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Original article

The relationship between BMI, WHR and serum vitamin B12, folic acid and ferritin levels in adults

Sabiha Zeynep Aydenk Koseoglu[1], Dilek Toprak[2], Nurhan Dogan[3]

[1]Istanbul Zaim University, Faculty of Health Sciences, Nutrition and Dietetics Dept. Halkali Cad. No:2 - E-mail: sabiha.koseoglu@izu.edu.tr; [2]Tekirdag Namik Kemal University, Faculty of Medicine, Family Medicine Dept. Namik Kemal Mah. Kampus Cad. No:1 Suleymanpasa, [3]Afyon Kocatepe University, Faculty of Medicine, Biostatistics and Medical Informatics. Alicetinkaya Kampusu, Izmir Yolu

Summary. *Aim:* The evaluation of relationship between serum vitamin B12, folic acid, ferritin levels and anthropometric measurements (Body Mass Index and Waist-Hipp Ratio) in 18-64 years Turkish citizens. *Material and Method:* The questionnaire including demographic features, health status, biochemical parameters (vitamin B12, folic acid, ferritin) was applied to the participants who were 18-64 years. Moreover their weight were measured by a delicate scales (Tanita HB 418) and height were taken by stadiometer. Waist – Hipp measurements were made by using a flexible tape recorder and all measurements were recorded. Their biochemical values were done by Sisli Hamidiye Etfal, Education and Resarch Hospital Lab. in Istanbul. *Results:* The findings in this study were obtained from 251 healthy volunteers. 72,9% (n:183) of 251 subjects were female and 27,1% (n:68) were male and mean age was 36,85 ± 12,17. According to findings there was found a significant relationship between gender with BMI (body mass index) and WHR (waist-hipp ratio) (p=0,000). Additionally the waist-hipp ratio (WHR) measurements were higher in male than female participants and it was statistically significant. According to gender vitamin B12 deficiency was more male than female. Besides the blood levels of hemoglobin (Hb), ferritin, folic Acid (PA) were lower in female than male (respectively, p=0,053; p=0,000; p=0,431). In this study, according to age BMI were observed and it was found meaningful relationship between them (p=0,000). *Conclusion:* The measurements of BMI and WHR of subjects can be related with serum folic Acid, ferritin and vitamin B12 levels. As a result there is more scientific research for supporting our study.

Key words: BMI, WHR, vitamin B12 level, folic acid level, ferritin level, adult

Introduction

High body mass index (BMI) can be an indicator of high body fatness and it can be used to screen weight categories that may lead to health problems but it is not diagnostic for the health of an individual (1).

Some common conditions related to overweight and obesity include: premature death, cardiovascular diseases, high blood pressure, osteoarthritis, some cancers and diabetes (2).

BMI does not measure body fat directly, but research has shown that it is moderately correlated with more direct measures of body fat obtained from skinfold thickness measurements, bioelectrical impedance, densitometry (underwater weighing), dual energy x-ray absorptiometry (DXA) and other methods (1, 3, 4).

As a water-soluble vitamin, vitamin B12 is naturally found in fish, meat, poultry, eggs, milk and milk products and it is required for proper blood cell formation, neurological function, and DNA synthesis. The main causes of vitamin B12 deficiency include vitamin B12 malabsorption from food, pernicious anemia, postsurgical malabsorption, and dietary deficiency (5).

Folic acid, also known as folate is found naturally in foods, is one of the B-group vitamins. Folic acid has several important functions like working together with vitamin B12 to form healthy red blood cells and to help to reduce the risk of central nervous system defects, such as neural tube defects (NTDs), in unborn babies. Folic acid deficiency could lead to anaemia. Folate can be found in many foods. Good sources include: broccoli, brussels sprouts, liver, spinach, asparagus, peas, and chickpeas fortified breakfast cereals (6).

Ferritin is a compound composed of iron molecules bound to apoferritin, a protein shell. Stored iron represents about 25% of total iron in the body, and most of this iron is stored as ferritin. Ferritin is found in many body cells, but especially those in the liver, spleen, bone marrow, and in reticuloendothelial cells. Ferritin is found in serum in low concentrations and is directly proportional to the body's iron stores (7).

This study aimed to identify relationships between BMI measuements and the level of "Vitamin B12", "Folic Acid", and "Ferritin" among Turkish citiziens.

