Original research-Orijinal araştırma

Evaluation of body composition and basal metabolic rate after acute exercise in menstrual phases in sportswomen

Kadın sporcularda menstrual siklus fazlarında akut egzersiz sonrası vücut kompozisyonunun ve bazal metabolik hızın değerlendirilmesi

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Abstract

Aim. In this study, we aimed to investigate the possible changes of body composition and basal metabolic rate in three phases of menstrual cycle by means of BIA technique in sportswomen. **Method.** We included twenty female students who are 19.8 ± 1.7 years of age, 1.7 ± 5.2 m tall and 53.7±5.5 kilograms of weight. The participants were all students at sport academy. The participants had normal and regular menstrual cycle (28 ± 2 days). Astrand's maximal bicycle ergometry test was applied to all of the participants. The body ergometry test was initiated by 50 watt and it was terminated with the top figure exhaustive point. TANİTA's TBF-300 body composition analizator was used and body mass index (BMI), basal metabolic rate (BMR), body mass fat, fat free mass (FFM), total body water (TBW) and total body fat percent (fat %) were analysed for each participant. Blood pressure, pulse and bioelectrical impedance (BIA) were measured just before and after exercises. **Results.** That there were no differences among the three phases of menstrual cycle regarding BMR measured just before and after exercises. We found that, BIA was high and TBW was low in luteal phase and FFM was decreased in follicular phase before exercise. BIA was increased after exercise in luteal phase. In early follicular phase FFM and TBW increased and body mass fat and fat % was decreased after exercise Although fat mass increased, BIA and fat % decreased just after the exercises in luteal phase. **Conclusion.** We think that the differences for body composition and BIA are because of TBW with menstrual cycle hormonal changes.

Keywords: Basal metabolic rate,bioelectrical impedance, menstrual cycle, exercise, sportswomen

Özet

Amaç. Çalışmamızda biyoelektriksel impedans tekniğini kullanarak menstrual dönemin üç fazındaki bazal metabolizma hızını ve vücut kompozisyonundaki olası değişiklikleri değerlendirmeyi amaçladık. **Yöntem.** Çalışmaya 19,8 ± 1,7 yaş, 1,7 ± 5,2 m boy ve 53,7±5,5 kg ağırlık ortalamasında yirmi bayan öğrenci alındı. Katılımcıların tümü spor akademisi öğrencileri idi. Katılımcılar normal ve düzenli menstruasyon süresine (28±2 gün) sahipti. Denekler Astrand'ın maksimal bisiklet ergometri testine tabi tutuldular. Egzersiz testinde yüklemeye 50 Watt'dan başlandı, denekler tükeninceye kadar çalıştırıldı ve bu noktada test sona erdirildi. Tanita TBF-300 vücut kompozisyon analizatörü kullanılarak; vücut kitle indeksi, bazal metabolik hız, vücut yağ dokusu, yağsız vücut ağırlığı, total vücut su miktarı, vücut yağ oranı ölçümleri yapıldı. Egzersizden önce ve sonra kan basıncı, nabız ve biyoelektriksel impedans (BİA) ölçümleri yapıldı. **Bulgular.** Bazal metabolik hız (BMR) tüm fazlarda egzersiz öncesinde ve sonrasında farklılık göstermemiştir. Egzersiz öncesi; luteal fazda impedans yüksek, total vücut su oranı (TVS) düşük, foliküler fazda ise yağsız vücut ağırlığı (YVA) düşük olarak saptanmıştır. Egzersiz sonrası ise luteal fazda impedans artmıştır. Erken foliküler fazda YVA ve TVS egzersiz sonrası artarken, yağ dokusu ve yüzde yağ oranı azalmıştır. Luteal fazda ise egzersiz sonrasında BİA ve yağ yüzde değerleri azalırken, yağ dokusu oranları artış göstermiştir. **Sonuç.** Menstrual siklus fazlarında saptanan vücut kompozisyonuna ait farklılıkların, menstrual siklusun hormonal değişimleri ile birlikte hipohidratasyona bağlı olduğunu düşünmekteyiz.

