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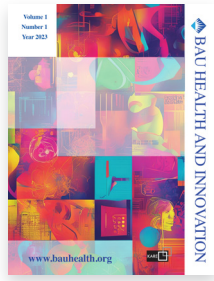

Original Article

Nutritional Intake and Anthropometric Changes during the Menstrual Cycle in Women of Childbearing Age

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Abstract

Objectives: The impact of the menstrual cycle on mood, appetite, dietary intake, and body composition remains a topic of debate in scientific literature. This study aims to evaluate nutritional behavior and body changes across the menstrual cycle by comparing dietary records and anthropometric measurements during the three distinct phases: the secretory phase, menstruation, and the proliferative phase.

Methods: This prospective study involved 34 healthy, regularly menstruating women aged 20–39 years. The phases of the menstrual cycle – secretory, menstruation, and proliferative – were determined by an obstetrician. The data collection form included sociodemographic questions (age, marital status, income, and education level) and a section on nutritional behaviors across the three menstrual cycle phases. Anthropometric measurements were obtained using bioelectrical impedance analysis during each phase of the menstrual cycle. In addition, 3-day food records were collected for each phase to assess dietary intake.

Results: Women experienced significant changes in anxiety, tiredness, irritability, depressive thinking, pain, swelling, edema, sweet cravings, and appetite across menstrual cycle phases ($p<0.05$). The body water and weight were highest during the secretory phase, while body fat percentage peaked during menstruation, and body muscle percentage was greatest in the proliferative phase. However, these differences were not statistically significant ($p>0.05$). During the menstruation phase, there was a notable increase in the intake of fiber, vitamin B1, vitamin B9, vitamin C, potassium, magnesium, phosphorus, iron, and zinc compared to the secretory phase. While energy, carbohydrate, and protein intakes increased during menstruation and fat intake was higher in the proliferative phase, these differences were not statistically significant.

Conclusion: Women experienced changes in mood and appetite throughout the menstrual cycle, but no significant alterations were observed in anthropometric measurements. Understanding these variations is crucial for addressing women's health and menstrual well-being.

Keywords: Dietary intake, menstrual cycle, weight, women.

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The menstrual cycle is a naturally occurring cycle in the female reproductive system which occurs every month from menarche until menopause.[1] Endocrine, autocrine, and paracrine systems which control ovarian follicular growth, ovulation, luteinization, luteolysis, and endometrial reshaping all have a role in women's menstruation cycle. However, the accurate detection of phase or ovulation is very challenging due to menstruation cycle duration

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variability which varies from 25 to 34 days.[2] The average cycle lasts 28 days. In addition, ultrasonography and hormonal tests demonstrate that women who are 19–42 years old have 14.6 days follicular phase and 13.6 days luteal phase in an average.[3]

Many women suffer from multiple physiological and psychological symptoms associated with the menstrual cycle, such as pain, dysmenorrhea, mood changes, tension, anxiety, irritability, depression, fatigue, headache, breast tenderness, increased appetite, and edema may indicate reproductive health issues such as endometriosis, premenstrual syndrome, and premenstrual dysphoric disorder.[4] Premenstrual syndrome (PMS) occurs in luteal phase and ends a few days after menstruation. Appetite and mood shifts, weight increase, back pain, headaches, breast swelling and sensitivity, anxiety, nervousness, fatigue, crying, and digestive problems such as stomach discomfort, nausea, and constipation are among the signs.[5]

Estrogen and progesterone hormone fluctuations during the menstrual cycle can cause significant differences in women's appetite, energy, and macronutrient intake.[6] Energy intake is lower during the follicular phase, where estrogen levels are relatively high, and energy intake increases during the luteal phase, where progesterone levels are highest.[7] In general consensus, there is an increase in energy intake in the secretory phase compared to the proliferative phase even though there is no significant difference in caloric intake throughout the menstrual cycle. Moreover, reports are not consistent about macronutrient intake. Carbohydrate and fat intakes have changed dramatically, but while macronutrient total consumption may shift considerably during the menstrual cycle, its contribution to energy may not vary.[8]

Due to cultural differences, it is important to study the changes in women from different populations during menstrual cycle. Moreover, in terms of physiological and psychological symptoms, comparing all phases of menstrual cycle and following women for whole cycle could give a better understanding on menstrual health which is an integral part of overall health. The aim of this study is to determine the nutritional behavior and body changes during the menstrual cycle in women of childbearing age by comparing dietary records and anthropometric measurements in three phases of menstrual cycle.