Material And Methods

The survey was performed with face to face interviews by the researchers over 300 adults, aged between 18-64 years. Measurements of weight, height, body mass index (BMI), waist and hip circumferences and blood analysis of 251 adults were recorded.

Population and Sampling

The population for the survey was defined as adults aged between 18 -64 years. The study population was randomly selected fromTurkish citiziens who applied to Family Medicine Polyclinics of Sisli Hamidiye Etfal Training and Research Hospital. 251 of the subjects gave permission for the research. Pregnant, women who were in postpartum period, vegetarians or vegans, people who were taking H2 receptor inhibitors, vitamins, metphormin or were taken antibiotics in the last week, who had diagnosed as gastritis, peptic ulcus, anemia, Chronic Renal Deficiency or Chronic Heart Disease and people who had (known) excessive homocysteine were excluded from the study.

Data collection

A questionnare structered by us was applied to all subjects and socio-demographical features (gender, age) health status.

From the general questionnaire, we extracted information on sex, age, smoking, and alcohol consumption. Blood sampling and biochemical determinations during the normal life condition over the 8 hours fasting period venous blood samples were obtained from subjects in a sitting position.

Respondents were chosen from the volunteer patients who applied to the Family Medicine Polyclinics of Sisli Hamidiye Etfal Hospital in Istanbul in Turkey for any complain, in 6 months and who were between the age of 18 -64 years, in both gender. After the face to face interviews, height, weight, BMI, waist, and hip circumferences were measured. Socio-demographic and medical histories were recorded. Serum levels of vitamin B12, folic acid and Ferritin levels that had been obtained in the last 3 months were evaluated retrospectively.

Measurements

Height and weight were measured; BMI was calculated from measured height and weight. Height was measured with a steel anthropometer. Weight was measured on a Tanita bathroom digital scale. The waist was measured at the smallest horizontal trunk circumference and the hip was measured at the largest horizontal circumference around the hip and buttocks, with nonstretching fiberglas. Three trained fieldworkers acquainted with standardized methods took all anthropometric measurements. All measurements were performed in duplicate, and the average was used for analysis, or metal tapes. BMI was expressed as weight (kg) divided by height (m) squared and also waist / hip ratio was calculated.

Statistical Analysis

All statistical analyses were performed using the survey analysis method except for factor analysis and correlation. In defining statistics of datas had been used average, standard deviation, median, minumum, maximum, rate and frequency values. Distribution of variables had been controlled by kolmogorov and simimov test. In the analysis of quantitative datas had been used independent-sampling t test and mann-whitney u test. In analysis of qualitative datas had been used chi-square test. In analysis of correlation according to distribution of datas had been used correlation analysis of pearson and spearman. Analyses were conducted using SPSS 16.0.

Study Delivery

Study protocols were piloted and refined. Protocols were given ethical approval by the Research Ethics Committee of the Sisli Hamidiye Etfal Hospital Istanbul in Turkey. Study interviews were conducted by trained researchers.

Table 1. Demographical Characteristics

	n	%
Gender		
Female	183	72,9%
Male	68	27,1%
Marital status		
Married	127	50,6%
Single	105	41,8%
Divorced	19	7,6%
Educational status		
Low	56	22,3%
High	195	77,7%
Working status		
Yes	188	74,9%
No	63	25,1%
Child number		
Have no child	145	57,8%
Have one or more than one child	106	42,2%
Income status		
Low	26	10,4%
Medium	174	69,7%
High	50	19,9%
Using alcohol		
Yes	70	27,9%
No	181	72,1%

Results

The findings reported in this research are collected from the 251 eligible healthy volunteer participants. Of 251 participants 72,9% (n=183) were female and 27,1% (n=68) were male with the mean age of 36.85±12.17 (min:18; max:64 years). 99,6% (n=250) of participants were lived in downtown. A total of 50,6% (n=127) were married, 33,1% (n=83) were active smokers, 74,9% (n=188) were working and 34,1% (n=61) had chronic disease.

While a total of 16,3% (n=41) had at least one children, 57,8% (n=145) had no children. Of 251 participants, 69,7% (n=175) had mid level income. 45.8% (n=115) of the participants were low educated and 54,2% (n=136) were high educated.

