Clinical and Experimental Health Sciences

Original Article / *Özgün Araştırma*

Evaluation of Dietary Boron in terms of Health: A Retrospective Study

Diyet ile Alınan Borun Sağlık Açısından Değerlendirilmesi: Retrospektif Bir Çalışma

Ruya Kuru[1], Esra Kurt Mutlu[2], Ela Cempel[3], Sedef Belentepe Celik[4], Aysen Yarat[1]

[1] Department of Basic Medical Sciences-Biochemistry, Faculty of Dentistry, Marmara University, Istanbul, Turkey
[2] Department of Nutrition and Diet, Turkey Hospital, Istanbul, Turkey
[3] Department of Nutrition and Diet, Maltepe Ersoy Hospital, Istanbul, Turkey
[4] Department of Internal Medicine, Maltepe Ersoy Hospital, Istanbul, Turkey

ORCID IDw of the authors: R.K. 0000-0002-3031-8875, E.K.M. 0000-0001-9611-5133, E.C. 0000-0001-9272-2841, S.B.C. 0000-0001-8162-6651, A.Y. 0000-0002-8258-6118

Cite this article as: Kuru R., Kurt Mutlu E., Cempel E., Belentepe Celik S., Yarat A. Evaluation of Dietary Boron in terms of Health: A Retrospective Study. Clin Exp Health Sci 2018; 8: 296-300. **DOI:** 10.5152/clinexphealthsci.2018.955

ABSTRACT

Objective: The aim of this retrospective study was to calculate the amount of daily boron intake according to the daily nutrition diary and to evaluate the effects of boron on health via the results of some biochemical and hematological parameters.

Methods: A total of 50 patients who were admitted to the Maltepe Ersoy Hospital Nutrition and Diet Clinic, had some biochemical and hematological examinations, had a weekly nutrition diary, and had anthropometric records were included in the present study. The relationships between daily boron intake and biochemical, hematological, and anthropometric records of the patients were examined.

Results: The average daily boron intake was calculated as 1.45±0.4 (women: 1.4±0.4 and men: 1.5±0.5) mg/day and was mostly found in fruits. There was a significant and negative correlation between body mass index and daily boron intake (r=−0.3555, p=0.05); however, no significant relationship was found between daily boron intake level and other parameters.

Conclusion: To our knowledge, this is the first study in the literature that presents the dietary boron level in Turkey and also examines the relationship between dietary boron level and biochemical and hematological parameters retrospectively. The results of our study could provide useful information and contribution to ongoing boron studies.

Keywords: Boron, Diet, Health, Body Mass Index

ÖZ

Amaç: Bu retrospektif araştırmanın amacı, insanların bir günde diyet ile almış oldukları bor miktarını hesaplamak, günlük bor alımının bazı biyokimyasal ve hematolojik parametrelere ve sağlığa olan etkilerini değerlendirmektir.

Materyal Metot: Maltepe Ersoy Hastanesi Beslenme ve Diyet Kliniğine başvuran, biyokimyasal ve hematolojik incelemeleri yapılmış, haftalık beslenme günlükleri ve antropometrik kayıtları olan 50 hasta çalışmaya alındı. Hesaplanan günlük bor alımı ile hastaların biyokimyasal, hematolojik ve antropometrik kayıtları arasındaki ilişki incelendi.

Bulgular: Ortalama günlük bor alımı, 1.45 ± 0.4 mg/gün (kadınlar için: 1.4 ± 0.4, erkekler için: 1.5 ± 0.5 mg/gün) olarak hesaplandı ve çoğunlukla meyvelerden kaynaklandığı tespit edildi. Beden kitle indeksi ile günlük bor alımı arasında anlamlı ve negatif korelasyon vardı (r = – 0.3555, p = 0.05), ancak günlük bor alımı seviyesi ile diğer parametreler arasında anlamlı bir ilişki bulunamadı.

Sonuç: Bu çalışmanın bulguları, Türkiye'de diyetle alınan günlük bor miktarını hesaplayan ve diyetteki bor miktarı ile biyokimyasal ve hematolojik parametreler arasındaki ilişkiyi literatürde retrospektif olarak inceleyen ilk çalışma olması açısından önemlidir. Bu çalışmanın sonuçları gelecekte bor çalışmaları için faydalı bilgiler ve katkılar sağlayabilir.

Anahtar Kelimeler: Bor, Diyet, Sağlık, Vücut Kitle İndeksi

INTRODUCTION

Boron is known to be an essential micronutrient for plant growth (1). It is a considerable component of the diet (2). As boron is consumed with food and drinking water, it is present in human tissues and body fluids (3). There is strong evidence that it has many important roles in animal and human health. Studies have shown that boron regulates mineral and steroid hormone metabolism, contributes to bone development, has an antioxidant effect, strengthens the immune system, accelerates wound healing, regulates energy metabolism, and improves mental performance (4-12).