Materials and Methods

Inclusion-Exclusion Criteria and Participants

This prospective study was conducted in a gynecology outpatient clinic of a private hospital between April 2022 and May 2022. 54 women were reached in this study, in which participation was voluntary. Women who do not have any diagnosis of reproductive health issues, are regularly menstruating (25–34 days),[2] aged between 18 and 40 years, and are literate were included in the study. Women who were pregnant or lactating, in menopause or had undergone total or partial hysterectomy, taking hormone replacement therapy, had chronic diseases, diagnosis with eating behavior disorders, and following any diet therapy were excluded from the study. 43 women were included in the study. Incomplete or missing data are excluded from the study. 4 women withdrew from the study during the menstrual cycle, and 5 women were excluded from the study due to lack of communication. As a result, the study was completed with 34 women. Participants were informed by the study researcher, and written consent form was obtained. The study was approved by the KTO Karatay University Non-Drug and Non-Medical Device Research Ethics Committee and was conducted in accordance with the Declaration of Helsinki (date: March 2022, number: 2022/31).

Study Design

In this prospective study, face-to-face interview technique was used. Researcher followed the participants during whole menstrual cycle. Three interviews were conducted at three phases during a cycle, and all the meetings were planned and followed by the same researcher. In this study, the phases of menstrual cycle follow as "secretory", "menstruation," and "proliferative" phases which occur naturally in a cycle. The phases of the menstrual cycle were identified by the research doctor, a specialist in obstetrics. The secretory phase was defined as the 3-day period between the 21st and 25th days of the menstrual cycle, the menstruation phase as the 3-day period between the 2nd and 5th days, and the proliferative phase as the 3-day period between the 10th and 13th days. During each phase, dietary records and anthropometric measurements were systematically collected by the researcher.

Data Form

The data form used in the study was developed by the researchers under literature review. The first part of data form consists of questions which are sociodemographic characteristics such as age, marital status, income, and education level, and the second part consists of questions about nutritional behaviors during the three phases of menstrual cycle.

A total of 27 questions were asked to the participants which consisted of both open-ended and multiple

choice. The survey questions collected data on various demographic and health-related factors, including age, height, weight, educational status, occupation, and marital status. In addition, the survey addressed the presence of chronic diseases, medication use, tobacco and alcohol use, oral contraceptive use, age at menarche, menstrual cycle duration, and menstruation length. Information was also gathered on the presence and intensity of menstrual pain, symptoms experienced during the secretory, menstruation, and proliferative phases, changes in appetite and weight, and the date of the 1st day of the last menstruation.

Anthropometric Measurements

All anthropometric measurements were consistently taken by the same researcher across the three phases of the menstrual cycle using bioelectrical impedance analysis (BIA). The parameters assessed included body weight (kg), body mass index (BMI) (kg/m^2), body fat mass (kg) and percentage (%), total body water (L) and its percentage (%), body muscle mass (kg) and percentage (%), as well as the muscle and fat mass (kg) of the arms, legs, and trunk. These measurements were obtained using the InBody 230 device (InBody Co. Ltd., South Korea©) in accordance with the manufacturer's guidelines. Participant measurements were conducted under standardized conditions, ensuring that each individual fasted for at least 4 h, refrained from showering and exercising before measurement, and completed urination. All measurements were taken before midday to maintain consistency.

Dietary Intake

Three-day food records were collected from participants during each of the three phases of the menstrual cycle to assess daily energy and nutrient intake. Participants were initially instructed by the study researcher on how to accurately record their food and beverage consumption. During interviews with the research dietitian, the reported quantities of consumed foods and beverages were verified using a food atlas. Standardized recipes were employed when participants were uncertain about the ingredients. Energy and macro/micronutrient intake were analyzed using the Nutrition Information System (BeBIS) 8.1 software (Stuttgart, Germany, Turkish Version).[9] Due to missing information or inconsistencies in the dietary records of 4 participants, dietary intake evaluation was completed for 30 participants.