Consumption rate of alcohol were 27,9% (n=70) in total participants (Table 1).

There was a significant relationship between gender and BMI and WHR values. According to gender, BMI values were higher among women (p=0,000). On the other hand weist/height ratio (WHR) values were higher in men than women (p=0,013) (Table 2).

According to gender, vitamin B12 deficiency were more common in men (n=17; 25,0%) than women (n=36; 19,7%) (p=0,358). On the other hand, Hemo-

Table 2. Anthropometry measurements according to gender

Gender	WHR		BMI		
	Lower than 0,85	Upper than 0,85	<25	25≤BMI≤30	≥30
Female	146 (79,8%)	37 (20,2%)	115 (62,8%)	38 (20,8%)	30 (16,4%)
Male	44 (64,7%)	24 (35,3%)	27 (39,7%)	32 (47,1%)	9 (13,2%)
P	0,013		0.000		

globin, ferritin, and folic acid levels were lower in women than men (p=0,053, p=0,000, p=0,431) (Table 3).

While no relationship was found between WHR, BMI, and vitamin B12, folic acid values, there was a significant relationship between BMI and Ferritin levels (p=0,013) (Table 4).

Regarding the age 28,4% (n=29) of people who were ≥40 age group had high BMI (≥30kg/m2) and it was 6,7% (n=10) among 18-39 age group (p=0,000)

There was a significant relationship between age group and WHR measurements (p=0,010) that WHR measurements were higher as 35,3% (n=36) in ≥40 age group in comparison with 18-39 age group (n=25; 16,8%) (Table 5).

The results of serum vitamin B12, hemoglobin, folic acid, and ferritin levels. Regarding age were shown in Table 6.

No relationship was found between education level and vitamin B12, folic acid, Hb and Ferritin values (p>0.05)

There were significant relationship between education level and BMI values and WHR measurements (p=0,000, p=0,000). BMI measurements were 9,7% (n=19) in high educated people and 35,7% (n=20)in low educated subjects (p=0,000). According to education level, WHR measurements were lower in high educated people (n=37; 19,0%) than in low educated people (n=24; 42,9%) (p=0,000) (Table 7, 8).

There was a significant relationship between having children and BMI and WHR measurements (p=0,000, p=0,000). BMI measurement was higher in people who has got one or more children (n=30; 28,3%) than participants who haven't got any children

Table 3. Biochemistry values according to gender

Gender	Vitamin B12		Folic Acid		Ferritin	
	126,5 pg/mL	**505 pg/mL**	**3,1 ng/mL**	**19,9 ng/mL**	**11 ng/mL**	**306,8 ng/mL**
Female	36 (19,7%)	147 (80,3%)	11 (6%)	172 (94%)	52 (28,4%)	131 (71,6%)
Male	17 (25%)	51 (75%)	6 (8,8%)	62 (91,2%)	1 (1,5%)	67 (98,5%)
P	0,38		0,431		0.000	

Table 4. Biochemical values according to Anthropometric measurements

WHR	Vitamin B12		Folic Acid	
	126.5 pg/mL	**505 pg/mL**	**3.1 ng/mL**	**19.9 ng/mL**
n (lower than 0,85)	42	148	15	175
n (upper than 0,85)	11	50	2	59
P	0,498		0,212	

BMI	Vitamin B12	Folic Acid	Ferritin
<25	333,6	8,3	28,1
25≤BKI<30	339,8	8,7	43,5
≥30	323,2	9,5	40,4
P	0,666	0,176	0,013

Table 5. Anthropometry measurements according to age

Year	WHR		BMI		
	Lower than 0,85	**Upper than 0,85**	**<25**	**25≤BMI≤30**	**≥30**
18-39 (n=149)	124 (83,2%)	25 (16,8%)	105 (70,7%)	34 (22,8%)	10 (6,7%)
40 and upper (n=102)	66 (64,7%)	36 (35,3%)	37 (36,3%)	36 (35,3%)	29 (28,4%)
P	0,001		0.000		

Table 6. Biochemical measurements according to age

Year	Vitamin B12		Folic Acid		Ferritin	
	126.5 pg/mL	505 pg/mL	3.1 ng/mL	19.9 ng/mL	11 ng/mL	306.8 ng/mL
18-39 (n=149)	30 (20,1%)	119 (79,9%)	15 (10,1%)	134 (89,9%)	42 (28,2%)	107 (71,8%)
40 and upper (n=102)	23 (22,5%)	79 (77,5%)	2 (2%)	100 (98%)	11 (10,8%)	91 (89,2%)
P	0,645		0,012		0,001	

