ORIGINAL ARTICLE

Prospective evolution of body compositions based on bioelectrical impedance analysis and water intake on patients with gallstone

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ABSTRACT

BACKGROUND: We aimed to compare bioelectrical impedance analysis (BIA) body composition and to reveal predictive factors that may help prevent gallstone formation.

METHODS: Patients with gallstones by ultrasonography were selected as the case group, while participants without stones were selected as the control group. The body composition of the participants in both groups was measured by BIA. Demographic characteristics, mean water intake daily of the participants (MWID) and body mass index (BMI), total body fat mass (TBFM), total body fat percentage (BFP), total body water (TBW), body fat mass of trunk (BFM of trunk), and visceral fat level (VFL) measured by BIA were recorded. Predictive risk factors for gallstone formation were revealed by statistical analysis.

RESULTS: The data of a total of 191 participants, including 83 participants in the group with gallstones and 108 participants in the group without gallstones, were analyzed. Both groups were statistically similar in terms of age and sex (P>0.05). In univariate analysis, BMI, TBFM, BFP, BFM of trunk, and VFL were statistically significantly higher (P = 0.007, P=0.004, P=0.003, P=0.003, and P=0.005, respectively) while MWID was lower (P<0.001) in the group with gallstone. In multivariate analysis, MWID (ref: ≥1.5 odds ratio [OR]: 7.786 95% confidence interval [CI]: 3.612–16.781) and BFP (ref: ≥0.24 OR: 3.102 95%CI: 1.207–7.972) were independent factors in gallstone formation.

CONCLUSION: The MWID and BFP level measured by the BIA technique, which is an easily applicable, noninvasive method, are independent risk factors for gallstone formation.

Keywords: Bioelectrical impedance analysis; body composition; gallstone; mean water intake daily; total body fat percentage.

INTRODUCTION

Gallstones have a prevalence of 10–15% in Western countries.[1] Althousgh gallstones are mostly asymptomatic, they are a serious public health problem because of their social and economic impacts.[2] Gallstones cause the following severe complications: Acute/chronic cholecystitis, Mirizzi syndrome, choledocholithiasis, biliary pancreatitis, cholangitis, and gallstone ileus, and thus, increase morbidity and mortality.[3,4] These complications prolong the treatment process and lead to the application of additional treatment methods with a non-zero rate of invasive morbidity and mortality, such as endoscopic retrograde cholangiography (ERCP) and cholecystectomy.[5-8] For these reasons, studies have focused on the pathogenesis of stone formation in the gallbladder and its predictive factors. Studies have shown that high body mass index (BMI), genetic factors, changes in lipid metabolism, gallbladder and intestinal motility, diet factors, dehydration, and central adiposity are effective.[9-11] In the clinical practice guideline of the European Association for the Study of the Liver on gallstones, there are recommendations such as a healthy lifestyle, regular physical activity, and ideal body

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weight to prevent the formation of gallstones.[12] However, these recommendations are at level of low-quality evidence and weak recommendation.

Preventing the formation of gallstones means that the prevalence will decline, and morbidity and mortality will decrease during the follow-up and treatment process. Establishing measurable predictive factors will contribute to the prevention of gallbladder stone formation. However, studies on this subject are limited.

Body components previously measured using methods such as computed tomography, magnetic resonance imaging, and Dexa can be measured more easily and cheaply with bioelectrical impedance analysis (BIA) devices carried to advanced levels with technological developments. The BIA method is a non-invasive, easy, and effective method.[13-15]

This study aimed to compare the body components measured by the BIA method in patients with and without gallstones and to reveal predictive factors that can help prevent the formation of gallstones.

MATERIALS AND METHODS

This prospective cross-sectional case–control study compared the differences in body components measured by BIA in patients with and without gallstones in the gallbladder. Approval was obtained from theTokat Gaziosmanpaşa University Clinical Research Ethics Committee. The study was conducted between January 2022 and August 2022.

Ultrasonography (USG) and clinical examination findings were used for diagnosis. In the USG examination, healthy people without gallstones in the gallbladder were included in the control group, while patients who were symptomatic or asymptomatic and who had stones in the gallbladder in the USG were included in the case group. All participants underwent BIA with InBody 270 (Biospace, Seoul, Korea). Age, sex, BMI, height, weight, comorbidities, drugs used, mean water intake, daily (MWID), body fat percentage (BFP), total body fat mass (kg) (TBFM), total body water (TBW), body fat mass of trunk (kg) (BFM of the trunk), and visceral fat level (VFL) of the patients were recorded.