Anahtar sözcükler: Bazal metabolik hız, biyoelektriksel impedans, menstrual siklus, egzersiz, kadın sporcu

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Introduction

In the settings where the environmental heat is 26-30 C, basal metabolic rate is the minimal energy level required for life [1-4]. The basal metabolic rate may change according to age, weight, length, and sex [5]. For men, it is 5-10% higher than women [3]. As the body composition and especially fat free mass (FFM) decreases or total body fat rate increases, basal metabolic rate (BMR) decreases 2-3% in every decade. Systematic exercise programs on the one hand influence body composition and on the other hand it has a stimulative effect on relaxation metabolism. When BMR is compared to sedentaries in training subjects, it is 20% higher related to FFM [3, 5].

In menstrual cycle, evident hormonal changes and important energy needs resulting from these changes have been observed among women. A great number of researches have been done on the consumption of energy in the different phases of menstrual cycle. Most of them are directed towards the exercise and the impacts on the consumption of exercise during the various intensities of exercises [1]. Exercise is especially important for women. Because it increases the loss from fatty tissue, bone mineral density and as it decreases the fatty tissue it also decreases the risk of obesity. By means of exercise, the daily use of energy increases and body weight increases [2].

Many studies on the differences of energy need of menstrual phase have been done. BMR decreases in follicular phase, whereas BMR and body temperature increase in luteal phase [7]. It has been put forward that changes in follicular and luteal phases are dependent upon estrogene and progesterone hormones [7-9]. In menstrual cycle, in luteal phase not only carbonhydrate taking rises but also fat oxidation increases. Chronic adaptations created by aerobic exercises increase fat consumption. The level of exercise is also effective in substrate usage [10, 11]. There are many indirect methods to evaluate BMR and body composition. Among these 2, 3, 4 and multi-compartmented models, body density and volume measurement, dilution methods, total body potassium and neutron activation analyses, dual-energy x-ray absorptiometry (DEXA), magnetic resonance (MR), and computerized tomography have constituted important research methods [12]. Bioelectrical impedance measurements come into existence by means of circulation of the current less than 1mA in body tissues. By means of measurement of resistance; total body water, fat free mass, and fat tissue are measured [3]. Bioelectrical impedance analysis (BIA) is one of the most developed techniques of our day. BIA technique is a popular measurement developed in 1960s and used for the evaluation of body composition. As the bioelectrical impedance measurement apparatus is portable and noninvasive it is a method that can easily be used in clinics, offices, and centers for getting thin and hospitals [12-14].

In our study we have aimed to evaluate possible changes in BMR and body composition in the three phases of menstrual cycle by using BIA technique.

Material and methods

Study population

In this study, twenty female students with normal and regular menstruation period (28±2days) who have the average age of 19.8±1.7, 1.7±5.2 m height and 53.7+ 5.5 kg of weight from Cumhuriyet University Institute of Physical Education and Sport have been take into the study. All subjects took part in the study as volunteers. They were informed about the test and how the test would be performed. The subjects were not allowed to take alcohol 48 hours before the test or to make intense exercise 12 hours before the test, they were not allowed to eat anything 4 hours before the test, and their urinary bladders were emptied 30 minutes before the test. Test was performed every morning between 10:00 am and 12:00 am. Tests were performed in early follicular phase, (3-5th days), in follicular phase (11-16th days) and luteal phase (22-25th days). Menstrual period was determined according to calendar method.

Test producere

Asrtrand's maximal bicycle ergometry test was applied to all the subjects. Exercise was performed on Monark trademark ergometry. Before the test the blood pressure and pulse measurements were performed. By using TBF-300 Body Composition Analyzer; body mass index (BMI), basal metabolic rate (BMR), body fatty tissue (fat mass), fat free mass (FFM), total body water (TBW) and, body fat percentage (fat%) measurements were done. Making the measurements the weight of the clothes was accepted as 1.5 kg and it was subtracted. Before measuring the steel scale was wiped up with a damp piece of cloth and by means of this conductivity was increased. During the test we have begun to load from the beginning level of 50 Watt, the subjects were made to work till they are exhausted and in this point the test was ended. In every three minutes loading was increased by 25 Watt. In this point loading point to be reached was 100 and 150 Watt. After the exercise, blood pressure, pulse and BIA measurements were done again [15].

Statistical Analysis

Statistical analysis of our study was done with SPSS packet program in a computer. Repeated measures ANOVA, Wilcoxon sign and Tukey importance tests were applied as appropriate [16].

Results

In our study, the values of impedance, FFM and TBW measured before exercise were found to be different among menstrual cycle phases. It was found that impedance is higher in luteal phase than that of the other phases. We also found that FFM analysed before exercise was lower in follicular phase than that of the other phases. TBW was lower in luteal phase than that of the other phases. There were no significant differences among the phases regarding BMR, BMI, fat mass or fat rate (Table1).