Table 7. Education and Anthropometric measurements

Education	WHR		BMI		
	Lower than 0,85	Upper than 0,85	<25	25≤BMI≤30	≥30
Low	32 (57,1%)	24 (42,9%)	23 (41,1%)	13 (23,2%)	20 (35,7%)
High	158 (81%)	37 (19%)	119 (61%)	57 (29,2%)	19 (9,7%)
P	0.000		0.000		

Table 8. Education and Biochemical values

Education	Vitamin B12		Folic Acid		Ferritin	
	126,5 pg/mL	505 pg/mL	3,1 ng/mL	19,9 ng/mL	11 ng/mL	306,8 ng/mL
Low	10 (17,9%)	46 (82,1%)	2 (3,6%)	54 (96,4%)	10 (17,9%)	46 (82,1%)
High	43 (22,1%)	152 (77,9%)	15 (7,7%)	180 (92,3%)	43 (22,1%)	152 (77,9%)
p	0,498		0,279		0,498	

(n=9; 6,2%) while in subjects who haven't got any children had lower WHR measurements (n=23; 15,9%) than people who has got one or more children (n=38; 35,8%). There was no significant relationship between having children and biochemical parameters (p >0.05) that vitamin B12, hemoglobin, ferritin, and folic acid deficiences were more common in people who had no child.

While the relationship between family income and BMI was significant (p=0,011) there was no relationship between family income and biochemical parameters (p>0,05).

The relationship between BMI, WHR, alcohol consumption, and serum biochemical parameters were shown in Table 9 and Table 10. In addition to the results there was a limited significant relationship between cardiovaskular disease and serum folic acid levels.(p=0,066)

Discussion

According to our study results, there was a statistically significant relationship between gender and

Table 9. Alcohol and anthropometric measurements

Alcohol Type	BMI			WHR	
	<25	25≤BMI≤30	≥30	Lower than 0,85	Upper than 0,85
yes (n)	24	4	4	22	10
yes (%)	75%	12,5%	12,5%	68,8%	31,3%
beer, vine (fermented) n	27	5	2	27	7
fermented (%)	79,4%	14,7%	5,9%	79,4%	20,6%
raki, wisky, vodka (not fermented) n	11	5	1	13	4
not fermented (%)	64,7%	29,4%	5,9%	76,5%	23,5%
P	0,136			0,793	

anthropometric measures BMI (p=0,000) and WHR (p=0,000). BMI was found high in female subjects, while WHR in men was higher than in women. Noh J.W. *et al*. (8), Reas L.D. *et al*. (9) and Fan M. *et al*. (10) reached conclusions that support our study. On the other hand, McKinnon E.J. *et al*. (11) did not find significant correlation between gender and anthropometric measurements in that study. The results we achieved in our study show similarities to those of most scientific studies.

According to gender biochemistry findings, there was not statistically significant relationship between gender and serum vitamin B12 and serum folic acid levels, but only between gender and serum ferritin level (p=0,358, p=0,431, p=0,000, respectively).

Serum ferritin level was found to be higher in females than males in our study but Ellidag H.Y. *et al*. (12), McNamee T. *et al*. (13), McKinnon E.J. *et al*. (11), Rushton D.H. & Barth J.H. (14) and Cafolla A. *et al*. (15) found significantly lower levels of serum ferritin in women than in men. In our study, the presence of lower serum ferritin levels in men suggests that it may be due to more caffeine consumption in men's diet (16). We could not observe a statistically significant difference between gender and serum vitamin B12 level in our study. Likewise, Baltacı D. *et al*. (17) and Cafolla A. *et al*. (15) did not correlate gender and vitamin B12 levels. Shams M. *et al*. (18) and Fakhrzadeh H. *et al*. (19) observed significant differences between gender and serum vitamin B12 levels. Shams M. *et al*. (18) found serum vitamin B12 levels lower in males, while Fakhrzadeh H. *et al*. (19) found higher levels. No statistically significant correlation was observed between gender and serum folic acid level in our study. Shams M. *et al*. (18) and Fakhrzadeh H. *et al*. (16) found that serum folic acid levels were lower in males in their studies, while Cafolla A. *et al*. (15) found no relationship between gender and serum follicle, which supports our study.