Participants over the age of 18 were included in this study. Patients with hematological diseases that increased the incidence of stones in the gallbladder, the use of glucocorticoids, and liver failure were excluded from the study. In addition, patients with kidney failure, diabetes mellitus, acute cholecystitis, and jaundice findings that may affect body components and TBW and patients using diuretic and diuretic combination antihypertensive drugs were not in the study.

Sample Size

Cohen's d-value calculation method determined the appropriate sample size to investigate the factors affecting the presence of gallstones.[16] The findings of Lu et al. in 2022 to predict gallstone disease (GD) were used to determine the effect size index d.[17] In this study, a median difference of 8 points was present between the BFP level of the GD group and the control group. Based on this finding, the effect size was >1. However, the effect size was taken as 0.5 to obtain a larger sample size in the study. Accordingly, to test the difference between the two groups, a total of 176 participants were envisaged to be taken as the sample group using the d=0.5, 95% confidence level ($1-\alpha$), 95% test power ($1-\beta$) values were entered G-power (version 3.1) package program. Then, the study included 191 participants.

Statistical Analysis

SPSS (Statistical Package for the Social Sciences) version 25.0 (IBM Corp., Armonk, NY, USA) program was used for statistical analysis. Descriptive, graphical, and statistical methods were used to examine whether the scores obtained from each variable were in a normal distribution. The Kolmogorov−Smirnov test checked the normality of the scores obtained from a continuous variable by statistical methods. Descriptive statistical methods (number, percentage, mean, median, standard deviation, etc.,) were used to evaluate the study data. In the quantitative data, comparisons between the two groups were made with the independent sample t-test, while qualitative comparisons between the groups were made with the Pearson Chi-square test. In the study, the presence of gallstones was the dependent variable, whereas demographic and body composition characteristics were considered independent variables. Univariate and multivariate logistic regression modeling measured the effect of independent variables on the dependent variable. In addition, receiver operator characteristic analysis distinguished the most appropriate body composition index to predict the presence of GD. Results: Significance in the 95% confidence interval (CI) will be evaluated under P<0.05.

RESULTS

Demographic and Body Composition Characteristics of the Participants

Eighty-three people with GD were in the GD group, and 108 people without gallstones were in the control group. The mean age of the GD patients was 52.13 (standard deviation [SD]: 13.96) and 54.2% were female. The mean age of the control group was 47.79 (SD: 17.27) years and 56.5% were male. However, the mean BMI was higher in the GD group (P=0.007). In the body, composition indices between the two groups were examined, TBFM (P=0.004), BFP (P=0.003), BFP of the trunk (P=0.003), and VFL (P=0.005) were statistically significantly higher in the GD group than in the control group, whereas MWID (P<0.001) was statistically significantly lower (Table 1).

Table 1. Characteristics and body composition of the two groups

Variable	GD (n=83)	Control (n=108)	t/χ2	P-value
Age[#]	52.13±13.96	47.79±17.27	1.922[a]	0.056
Sex, n (%)				
Male	38 (45.8)	61 (56.5)	2.152[b]	0.142
Female	45 (54.2)	47 (43.5)		
BMI (kg/m^2)[#]	30.80±6.28	28.48±5.48	2.723[a]	0.007*
BMI group, n (%)				
Ideal	11 (13.3)	27 (25)	5.572[b]	0.062
Overweight	32 (38.6)	44 (40.7)		
Obese	40 (48.2)	37 (34.3)		
Height (cm)[#]	161.64±9.21	163.67±9.61	1.472[a]	0.143
Weight (kg)[#]	79.45±16.18	76.05±14.10	1.546[a]	0.124
Total body fat mass (kg)[#]	30.23±12.10	25.25±11.15	2.951[a]	0.004*
BFP (%)[#]	36.95±9.57	32.36±11.07	3.008[a]	0.003*
Total body water[#]	36.56±6.73	37.35±7.20	0.777[a]	0.438
Body fat mass of trunk (kg)[#]	15.32±5.19	12.91±5.55	3.056[a]	0.003*
Visceral fat level[#]	13.43±4.93	11.25±5.48	2.851[a]	0.005*
Mean water intake daily (L)[#]	1.49±0.59	1.88±0.35	5.256[a]	<0.001*

*: P<0.05; #: Mean±SD; [a](t): Independent sample t-test; [b]Pearson Chi-square; [c]Continuity correction; [d]: Fisher's exact test; χ^2: Chi-square tests; BMI: Body mass index; BFP: Body fat percentage; GD: Gallstone disease; SD: Standard deviation.