Statistical Analysis

Data were statistically evaluated in the SPSS 21.0 package program (Armonk, NY: IBM Corp).[10] The compatibility of data to normal distribution was checked with the Kolmogorov–Smirnov test. Number, percentage, mean, and standard deviation values are included in descriptive statistics. Continuous variables were expressed as mean±standard deviation (minimum-maximum) and categorical variables as percentages. Chi-square test was applied to examine the qualitative variables. Changes in mood and appetite in three phases of menstrual cycle were compared with the Cochran's Q test. Anthropometric measurements of participants and differences in energy and macro/micronutrient intake in three phases of menstrual cycle were analyzed with repeated measurements of one-way variance analysis, ANOVA. Regarding the significantly differed data, between which phases was determined by Bonferroni correction. In all analyses, statistical significance was defined as $p<0.05$.

Table 1. General characteristics of participants

General Characteristics	Mean±SD (min-max)	
Age (year)	27.9±6.5 (20–39)	
Menarche age (year)	12.9±1.3 (10–15)	
Cycle duration (day)	29.2±1.9 (26–33)	
Menstruation duration (day)	5.4±0.6 (4–7)	
	n	**%**
Tobacco use	16	47.1
Alcohol use	8	23.5
Chronic disease	4	11.8
Education level		
High school	15	44.1
University	19	55.9
Marital status		
Married	9	26.5
Single	25	73.5

SD: Standard deviation

Results

The mean age of the participants was 27.9±6.5 years, with an average menarche age of 12.9±1.3 years. The average menstrual cycle duration was 29.2±1.9 days, and the average menstruation duration was 5.4±0.6 days. In addition, over 70% of the participants were unmarried, and more than half held a university degree (Table 1).

Table 2 presents the changes in anthropometric measurements throughout the menstrual cycle. While body water and weight were observed to be at their highest levels during the secretory phase, and body fat percentage peaked during the menstruation phase, these

Table 2. Changes in anthropometric measurements across the menstrual cycle

	Secretory phase	Menstruation phase	Proliferative phase	F	p
Body mass index (kg/m^2)	23.46±4.42	23.40±4.40	23.41±4.48	0.710	0.495
Total body composition					
Weight (kg)	62.84±12.46	62.69±12.39	62.66±12.48	0.997	0.375
Fat mass (kg)	20.84±8.92	20.83±8.93	20.82±9.03	0.011	0.989
Fat percentage (%)	31.89±7.96	31.93±8.08	31.92±8.14	0.033	0.968
Water (L)	30.79±3.53	30.69±3.47	30.67±3.46	0.568	0.570
Water percentage (%)	49.93±5.85	49.90±5.97	49.92±6.00	0.019	0.981
Muscle mass (kg)	22.75±2.87	22.70±2.83	22.69±2.82	0.243	0.785
Muscle percentage (%)	36.82±4.11	36.82±4.22	36.87±4.24	0.125	0.883
Segmental analysis					
Arm muscle mass (kg)	4.09±0.76	4.09±0.76	4.10±0.77	0.172	0.843
Leg muscle mass (kg)	13.16±1.79	13.12±1.63	13.14±1.66	0.290	0.749
Trunk muscle mass (kg)	18.71±2.34	18.75±2.37	18.76±2.38	0.246	0.783
Arm fat mass (kg)	3.04±1.75	3.04±1.76	3.05±1.79	0.160	0.853
Leg fat mass (kg)	6.43±2.45	6.42±2.39	6.40±2.38	0.213	0.809
Trunk fat mass (kg)	10.26±4.63	10.28±4.74	10.31±4.80	0.353	0.704

Repeated measures ANOVA, statistical significance $p<0.05$. ANOVA: Analysis of variance.

differences were not statistically significant ($p>0.05$). The body muscle percentage reached its highest value during the proliferative phase. Although there were variations in both total and segmental anthropometric measurements across the three phases, none of these changes were statistically significant ($p>0.05$). Overall, no significant changes in anthropometric measurements were detected during the menstrual cycle.

Significant differences were observed between menstrual cycle phases regarding anxiety, tiredness, irritability, depressive thinking, pain, swelling and edema, sweet cravings, and increased appetite ($p<0.05$) (Table 3). Notably, these mood and appetite changes were particularly reduced during the proliferative phase. Although there was a decrease in sleep disturbances during the proliferative phase, this change was not statistically significant.