When we examine the relationship between anthropometric measurements and bio-chemical values of the participants (serum vitamin B12, serum folic acid, serum ferritin); there was no significant correlation between BMI and serum vitamin B12 and serum folic acid (p=0,666; p=0,176) while BMI and serum ferritin levels were found to be statistically significant (p=0,013). There was no significant relationship between WHR and biochemical parameters (p=0,498 for vitamin B12, p=0,212 for folic acid).

Arshad M. *et al*. (20), Abu-Samak M. *et al*. (21) (p<0,001) and Baltacı D. *et al*. (17) (p<0,001) found a statistically significant relationship between BMI and serum vitamin B12 in their studies. Abu-Samak M. *et al*. (21) and Baltacı D. *et al*. (17) (p=0,673) did not reach a statistically significant relationship between BMI and serum folic acid, similar to our study. Alam F. *et al*. (22) (p<0,001) and McKinnon E.J. *et al*. (11) (p<0,001) found a statistically significant relationship between BMI and serum ferritin, like our study. However, Baltacı D. *et al*. (17) and Ghadiri-Anaria A. *et al*. (23) did not find statistical significance between BMI and serum ferritin (p=0,132).

Regarding the relationship between haemoglobin (Hb) and BMI; Hemamalini J. (24) showed that serum Hb level increases as BMI increases. In a study to find the relationship between Hb and WHR, Jamshidi L. *et al*. (25) found that serum Hb levels were low in people with normal WHR. Statistically significant differences were found between them (p<0,0005).

The relationship between Hb and BMI was observed by Ghadiri-Andri A. *et al*. (23), and they found no statistical significance in their study.

Anthropometric measurements (BMI and WHR) by age were evaluated in our study, and we reached a statistically significant relationship between age and BMI, age and WHR, respectively (p=0,000; p=0,01). In other words, we observed that as the age advances, there is an increase in BMI and WHR as expected.

In studies conducted by Dalvand S. *et al*. (26) and Gillum R.F. (27), BMI and WHR increased as age advanced. Moreover, according to the study by Gillum R.F. (27), WHR was found to increase with age. These two studies support our work in terms of the results they found.

Reas L.D. *et al*. (9) reported that the correlation between age and BMI was negative and significant (p<0,001). In the study by Akhlaghi M. *et al*. (28), however, the relationship between age and BMI was not statistically significant.

When the relationship between age and biochemical parameters (vitamin B12, folic acid, ferritin) was examined in our study, only the relationship between serum vitamin B12 and age was insignificant (p=0,645), while the relationship between serum folic acid and serum ferritin and age was statistically significant (p=0,012; p=0,001).

Heilmann E. & Bartling K. (29) showed that serum vitamin B12 decreased with age and there was a negative correlation between them with statistical significance (p=0,001). Fakhrzadeh H. *et al*. (19) reported in their study that the lowest level of vitamin B12 was between 35-44 years for women and 45-54 years for men. Andres E. *et al*. (30) found a negative correlation between aging and vitamin B12. In our study, the relationship between age and vitamin B12 was not statistically significant. We think that this is due to the unequal number of women and men in the sample group that we included in the study.

Fakhrzadeh H. *et al*. (19) found similar results with ours, that is, as the age increases a decrease in the serum folic acid value is observed, with a significant relationship found between them.

In a study in women, Ellidag H.Y. *et al*. (12) found that serum ferritin levels increases with age. Gillum R.F. (27) observed a decrease in serum ferritin with age, similar to our results. We think that the reason Ellidag H.Y. *et al*. (12) reached a conclusion that is the contradicting to ours is that because they only included women in their study.

In our study, the relationship between education and BMI and WHR was examined and the correlation was found to be significant respectively (p=0,000; p=0,000). According to our study, as the level of participants' education increases, BMI and WHR also increase.