Subgroup Analysis of Body Composition

In males, the mean age was higher in the GD group than in the control group (53.5 vs. 45.4; P=0.031); in females, the difference between the mean age of both groups was not significant (P=0.726). MWID was significantly lower in both men and women in the GD group (male, 1.5 L vs. 1.9 L; P<0.001 and female, 1.5 L vs. 1.8 L; P=0.002). In females, BMI (P=0.026), TBFM (P=0.030), and BFM of the trunk (P=0.017) were statistically significantly higher in the GD group than in the control group (Table 2).

Receiver Operator Characteristic Curve Analysis Results

The results of the *receiver operator characteristic* analysis to determine gallstone disease are in Table 3 and Figure 1. *Thereafter;* In determining the presence of GD, the cutoff value for BFP was 0.24, and the AUC value was 62%. For the BFP, 0.24 cutoff value was detected in determining the presence of GD, sensitivity was 92%, specificity 27%, and accuracy 55%. In determining the presence of GD, the cutoff value for the BFM of the trunk was 13 kg, and the AUC value was 62%. Sensitivity was 66%, specificity 55%, and accuracy 60% for the 13 kg cutoff value detected in determining the presence of GD. In determining the presence of GD, the cutoff value for MWID was 1.5 L, and the AUC value was 70%. For the daily, 1.5 L water consumption cutoff value detected in determining the presence of GD, sensitivity was 49%, specificity 89%, and accuracy 72%.

Variables Associated with Gallstone Disease

Results of univariate analysis

According to the univariate logistic regression analysis, BMI, TBFM, BFP, BFM of the trunk, VFL, and MWID were associated with the presence of GD (P<0.05). Accordingly, those with a BFP level of ≥0.24 compared to those with a BFP level of <0.24 had a GD risk of 3.9 (95% CI: 1.6–9.6) times higher than others. While those with a BFM of the trunk of 13 kg and over 2.1 (95% CI: 1.2–3.8) times higher than others. Moreover, those with a BMI of 13 kg and over had 2.7 (95% CI: 1.2–6.1) times higher risk than others with normal BMI. Furthermore, those with daily water consumption of 1.5 liters and above compared to those with less than 1.5 liters had a GD risk 88% lower (OR: 0.12; 95% CI: 0.05–0.25). In addition, a 1-unit increase in VFL increased the risk of GD 1.1 (95% CI: 1.02–1.15) times (Table 4).

Multivariate Regression Analysis Results

In the univariate analyses, multivariate logistic regression analysis established by the stepwise method was applied by including variables (age, sex, BMI, TBFM, BFP [%], BFM of

Table 2. Body composition of male and female subgroups

Variable	Male		
	GD	Control	Pa-value
Age#	53.50±14.38	45.37±18.72	0.031*
BMI (kg/m^2)#	28.13±3.89	27.35±4.64	0.392
Height (cm)#	168.47±7.36	169.15±7.67	0.667
Weight (kg)#	79.80±11.56	78.43±14.01	0.616
Total body fat mass (kg)#	23.88±7.23	21.46±10.01	0.199
BFP (%)#	29.60±6.33	26.44±8.95	0.061
Total body water#	41.16±5.66	41.81±5.85	0.583
Body fat mass of trunk (kg)#	12.80±3.75	11.45±5.51	0.150
Visceral fat level#	10.50±3.67	9.16±4.84	0.148
Mean water intake daily (L)#	1.50±0.58	1.93±0.33	<0.001*
Variable	**Female**		
	GD	**Control**	**Pa**
Age#	50.98±13.66	49.94±14.71	0.726
BMI (kg/m^2)#	33.06±7.02	29.95±6.15	0.026*
Height (cm)#	155.87±6.178	156.55±6.81	0.614
Weight (kg)#	79.15±19.38	72.96±13.75	0.080
Total body fat mass (kg)#	35.59±19.38	72.96±13.75	0.030*
BFP (%)#	43.16±7.13	40.05±8.59	0.063
Total body water#	32.68±4.87	31.56±3.93	0.230
Body fat mass of trunk (kg)#	17.45±5.32	14.81±5.06	0.017*
Visceral fat level#	15.91±4.50	13.96±5.10	0.055
Mean water intake daily (L)#	1.48±0.60	1.81±0.37	0.002*