During the menstruation phase, increased intakes of fiber, vitamin B1, vitamin B9, vitamin C, potassium, magnesium, phosphorus, iron, and zinc were observed compared to the secretory phase (Table 4). Although energy, carbohydrate, and protein intakes were higher during the menstruation phase, and fat intake was greater during the proliferative phase, these differences were not statistically significant ($p>0.05$) (Fig. 1).

Discussion

In this prospective study aimed at evaluating nutritional behavior and body changes during the menstrual cycle in women of childbearing age, no significant changes in anthropometric measurements were observed across the cycle phases. However, increased intake of fiber and several micronutrients, including vitamins B1, B9, and C, as well as potassium, magnesium, phosphorus, iron, and zinc, was noted during the menstruation phase. Although there were no significant differences in energy and macronutrient intake, the variations in micronutrient consumption could be attributed to hormonal changes that alter nutritional requirements and subsequently food preferences. Food records indicated an increase in the consumption of chocolate and other cocoa-containing foods, oily seeds, cereals, and fruits during menstruation. These foods are rich in vitamin C, vitamin B1, magnesium, potassium, and other essential minerals, suggesting that participants may naturally gravitate toward these nutrients to meet heightened physiological needs.

In this current study, significant changes were observed between menstrual cycle phases in terms of anxiety, tiredness, irritability, depressive thinking, pain, swelling and edema, sweet cravings, and appetite increases, with these changes notably reduced during the proliferative phase. Hormonal fluctuations, particularly involving progesterone and estrogen, influence these psychological and somatic symptoms. In a typical 28-day cycle, estrogen predominates during the first 14 days, while progesterone predominates in the latter half. Consequently, progesterone levels increase in the secretory phase, leading to increased appetite and sweet cravings, whereas estrogen levels rise

Table 3. Moods and appetite experienced during the menstrual cycle

	Secretory phase (1)		Menstruation phase (2)		Proliferative phase (3)		Cochran's Q	p	Difference
	n	%	n	%	n	%			
Anxiety									
Yes	15	44.1	17	50.0	2	5.9	26.533	0.000	1–3
No	19	55.9	17	50.0	32	94.1			2–3
Tiredness									
Yes	20	58.8	16	47.1	10	29.4	10.133	0.006	1–3
No	14	41.2	18	52.9	24	70.6			
Irritability									
Yes	27	79.4	23	67.6	5	14.7	34.333	0.000	1–3
No	7	20.6	11	32.4	29	85.3			2–3
Depressive thinking									
Yes	14	41.2	8	23.5	1	2.9	19.538	0.000	1–2
No	20	58.8	26	76.5	33	97.1			1–3
									2–3
Pain									
Yes	20	58.8	24	70.6	3	8.8	35.524	0.000	1–3
No	14	41.2	10	29.4	31	91.2			2–3
Sleep changes									
Yes	5	14.7	7	20.6	2	5.9	5.429	0.066	–
No	29	85.3	27	79.4	32	94.1			
Swelling and edema									
Yes	24	70.6	25	73.5	3	8.8	34.296	0.000	1–3
No	10	29.4	9	26.5	31	91.2			2–3
Sweet crawing									
Yes	26	76.5	27	79.4	5	14.7	35.615	0.000	1–3
No	8	23.5	7	20.6	29	85.3	2–3		
Appetite increase									
Yes	25	73.5	24	70.6	2	5.9	40.560	0.000	1–3
No	9	26.5	10	29.4	32	94.1			2–3

Cochran's Q test, statistical significance level $p<0.05$.

during menstruation and the proliferative phase, potentially inhibiting appetite.[11] Aldosterone secretion, responsible for sodium and water retention, increases during the secretory phase, peaks during menstruation, and then declines.[12] Progesterone, which rises in the secretory phase, impairs renal water excretion, contributing to water retention.[13] Contrary to expectations, water retention is higher on the 1st day of menstruation compared to the secretory phase.[14]

In the literature, the most consistent alteration observed in women has been changes in body weight during the secretory and proliferative phases. However, this study found no significant changes in weight or body composition throughout the menstrual cycle. These findings may not be generalizable to all healthy women, given that the study was conducted with a small sample size and within a specific cultural context. Larger studies with more diverse populations could potentially yield different results. Previous research has indicated that body weight typically increases during the secretory phase and decreases during menstruation.[15] For instance, Sevim and Yagar reported a 1.2 kg weight gain during the secretory phase,[16] with increased waist circumference and body mass index.[17] Conversely, some studies have found no weight changes during the secretory and proliferative phases,[18] while others reported weight increases during the secretory phase and reductions by the 8th day of the menstrual cycle.[19] The range of weight change reported has been from 0.59 to 2.07 kg.[19]

During the late secretory phase, it has been reported that daily caloric intake increases by approximately 150 calories.