Table 1: Preexercise BMR and body composition values among the menstrual phases

Pre-exercise	Early follicular phase	Follicular phase	Luteal phase	P
Impedans (ohm)	557.9±52.1	558.6±51.3	573.4±6.0*	<0.05
BMI	19.4 ± 2.0	19.3 ± 2.0	19.3 ± 2.1	>0.05
BMR (kg)	5798.5 ± 253.8	5795.2 ± 261.5	5801.6 ± 260.4	>0.05
FFM (kg)	45.1 ± 3.8	44.7 ± 4.0*	45.1 ± 3.8	<0.05
TBW (kg)	33.0 ± 2.8	33.0 ± 2.8	32.7 ± 3.0*	<0.05
Fat mass (kg)	8.5 ± 2.4	8.6± 2.6	9.0 ± 2.8	>0.05
% Fat	15.7 ± 3.3	15.8± 3.6	16.5 ± 4.0	>0.05

* The phase causing the difference

It was found that impedance values after the exercise are significantly different. This difference is between follicular and luteal phases. There was more electrical impedance in luteal phase than the other phases. There were no significant differences among the phases regarding BMR, BMI, FFM, fat mass or fat rate (Table 2).

Table 2: Post-exercise BMR and body composition values among the menstrual phases

Post exercise	Early follicular phase	Follicular phase	Luteal phase	P
Impedance (ohm)	555.7±52.7	557.8±50.8	571.2±57.8*	<0.05
BMI	19.4 ± 2.0	19.3 ± 2.0	19.3 ± 2.1	>0.05
BMR (kg)	5699.4 ± 519.5	5794.8 ± 261.5	5796.8 ± 268.0	>0.05
FFM (kg)	45.3 ± 3.8	45.2 ± 3.8	44.7 ± 3.9	>0.05
TBW (kg)	33.0 ± 2.7	33.1± 2.8	32.7 ± 3.0	>0.05
Fat mass(kg)	8.4 ± 2.4	8.6± 2.7	9.0 ± 3.1	>0.05
% Fat	15.5 ± 3.3	15.7± 3.5	16.5± 4.3	>0.05

* The phase causing the difference

In early follicular phase, it was found that there were important differences between the pre-exercise and the post-exercise evaluations regarding FFM, TBW, fatty tissue and fat rate values. Fat free body tissue and TBW increased after the exercise but fat rate decreased. There were no significant differences between the pre-exercise and the post-exercise evaluations regarding impedance, BMR or BMI (Table 3).

Table 3: The pre- and post-exercise values in early follicular phase

	Pre-exercise	Post-exercise	p
Impedance (ohm)	557.9±52.0	557.7±52.7	>0.05
BMI	19.4±2.0	19.4±2.0	>0.05
BMR (kg)	5798.5±253.8	5699.4±519.5	>0.05
FFM (kg)	45.2±3.9	45.3±3.8	<0.05
TBW (kg)	33.1±2.8	33.2±2.8	<0.05
Fat Mass (kg)	8.5±2.4	8.4±2.4	<0.05
% Fat	15.7±3.3	15.5±3.3	<0.05

In follicular phase no significant differences were found (Table 4).

Table 4. Pre- and post-exercise values in follicular values

	Pre-exercise	Post-exercise	P
Impedance (ohm)	558.6±51.3	557.8±50.8	>0.05
BMI	19.3±2.0	19.3±2.0	>0.05
BMR (kg)	5795.3±261.5	5794.8±261.4	>0.05
FFM (kg)	45.1±3.9	45.1±3.8	>0.05
TBW (kg)	33±2.9	33±2.8	>0.05
Fat Mass (kg)	8.6±2.7	8.6±2.7	>0.05
% Fat	15.8±3.6	15.7±3.5	>0.05

In luteal phase, it was found that pre- and post-exercise values of fatty tissue, and fat rate were significantly different. Impedance and fat rate was decreased and fatty tissue was increased in the post-exercise period.