*P<0.05; #Mean±SD; [a]: Independent sample t-test. BMI: Body mass index; BFP: Body fat percentage; SD: Standard deviation; GD: Gallstone disease.

Table 3. Receiver operating characteristic curve analysis results

Gallstone disease	BFP (%)	Body fat mass of trunk (kg)	Mean water intake daily (L)
Cutoff	0.24	13	1.5
AUC (95% CI)	0.616 (0.537–0.695)**	0.616 (0.537–0.695)**	0.696 (0.617–0.775)*
Sensitivity	0.92	0.66	0.49
Specificity	0.27	0.55	0.89
PPV	0.49	0.53	0.79
NPV	0.81	0.68	0.70
Accuracy	0.55	0.60	0.72

*P<0.001, **P<0.01; PPV: Positive predictive value; NPV: Negative predictive value; AUC: Area under the curve; BFP: Body fat percentage; CI: Confidence interval.

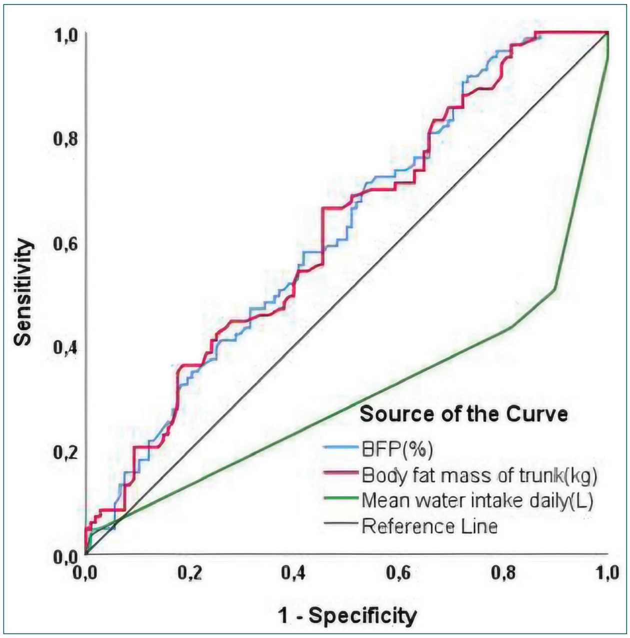

Figure 1. Receiver operator characteristic curve of gallstone disease.

trunk [kg], VFL, and MWID [L]) that were statistically significant or close to significance with the presence of GD. The most meaningful analysis results were from the stepwise method in step 2. In step 2, two independent factors related to the presence of GD were determined. According to the regression analysis, the model determination coefficient is *R2* (Nagelkerke)=0.28. This means that 28% of the variance in the dependent variable were explained by the predictors. The model (F=43.780, P<0.001) was significant at the 95% confidence level since the P<0.001. According to the multiple logistic regression model, a BFP level of ≥0.24 increased the risk of GD 3.1 (95% CI: 1.2–7.9) times, and water consumption of fewer than 1.5 l per day increased the presence of GD 7.8 (95% CI: 3.6–16.8) times. The probability of correct classification of the logistic regression model was 72%. The model correctly estimated the presence of GD by 72% with the clinical findings used. According to the logit model equation from the variables in the model, the probability of GD occurrence in an individual with a BFP rate of 24% and above, and daily water consumption of fewer than 1.5 liters was calculated as P(Y=1) = 1/1+e− (−1.758+1.132 *1+2.052 *1) approximately 80.6% (Table 5).