According to studies by Kroeger R.A. (31) and Hermann S. *et al*. (32), as education increases, BMI levels decrease. Maddah M. *et al*. (33) observed that in women, the level of BMI was found to be low as education increased, whereas in adults, this was the opposite. Fan M. *et al*. (10) reported that the level of education increased as the level of BMI increased (p=0,030). Garcia-Mendizabal M.J. *et al*. (34) observed an increase in BMI as the level of education decreased in the study they conducted. Maddah M. *et al*. (33) and Hermann S. *et al*. (32) found a negative relationship between WHR and education level.

As the reason why the levels of BMI and WHR were found to increase with the level of education in our study, can be attributed to the sedentary lifestyle as a consequence of the socioeconomic change in the society, and to the fact that the study was conducted in a metropolis with inadequate facilities for physical activity, and to the difficulties in accessing healthy food. The relationship between education and biochemical parameters (serum vitamin B12, serum folic acid, serum ferritin) of the subjects was statistically insignificant (p=0,498, p=0,279, p=0,498 respectively). Studies explaining the relation between education and biochemical parameters were searched but no relevant data about the topic were found.

The relationship between alcohol and anthropometric measurements (BMI, WHR) was statistically insignificant in our study (p=0,136; p=0,793 respectively). The reason for such a result can be attributed to the fact that participants did not use alcohol or the consumption of alcohol was small in quantity and frequency.

Noh J.W. *et al*. (8) found a positive relationship between alcohol intake and BMI (p=0,004).

Freshmen M.A.N. *et al*. (35) stated that individuals who use alcohol had a higher BMI and that there was a statistically significant relationship between alcohol intake and BMI (p<0,01). French M.T. *et al*. (36) observed a positive relationship between alcohol intake and BMI (p<0,01). Liangpunsakul S. *et al*. (37) stated that there was a significant positive significant relationship between alcohol intake and WHR. Kelly N. *et al*. (38) found a statistically significant association between alcohol consumption and visceral adiposity and WHR (p=0,025). While Lukasiewicz E. *et al*. (39) found a significant relationship between alcohol consumption and WHR in both genders, women who consumed alcohol at low levels found to have lower WHR than women who did not consume alcohol or consumed excessive alcohol. In men, that was the opposite, and the relationship between alcohol intake and BMI was significant (p=0,05).

In our study, the relationship between alcohol consumption and biochemical parameters (serum vitamin B12, serum folic acid, serum ferritin) was statistically insignificant (p=0,161, p=0,947, p=0,244 respectively). The reason why our study resulted in this way is that the number of alcohol users and alcohol use rates in the sample group taken for the study were low. Green P.H. (40) observed in a study that vitamin B12 level decreased with alcohol consumption. Cravo M.L. *et al*. (41) found that serum vitamin B12 increased due to alcohol consumption. Lieb M. *et al*. (42) and Eichner E.R. & Hillman R.S. (43) found no significant association between alcohol consumption and vitamin B12 in their studies. Eichner E.R., & Hillman R.S. (43) and Green P.H. (40) found low serum folic acid levels in alcohol users, whereas Cravo M.L. *et al*. (41) observed that the level of serum folic acid in alcohol consumers was high. Lieb M. *et al*. (42) found no significant relationship between alcohol intake and serum folic acid level. While McKinnon E.J. *et al*. (11) and Eichner E.R., & Hillman R.S. (43) found no significant relationship between alcohol consumption and serum ferritin, Lieb M. *et al*. (42) observed a high serum ferritin level in alcohol users.

Conclusion

All of the findings we have obtained in our study are approximately in line with similar studies and we think that the differences may be due to the selection of the participants in the study in a cross-sectional and randomized manner. In our work, we wanted to multiply the parameters to observe different results. For that reason, in some parameters we did not obtain exactly the same results as those of similar studies that had been conducted before. In the discussion part, information related to this topic is provided. Studies like ours, which was conducted in a metropolitan area, should be made in rural areas as well and be compared with groups with different socioeconomic and sociocultural characteristics so that we can shed light on the public health problems.

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We hope that the research will practice in the pursuit of good health.

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Correspondence:
Sabiha Zeynep Aydenk Koseoglu,
Istanbul Zaim University, Faculty of Health Sciences,
Nutrition and Dietetics Dept. Halkali Cad. No:2
Halkali Kucukcekmece, 34303, Istanbul, Turkiye.
Tel: +90 444 9798,
E-mail: sabiha.koseoglu@izu.edu.tr; szaydenk@gmail.com