groups and or within the sportswomen group at different times. However, a statistical difference ($p<0.05$) was found in the control group between the DM period and the other two periods, with a significantly lower value of chest fat in the DM period.

For the abdominal skinfold measurements, a difference between groups was found only in the AM period. On the other hand, a significant difference ($p<0.05$) was found in the sportswomen group between BM period and the other two periods. There was an increase in the abdominal skinfold measurement in the DM and AM periods. There were significant differences in the control group between all the periods. In this group, the BM period has the lowest values while the AM period has the highest values.

For the thigh skinfold measurements, no significant difference was observed between periods in the sportswomen group; however, there was a significant difference ($p<0.05$) between the DM period and the other two periods in the control group. The DM period was significantly lower than the BM and AM periods.

For the triceps and iliac skinfold values, no statistical differences were found either between or within groups. No significant difference was found between the groups for biceps and supscapula skinfold value. There was no significant difference between the periods for the biceps and subscapula skinfold values of the sportswomen group. However, in the control group a significant difference ($p<0.05$) was found in biceps skinfold and subscapula skinfold values between the BM period and the other periods, with the BM period having lower values in biceps skinfold and higher values in subscapula skinfold.

Discussion

A great number of studies have indicated that there are no significant differences between anaerobic capacity and menstruation periods [6,10,11]. However, in the present study, the anaerobic capacity measured by the vertical jump test showed significant differences in menstrual periods both between groups and within groups. Firstly, the sportswomen group had higher values. These results can be explained with the fact that the sportswomen's level was intermediate and they were actively engaged in sport. Secondly, the DM period had higher values in the sportswomen group. Lastly, the BM period had lower values in the control group. This difference is seen after the BM period in both groups. This difference is most apparent in the DM period in sportswomen group and in the AM period in the control group. On the other hand, in an anaerobic tests conducted with 32 subjects, Masterson showed that the cycle in which capacity was highest and tiredness was lowest was the BM period [12]. Similarly, [13] Perciavalle et al. argued that performance in a 6 second 10-repeat ergometric bicycle sprint test was better in the BM period when compared with the other periods. Greeves et al. also suggested that there was a large capacity increase in the BM period [14]. The difference between the results from the study and these previous studies is the period in which differences were observed. The difference seen in both groups during the AM period in the present study can be associated with the differences found in the body weight between the periods. However, the highest body weight values in this study were found in the BM and DM periods. In the 20 meter sprint test, both groups showed a significant difference ($p<0.05$) in DM and AM periods in which they showed lower times taken for the sprint.

While there was statistical larger grip strength in the right and left hand grip capacity tests in the sportswomen group in all three periods, there was no significance within groups in left hand grip capacity. In addition, in right (dominant) hand grip capacity tests, a significantly larger difference ($p<0.05$) was found in both groups in AM period (31.35±4.40 kg in sportswomen; 27.54±3.40 kg in control group) when compared with the other periods. These results compare with those from the study by Sarwar et al. conducted with women between the ages of 20.7±1.4 years, in which the dominant hand grip capacity was significantly greater in the AM period when compared with the other periods [5]. In another study supporting this view, a 10% increase was found in the contractile force of human adductor pollicis muscle in DM and AM periods of both the sportswomen and the control group and this increase was stated to be very significant ($p<0.01$ in the sportswomen group; $p<0.05$ in the control group) when compared with the other periods [8]. The observed increase in the muscle capacity in both the present and these previous studies can be associated with the increase in estrogen hormone during the AM period. In contrast, in another study that investigated the changes in handgrip strength and standing long jumps during the menstrual, ovulatory and luteal phases of the cycle, only stronger handgrip strength was found during the menstrual phase, which the authors attributed to lower estrogen and progesterone levels [9]. Other studies argue that there is no change in grip capacity between menstruation cycle periods [4].

When the sound and light reaction tests of this study were examined, a significantly shorter response was observed in the sportswomen group ($p<0.001$), as expected. In addition to this, while no significant differences were found in either group regarding the sound reaction tests, only the sportswomen group had a significant difference ($p<0.05$), which was shorter in the AM period (14.66±1.02) compared with the other periods. In contrast, research by Das et al., conducted with 105 healthy women between the ages of 17–20, showed significant increases in sound and light reaction in the BM period. The authors stated that the reason for this increase was an effect of the hormonal changes during the ovulation period on the processing capacity of the central nervous system [15]. The results of the present study, in which light reaction times decreased significantly and sound reaction time decreases were evident, even if not statistically significant, are at least in partial agreement with previous studies.

In most of the studies reported in the literature, it has been argued that there is no statistical difference in body weight between menstrual cycle phases [10,11,13,16]. However, in our study, when the body weights of the subjects in both groups were examined over a two month duration, although no statistical difference was seen between the two groups, a significant decrease was noted in body weight from BM period to the AM period in both groups. In other words, the BM period is the period when the body weight is the highest in both groups. Similarly, in a study that examined 28 female subjects between the ages of 18–20 for 68 days, an increase of more than 0.5 kilograms was observed in BM period and this gained weight was lost with the start of menstrual flow [17]. In another study by Cheikh et al., data taken from 43 women between the ages of 18 and 30 indicated an increase in body weight (p<0.008) in BM period when compared with other periods [18]. Das et al. 15] also reported a significant (p<0.001) weight gain in the BM period. The reason for this change in the body weight may be a result of the water retention effect due to the progesterone hormone, which increases during the BM period. Dye and Blundel [19 and Dalvit [20] also stated that women's appetites tend to increase and accordingly they tend to increase their caloric intake before menstruation and this can be because due to the low activity of serotonin hormone. Indeed, in humans, concentration of serotonin (*V*max) is lowest premenstrually [6,21]. The premenstrual phase can therefore be considered as a time when women are especially vulnerable to overconsumption, food cravings and depression; this is often associated with low serotonin activity [19, 22].

Parallel to the differences observed in body weight in BM period, a statistically significant increase (p<0.05) was seen in chest and abdominal circumference measurements of the both groups during the BM and DM periods. The results of the circumference measurements support the observed differences in body weight. An increase in hip circumference (p<0.05) was only observed in the BM period of the sportswomen group. Despite these significant differences in the body weight and circumference measurements, significant increases were not seen in fat measurements, except for a few differences in the control group.

Conclusions

The results of this study reveal that some motor performance show differences during the menstruation cycle. There is a significant capacity increase, especially in dominant hand grip capacity, in the AM period. On the other hand, DM and AM periods show a significant increase in anaerobic capacity when compared with BM period.

In the measurements that were recorded over a two month time span, a significant decrease was seen in body weight from the BM period to AM period in both groups. In both groups, the BM period is the period when body weight is the highest. Moreover, parallel to the change in body weight, a significant decrease is seen in chest and abdominal circumferences for both groups as the body progresses through the BM to the DM periods. The results in circumference measurements support the change in the body weight from BM period to the AM period.

In sound and light reaction times, the light reaction time decreases significantly in the sportswoman group in the AM period, along with evident, but not statistically significant, decreases in sound reaction time.

All of these results are not sufficient to fully explain the effects of menstruation on motor performance. Thus, for a better understanding of these differences, similar measurements, including hormonal changes and at least three or more menstrual periods, are needed.

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