Table 4. Univariate regression analysis results

Variable	Category	OR (95% CI)	P-value
Age	All	1.017 (0.999–1.036)	0.064
Sex	Male	1 (reference)	
	Female	1.537 (0.864–2.733)	0.143
BMI (kg/m²)	All	1.071 (1.017–1.128)	0.009*
BMI group	Ideal	1 (reference)	
	Overweight	1.785 (0.774–4.118)	0.174
	Obese	2.654 (1.155–6.094)	0.021*
Height (cm)	All	0.977 (0.948–1.008)	0.143
Weight (kg)	All	1.015 (0.996–1.035)	0.125
Total body fat mass (kg)	All	1.038 (1.011–1.065)	0.005*
BFP (%)	All	1.043 (1.014–1.073)	0.004*
BFP (%)	<0.24	1 (reference)	
	≥0.24	3.986 (1.648–9.642)	0.002*
Total body water	All	0.984 (0.944–1.025)	0.436
Body fat mass of trunk (kg)	All	1.086 (1.028–1.148)	0.003*
Body fat mass of trunk (kg)	≤13	1 (reference)	
	>13	2.127 (1.183–3.824)	0.012*
Visceral fat level	All	1.082 (1.023–1.145)	0.006*
Mean water intake daily (L)	All	0.187 (0.096–0.364)	<0.001*
Mean water intake daily (L)	<1.5	1 (reference)	<0.001*
	≥1.5	0.116 (0.054–0.248)	

*P<0.05. Univariate logistic regression analysis. OR: Odd ratio; CI:Confidence ınterval; 1: Reference value; BMI: Body mass index; BFP: Body fat percentage.

Table 5. Multivariate regression analysis results

Variables (model-2)	Category	β	SE	Wald's	OR (95%CI)	P-value
BFP (%)	<0.24	1.132	0.482	5.524	1 (reference)	0.019*
	≥0.24				3.102 (1.207–7.972)	
Mean water intake daily (L)	<1.5	2.052	0.392	27.437	7.786 (3.612–16.781)	<0.001*
	≥1.5				1 (reference)	
Constant	All	−1.758	0.454	14.983	0.172	<0.001

*P<0.05. Multiple logistic regression, R^2 (Nagelkerke): 0.28, Model χ^2: 43,780, P<0.001. Dependent variable: Gallstone disease (1: Yes, 0: No), Excluded variables: Age, sex, BMI (kg/m²), Body fat (kg), body fat mass of trunk (kg) and visceral fat level, correct classification probability of the model: 72,3%. OR and P-value were obtained using multivariate logistic regression analysis model. Method: Forward stepwise. OR: Odd ratio; CI: Confidence ınterval; 1: Reference value; SE: Standard error; BFP: Body fat percentage; BMI: Body mass index.

DISCUSSION

In our study, BMI, BFP, TBFM, BFM of the trunk (kg), and VFL were higher in patients with gallstones compared to the control group. MWID was lower in patients with gallstones than in the control group. Multivariate regression analysis revealed that BFP and MWID were independent risk factors for stone formation in the gallbladder. When women and men were evaluated separately, MWID was statistically significantly lower in both men and women with gallstones. Furthermore, BMI, TBFM, and BFM of the trunk were statistically significantly higher in women with gallstones. In the pathogenesis of gallstone formation, high cholesterol concentration in the bile, gallbladder motility, intestinal motility, and supersaturated bile acid are the effective factors.[18] In a study using body compositions measured by the BIA technique, BMI, BFP, and waist circumference were the risk factors for gallstone formation.[17] In two studies conducted in women and men separately, central adiposity determined by abdominal circumference and waist–hip ratio measurements were predictive factors in gallstone formation independently of BMI.[19,20] However, in these studies, we found that anthropometric measurements such as waist circumference, abdominal circumference, and waist–hip ratio were the measurements of the participants. Considering that there may be measurement errors during these measurements and that the body structures of individuals may be different, we believe that central adiposity should be evaluated with more standardized measurements. For these reasons, we included BFM of the trunk and VFL parameters measured with an InBody 270 device (Biospace, Seoul, Korea) instead of waist circumference, abdominal circumference, and waist–hip ratio. In the univariate analysis, BFM of the trunk and VFL were statistically significantly higher in the group with gallstones, but there was no independent variable compared with the multivariate analysis.