Discussion

In menstrual period, energy use varies. Many authors have shown that there are differences among BMR, the amount of energy used during sleep (SMR), or daily energy use among the menstrual phases [7, 17, 18]. In many studies, it was determined that BMR increases during luteral phase [8, 9]. Meijer et al. [5] have expressed that SMR increased 7.7 % in the postovulation phase of menstrual cycle. Various authors claim that BMR increase in luteal phase depends on thermal effect of progesterone [5, 8]. Bisdee et al. [8] have determined that, unlike this result, there is not harmony between BMR increasing more and more in late luteal phase and the increase of body temperature. Of the authors evaluating increase in temperature in luteal phase, Gonzales et al. [19] have pointed out the increase in temperature. Tenaglia et al. [20] has observed that rectal heat is higher in midluteal phase than early follicular phase. Piers et al. [21] have determined that thermal effects of the foods in luteal phase increased 18.5% compared to follicular phase. Thermal effects of foods, according to Piers et al. [21] are related to the increase in the energy use of insulin. Tai et al. [22] have determined that thermal effects of foods decrease in luteal phase. In their study, it was found that though the thermal effects of foods decrease BMR does not change and the reason of that has been accepted as the slowing down of upper gastrointestinal current and the decrease in glucose absorption [22]. It is known that there are more body mass and more energy need among the women with normal menstruation cycle in postovulation phase [23]. Depending on the balance between the diet taking shows differences. Depending on the dominance of progesterone taking increases in luteal phase. These changes increase the metabolic rapidity affecting basal metabolic rate and fat metabolism. The increase in luteal energy and fat taking have also influence on fat metabolism [7]. Kanaley et al. [24] have defended that consumption of carbonhydrate and fat increasing by means of exercise are due to growth hormone rather than sex steroids. Because it has been pointed out in this study that growth hormone increases by exercise independently from menstrual cycle and it increases gluconeogenesis. Lebensted et al. [18] compared athletes with normal menstruation with menstrual deficiencies and they found that there are lower BMR rates and eating defeats among athletes with disorder. In the present study, we did not find any differences regarding BMR among the menstrual phases neither in before or after exercise in females with normal menstruation period. That there is not any difference among the phases may be related to the exercise method we chose and the subjects' way of nourishment. On the other hand, in the BMR comparisons we made before and after exercise we could not find any significant difference, either.

Wimberly et al. [2] have found that among sedentary women body fat rate is 10% higher than women making exercises. Meijer et al. [5] have also pointed out in their study about body composition in menstrual cycle, the importance of FFM in estimation of BMR 14 and as FFM represents active cell tissues it can be used with an error of 10%. As for Toth et al. [25], they have found that exercise decreases the amount of fat but its effect is minimal on fat free body mass. These researches have expressed that resistant exercises both decrease the fate rate and increase fat free body mass [26]. Ribeyre et al. [26] have mentioned that FFM is determiner for daily energy requirement and determined that FFM increase by exercise among athletes. Wimberley et al. [2] have seen that basal metabolic rapidity rises among women exercising but there is not any difference when it is compared to sedentaries in FFM. But they did not keep menstrual cycle in mind [2]. In our study, we determined that FFM is lower in pre-exercise period in follicular phase than other phases. In the comparison of pre-exercise FFM values with post-exercise values, we found that FFM in early follicular phase significantly increased. We think that though FFM that increased after the exercise show harmony with literature, as our study is short-term and aimed at exhaustion, it does not create the effect that endurance sports do. We think that low FFM values may be dependent upon hypohydration. Because in the event of hypohydration BIA impedance values increase and as a result of this FFM may be lower and so the values of body fat rate can be determined as high [27, 28].

According to a study done by Özenoğlu et al. [29], for both men and women as body mass index rose, basal metabolic rapidity increased. In this study as BMI rose FFM and TBW decreased. In the study we found no differences among BMI phases. In before and after exercise comparisons, we, again, could not find any difference among the phases. Wilmore et al. [30] found that, after 20-week endurance training, BMI, fatty tissue, body fat rate, subcutaneal and visceral abdominal fatty tissue decreased and FFM decreased. It has been found out that the changes here are important but of small proportion. This suggests us the opinion that as to these changes occur, the exercise done must be long-term and aimed at endurance [30].

In our study in the evaluation of fatty tissue and body fat rate we could not get an important result. But, in the evaluation done before and after the exercise, fatty tissue and body fat rate after the exercise have decreased meaningfully. In luteal phase, body fat rate decreased but values of body fat rates increased meaningfully. Fatty tissue is also an important parameter for the determination of energy use and estimation of BMR.