Table 4. Changes in energy and nutrient intake during the menstrual cycle

	Secretory phase (1)	Menstruation phase (2)	Proliferative phase (3)	F	p	Difference
Energy (kcal)	1300±330	1408±385	1372±393	2.616	0.082	–
Water (ml)	766±279	856±326	861±278	2.110	0.130	–
Protein (g)	47.1±15.2	52.5±19.7	49.0±16.9	1.565	0.218	–
Protein (%)	15±3.7	15.4±4.3	14.8±3.6	0.256	0.775	–
Fat (g)	59.4±15.7	63.7±19.3	65.6±17.8	2.525	0.089	–
Fat (%)	41±6.4	40.7±6.4	43.1±5.2	2.244	0.115	–
Carbohydrates (g)	140.7±49.6	151.9±54.3	142.3±54.6	1.409	0.253	–
Carbohydrates (%)	43.5±8.4	43.9±7.8	41.8±6.6	1.174	0.316	–
Fiber (g)	14.5±4.7	17.4±6.7	16.3±6.5	4.571	0.014	1–2
Cholesterol (mg)	175.5±106.7	195.2±102.4	175±69.6	0.569	0.569	–
Vitamin A (µg)	878.4±1452.2	1357±2168.7	859.9±696	0.936	0.398	–
Vitamin E (mg)	14.7±5.1	14.5±5.7	16.4±4.8	1.394	0.256	–
Vitamin B1 (mg)	0.5±0.2	0.6±0.2	0.6±0.2	5.719	0.005	1–2
						1–3
Vitamin B2 (mg)	0.9±0.5	1.1±0.6	1±0.4	2.207	0.119	–
Vitamin B6 (mg)	0.9±0.3	1.0±0.4	0.9±0.4	2.833	0.067	–
Vitamin B9 (µg)	169±59	213±81	194±61	5.683	0.006	1–2
						1–3
Vitamin C (mg)	68±49	88±58	92±70	6.011	0.004	1–2
						1–3
Sodium (mg)	2556±763	2693±940	2806±723	1.416	0.251	–
Potassium (mg)	1521±494	1876±629	1742±594	6.576	0.003	1–2
						1–3
Calcium (mg)	484±235	556±266	563±216	2.151	0.126	–
Magnesium (mg)	171±61	214±85	198±78	7.137	0.002	1–2
						1–3
Phosphorus (mg)	754±265	867±307	814±268	3.262	0.045	1–2
Iron (mg)	7.8±2.6	9.2±3.2	8.5±2.9	3.935	0.025	1–2
Zinc (mg)	6.7±2.2	7.8±2.7	7.1±2.7	3.224	0.47	1–2

Repeated measures ANOVA, statistical significance level $p<0.05$. ANOVA: Analysis of variance.

[6] In fact, total energy intake may fluctuate during the menstrual cycle. The fact that the highest energy intake is observed during the luteal phase both in animal models and human studies may be explained by the different effects of estrogen and progesterone on hunger and appetite. Estrogen directly inhibits food intake and increases energy expenditure, whereas progesterone stimulates food intake.[20] It is noteworthy that there is a connection between estrogen levels and women's food perceptions, as evidenced by a study using a electroencephalogram (EEG) and functional magnetic resonance imaging, which indicated that during the luteal phase – when estrogen levels are lower and progesterone levels are higher – there is an increased response to images of high-calorie foods.[21] Moreover, during this phase, there is a tendency for more frequent food cravings, episodes of binge eating, and greater consumption of fats or carbohydrates. [22,23] Research also indicates a rise in eating demands and consumption of animal proteins during the secretory phase. [24] However, some studies have found no change in energy and macronutrient intake,[24] while others suggest that despite an increase in energy and macronutrient intake during the secretory phase, their relative proportions remain unchanged.[25] Furthermore, during menstruation, protein and carbohydrate consumption tends to decrease, while intake of sweets, chocolate, and fatty foods increases.[26,27] It has also been observed that fat consumption is higher during the secretory phase compared to menstruation [28,29] with a noted increase in appetite for sweets, chocolate, pastries, snacks, and salted foods during this phase.[24,30] The literature on dietary intake changes throughout the menstrual cycle is inconsistent, reflecting the complex interplay of physiological, hormonal, sensory, and cultural factors.