After understanding the pathogenesis of gallstones, studies conducted to prevent gallstones have focused on the factors in reducing obesity and fat ratios, especially diet and physical activity.[21-23] We did not find any study in the literature investigating the effects of daily water intake on gallstone formation. In our study, when the sexes were evaluated both separately and together, MWID was an independent risk factor for gallstone formation. We observed that the risk of gallstone formation increased 3.1 times in people with BFP above 24% and 8 times in people with MWID below 1.5 l. In studies investigating the effects of soft drinks, studies show that caffeinated soft drinks reduce the risk of gallstone formation,[24] as well as studies claiming the opposite.[25] In our study, while MWID amounts were effective, there was no statistically significant difference between the two groups in TBW measurements. We think that this situation is due to the high intake of black tea in Turkish society. In a study conducted on patients with jaundice, TBW, and extracellular water have been shown to be reduced.[26] However, we could not compare with this study because patients with jaundice were prone to hypovolemia and renal dysfunction due to conditions such as cholangitis and sepsis and patients with jaundice were excluded from our study.

One of the limitations of our study was that we selected participants from the outpatient clinic. This may have resulted in selection bias. In addition, the MWID values were the amounts stated by the participants. MWID amounts may vary periodically. Another limitation is that in this study, we did not evaluate the effects the soft drinks consumed by the participants other than water. However, since the same method was used in both groups, we believe that our results were not affected.

CONCLUSION

BFP and MWID are independent risk factors for gallstone formation. We believe that more effective results will be obtained in multicenter studies with a large population investigating the effects of total daily soft drink consumption on TBW. In addition, we believe that BIA, an inexpensive, easily applicable, and non-invasive technique, can be used not only as a guide for gallbladder stone disease but also for preventing diseases in many areas.

Ethics Committee Approval: This study was approved by the Tokat Gaziosmanpaşa University, Medical Faculty Research Ethics Committee (Date: 06.10.2022, Decision No: 22-KAEK-212).

Peer-review: Externally peer-reviewed.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Safra kesesi taşı olan hastalarda biyoelektrik impedans analizine dayalı vücut kompozisyonlarının ve su alımının prospektif değerlendirilmesi

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AMAÇ: Biyoelektrikal impedans analazi (BIA) vücut komponentlerinin karşılaştırılması, safra kesesi taşı oluşumunu engellemeye yardımcı olabilecek prediktif faktörlerin ortaya konulması amaçlanmıştır.

GEREÇ VE YÖNTEM: Safra kesesinde ultrasonografi ile taş saptanan hastalar vaka grubu olarak seçilirken, taş saptanmayan katılımcılar kontrol grubuna seçildi. Her iki gruptaki katılımcıların vücut komponentleri BIA ile ölçüldü. Katılımcıların demografik özellikleri, günlük ortalama su tüketim miktarları (MWİD), BIA ile ölçülen vücut kitle indeksi (BMI), total yağ ağırlığı (TBFM), total vücut yağ oranı (BFP), total vücut su miktarı (TBW), gövde yağ ağırlığı (BFM gövde) ve iç organ yağ düzeyi (VFL) kaydedildi. Safra taşı oluşumunda prediktif risk faktörleri istatiksel analiz ile ortaya konuldu.

BULGULAR: Safra kesesinde taş saptanan grupta 83, saptanmayan grupta 108 katılımcı olmak üzere toplamda 191 katılımcının verileri incelendi. Her iki grup yaş ve cinsiyet açısından istatiksel olarak benzerdi ($p>0.05$). Tek değişkenli analizde BMI, TBFM, BFP, BFM gövde ve VFL safra kesesinde taş saptanan grupta istatiksel anlamlı olarak daha yüksek iken (sırasıyla $p=0.007$, $p=0.004$, $p=0.003$, $p=0.003$, $p=0.005$) MWİD miktarı daha düşük idi ($p<0.001$). Çok değişkenli analizde ise MWİD (ref: ≥1.5 OR: 7.786 95%CI: 3.612-16.781) ve BFP (ref: ≥0.24 OR: 3.102 95%CI: 1.207-7.972) safra taşı oluşumunda bağımsız faktörler olarak karşımıza çıkmaktadır.

SONUÇ: Günlük ortalama su tüketim miktarı ve kolay uygulanabilir, non-invaziv bir yöntem olan BIA tekniği ile ölçülen BFP düzeyi safra taşı oluşumunda bağımsız risk faktörleridir.

Anahtar sözcükler: Safra kesesi taşı; günlük ortalama su tüketim miktarı; biyoelektrikal impedans analazi; vücut komponentleri; total vücut yağ oranı.

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