Another measure parameter was body water rate in our study. The difference of TBW among phases was significant. TBW decreased in luteal phase sinificantly compared to other phases. In addition, we observed in our pre-and post-exercise TBW evaluation that there was an increase in fopotassium and sodium concentrations increased in luteal phase because of the changes in electrical balance and water delivery. And finally they explained that FFM changed depending on hydration level [27].Another important parameter in BIA analyses is electrical impedance of body tissues. It makes important changes on both menstrual cycle and exercise impedance. Gleichauf and Roe [27] have shown that TBW changes will be effective on impedance in premenstrual period. These researches have explained that impedance that depends on hypohydration changes. The weight of liquid in women increases during premenstrual period. Here in luteral phase both resistance and FFM increased [27].

In our study it was found that electrical impedance is high both before and after the exercise. Besides, in luteal phase the impedance values before the exercise have been found higher than the values after the exercise. This situation may be due to the TBW rates decreasing in luteal phase. Segal [28] has stated that the decrease in body water rate occurring with the exercise is going to increase the impedance in BIA measures. This researcher has stated that with the increase of the impedance FFM is going to be seen less than really it is and as a result of this, body fate rate will be seen higher. According to Segal, because of some reasons like the increase in the lose of water, the heat of skin, vascular perfusion, hyperemy, cutaneal blood current and vasodilatation by means of exercise BIA measures must be done before the exercise [28]. Liang et al. [31] have also stated that the increase in body water rate, the heat of skin, and skin blood current increase the bioelectrical resistance. Eckerson et al. [32] has stated that BIA measures are affected by position of the body, electrot place, place they are in, the heat of skin, physical activity and hydration. According to these authors, when measures are done among the gymnast athletes who lose weight using dehydration hydration level must be taken into consideration [32].

Finally, we think that differences belonging to body composition we have found using BIA technique before and after the exercise, in menstrual cycle, especially in luteal phase may be connected to hormonal changes of menstrual cycle together with changes in hydration levels. Because the amount of TBW decreasing in luteal phase possibly affects both impedance, FFM and fatty tissue and body fat rate. Therefore we think that in the studies performed on female sportsmen, in the arrangement of programs, and in the assessment stage of the results it is necessary to take the characteristics of menstrual cycle into consideration.

References

1. Galliven EA, Singh A, Michelson D, Bina S, Gold PW Deuster P. Hormonal and metabolic responses to exercise across time of day and menstrual cycle phase. J Appl Physiol 1997; 83: 1822-31.
2. Wimberly MG, Manore M M, Woolf K, Swan PD, Carrol SS. Effects of habitual physical activity on the resting metabolic rates and body composition of women aged 35 to 50 years. J Am Diet Assoc 2001; 101: 1181-8.
3. Mcardle WD, Katch FI, Katch VL. Exercise Physiology. Williams & Wilking, fourth edition, Baltimore, 1996, 559-61.
4. Jequier E, Tappy L. Regulation of body weight in humans. Physiol Rev 1999; 79: 451-80.