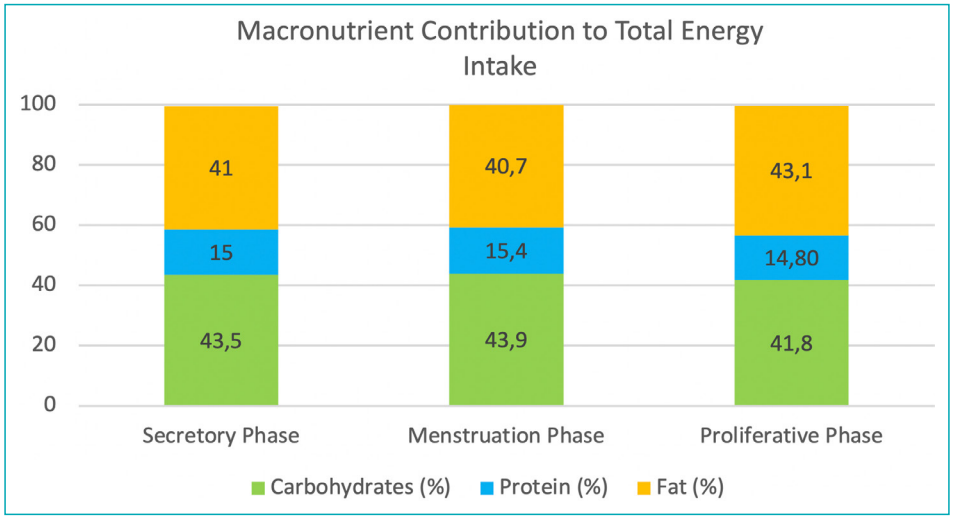

Figure 1. Percentage energy contributed by macronutrients across three phases in a menstrual cycle (n=34). Percentage macronutrient between phases showed no significant difference (p>0.05).

During menstruation, the body's demand for iron increases due to blood loss,[31,32] which likely explains the natural rise in iron intake observed among women during this phase. In addition, magnesium is known to alleviate premenstrual syndrome (PMS) symptoms and menstrual pain.[33] This may account for the increased consumption of magnesium-rich foods, such as oily seeds and cocoa-containing products,[34] observed in this study during the menstruation phase.

This study has several limitations, including a small sample size, a single cycle assessment, and reliance on self-reported dietary records, which may not fully capture women's usual dietary habits. The 3-day dietary records used in this study might not accurately reflect typical eating patterns, as dietary intake can be influenced by factors such as culture, income, education, and religion. In addition, the self-reported nature of dietary records introduces subjectivity in food amount reporting. Consequently, the findings of this study may not be generalizable to all women of childbearing age. Despite these limitations, the study's strength lies in its comprehensive examination of anthropometric measures, mood, and dietary intake across all three phases of the menstrual cycle.

Conclusion

Women participating in this study exhibited changes in mood and appetite throughout the menstrual cycle, but no significant alterations in anthropometric measurements were observed. These findings highlight the importance of considering menstrual cycle phases when assessing nutritional status. To gain a deeper understanding of these cyclical changes, further research with larger and more diverse populations is warranted.

Disclosures

Ethics Committee Approval: The study was approved by the KTO Karatay University Non-Drug and Non-Medical Device Research Ethics Committee (no: 2022/31, date: 22/03/2022).

Authorship Contributions: Concept – Y.S., A.I.K.; Design – Y.S., A.I.K.; Supervision – Y.S.; Funding – H.K.; Data collection and/or processing – A.I.K., H.K.; Data analysis and/or interpretation – T.Ö.K.; Literature search – Y.S., A.I.K.; Writing – Y.S., A.I.K., T.Ö.K.;

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