5. Meijer GA, Westerterp KR, Saris WHM, ten Hoor FT. Sleeping metabolic rate in relation to body composition and the menstrual cycle. Am J Clin Nutr 1992; 55: 637-40.
6. Sjödin AM, Forslund AH, Westerturp KR, Adersson AB, Forslund JM, Hambraesus LM. The influence of physical activity on bmr. Med Sci Sports Exerc 1996; 28: 85-91.
7. Johnson WG, Coorigen SA, Lemmon CR, Bergeron KB, Crusco AH. Energy regulation over the menstrual cycle. Physiol Behav 1994; 56: 523-7.
8. Bisdee JT, Garlic PJ, James WP. Metabolic changes during the menstrual cycle. Br J Nutr 1989; 61: 641-50.
9. Solomon SJ, Kurzer MS, Colloway DH. Menstrual cycle and basal metabolic rate in women. Am J Clin Nutr 1982; 36: 611-6.
10. Ashely CD, Bishop P, Smith JF, Reneau P, Perkins C. Menstrual phase effects on fat and carbonhydrate oxidation during prolonged exercise in active females. An İnternational Electronic Journal 2000; 3: 67-73.
11. Zderic TW, Coggan AR, Ruby BC. Glucose kinetics and subtrate oxidation during exercise in the follicular and luteal phases. J Appl Physiol 2001; 90: 447-53.
12. Ellis KJ. Human Body composition: in vivo methods. Physiol Rev 2000; 50: 649-80.
13. Powell LA, Nieman D C, Melby C, Cureton K, Schmidt D, Howley ET, Hill JO, Mault JR, Alexander H, Stewart DJ. Assesment of body composition change in a community- based weight management program. J Am Coll Nutr 2001; 20: 26-31.
14. Baumgarter RN, Cameron C, Roche AF. Bioelectrical impedance for body composition.; Am J Clin. Nutr 1988; 48: 16-23.
15. Heyward VH. Advanced fitness assesment and exercise prescription. Human Kinetics books, second edition, New Mexico, 1991, 47-8.
16. Ergün M. Bilimsel araştırmalarda bilgisayarla istatistik uygulamaları,SPSS for windows.,Minpa matbaacılık birinci baskı, Ankara, 1995, 164-85.
17. Mawson JT, Braun B, Rock PB, Moore LG, Mazzeo R, Butterfıeld E G. Women at Altitude: Energy requriment at 4300 m. J Appl Physiol 2000; 88: 272-81.
18. Lebenstedt M, Platte P, Pirke KM. Reduced resting metabolic rate in athletes with menstrual disorders. Med Sci Sport Exerci 1999; 31: 1250-6.
19. Gonzalez RR, Blanchard LA. Thermoregulatory responses to cold transients: effects of menstrual cycle in resting women. J Appl Physiol 1998; 85: 543-53
20. Tenaglia SA, Mclellan TM, Klentrou PP. İnfluence of menstrual cycle and oral contraceptives on tolerance to uncompensable heat stress. Eur J Appl Physiol Occup Physiol 1999; 80: 76-83.
21. Piers LS, Diggavi SN, Rijskamp J, Raaij J MA, Shetty PS. Resting metabolic rate and thermic effect of a meal in the folicular and luteal phases of the menstrual cycle in well-nourished Indian women. Am J Clin Nutr 1995; 61: 296-302.
22. Tai MM, Castillo PF, Pi- Sunyer FX. Thermic effect of food during each phase of the menstrual cycle. Am J Clin Nutr 1997; 66: 1110-5.
23. Dalvit SP, Mc Phillips. The effect of the human menstrual cycle on nutrient intake. Physiol Behav 1983; 31: 209-12.
24. Kanaley JA, Boıleau RA, Bahr JA, Mısner JE, Nelson RA. Substrate oxidation and GH responses to exercise are independent of menstrual phase and status. Med Sci Sports Exerc 1992; 24: 873-80.
25. Toth MJ, Beckett T, Poehlman ET. Physical activity and the progressive change in body composition with aging: current evidence and research issues. Med Sci Sports Exerc 1999; 31: 590-6.
26. Ribeyre J, Fellmann N, Montaurier C, Delaitre M, vernet J, Coudert J, Vermorel M. Daily energy expenditure and its main components as measured by whole-

body indirect calorimetry in athletic and non- athletic adolescent. Br J Nutr 2000; 83: 355-62.
27. Gleichauf CN, Roe DA. The menstrual cycle's effect on the reliability of bioempedance measurement for assessing body composition. Am J Clin Nutr 1989; 50: 903-7.
28. Segal KR. Use of bioelectrical impedance analysis measurements as an evaluation for participating in sports. Am J Clin Nutr 1996; 64: 469-71.
29. Özenoğlu A, Can G, Taşan E , Hatemi H. Beden kitle indeksine göre normal ağırlıklı, fazla kilolu obez ve morbid olarak gruplandırılan yetişkin kadın ve erkeklerde vücut kompozisyonu referans değerleri. Endokronolojide yönelişler 2001; 10: 58-63.
30. Wilmore JH; Despres J-P, Stanforth PR, Mandel S, Rice T, Gagon J, Leon A S, Rao DC, Skinner JS, Bouchard C. Alterations in body weight and composition consequent to 20 wk of endurance training: the herıtage family study. Am J Clin Nutr 1999; 70: 346-52.
31. Liang MTC, Su HF, Lee NY. Skin temperature and skin blood flow affect bioelectric impedance study of female fat-free mass. Med Sci Sports Exerc 2000; 32: 221-7.
32. Eckerson JM, Evetovich KT, Stout JR, Housh JT, Johnson GO, Housh DJ, Ebersole KT, Smith DB. Validity of bioelectrical impedance equations for estimating fat-free weight in high school female gymnasts. Med Sci Sports Exerc 1997; 29: 962-8.