Foods of plant origin as nuts, fruits, leafy vegetables, and legumes are known to be rich in boron. However, meat, fish, and dairy products are poor sources of boron (13). Although dietary boron intake varies depending on geographical conditions and dietary characteristics, it is known that it is 1–7 mg/day (14). "Dietary reference intakes" are not yet established for boron. The safe uptake level was set at 20 mg/day by the

Correspondence Author/Sorumlu Yazar: Aysen Yarat **E-mail/E-posta:** ayarat@marmara.edu.tr

United States Institute of Medicine, Food and Nutrition Board (15). The acceptable daily intake for boron was determined to be 11.2 mg/day for a person of 70 kg at the 2013 European Food Safety Authority Panel (16).

Data related with the daily dietary boron level in Turkey are very limited. Therefore, the purpose of the present study was to calculate the amount of daily boron according to both weekly nutrition diary and literature data and to evaluate its effects on health via the results of some biochemical and hematological parameters. Estimating dietary boron levels will provide useful information for planning and assessing diets. To our knowledge, this is the first study in Turkey where the amount of boron consumed in the diet is calculated and the first in the literature where the relationship between dietary boron level and biochemical and hematological parameters is examined.

Methods

Fifty patients who were 19 and 69 years old, who were admitted to the Maltepe Ersoy Hospital Nutrition and Diet Clinic between January 2016 and January 2017, had some biochemical and hematological examinations, had a weekly nutrition diary, and had anthropometric records were included in the present study. The biochemical and hematological parameters investigated included fasting blood glucose, thyroid-stimulating hormone, complete blood count, alanine aminotransferase (ALT), and total cholesterol. The body mass index (BMI) of each patient was calculated using weight and height data, and patients were classified according to the World Health Organization (WHO) (17).

For calculation of the daily boron intake of each patient via their food records from weekly nutrition diaries, food boron data obtained from studies conducted in Turkey were used (18-24). Food groups that contributed to the daily boron intake were also identified. The relationship between daily boron intake and biochemical and hematological parameters and BMI values of the patients was statistically analyzed. Ethical approval was obtained from the Marmara – University Health Sciences Institute Ethics Committee (06.03.2017-85).

Statistical analysis

Comparisons of means and standard deviations, Pearson's correlation analysis, Student's t-test, and ANOVA variance analysis were performed by using the SPSS statistical program (version 15.0 for Windows; SPSS, Chicago, IL, USA).

Results

When weekly diets of the subjects participating in the study were examined in terms of boron, it was determined that daily boron intake was mostly in fruits. This was followed by vegetables, foods of animal origin, legumes, nuts, grains, and other foods (tea, coffee, alcoholic beverages, candies, and drinking water) (Fig. 1).

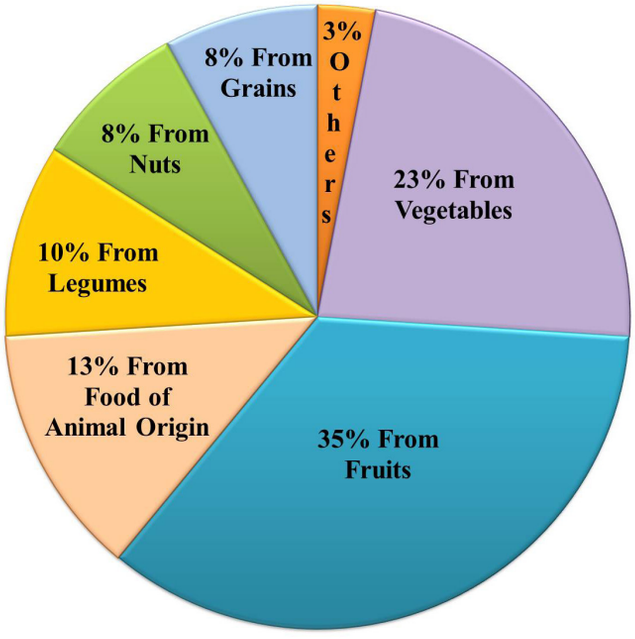

Figure 1. The contribution of food groups to the percentage of daily boron intake.

The average daily boron intake of 50 patients was calculated as 1.45±0.4 mg/day according to both weekly nutrition diary and literature data. Table 1 shows the values of all the examined parameters of the patients included in the study.

Table 1. The mean values of all the parameters of 50 patients.

Parameters	Mean	SD
Age (year)	37.6	11.4
Body Mass Index (kg/m^2)	30.3	5.4
Fasting Blood Glucose (mg/dL)	99.0	13.8
Thyroid-Stimulating Hormone (μU/mL)	2.9	5.7
Total Cholesterol (mg/dL)	198.9	35.5
Alanine Aminotransferase (U/L)	25.8	22.2
White Blood Cell (10^9/L)	7.3	1.7
Red Blood Cell (10^9/L)	4.7	0.4
Hemoglobin (g/dL)	13.6	1.4
Hematocrit (%)	40.2	3.7
Platelet (10^9/L)	269.8	50.6
Daily Boron Intake (mg/day)	1.45	0.4

SD: standard deviation

Table 2 shows the results of all the examined parameters of the patients who were divided into groups according to sex. The only significant difference between the groups was found for ALT levels. The average daily boron intake levels were calculated as 1.4±0.4 mg/day for women and 1.5±0.6 mg/day for men in the present study (Table 2). Table 3 shows the dietary boron levels according to sex in the present study and in other studies in various countries.

Table 2. The mean values of all the parameters according to sex.

Sex	Female (n=39)		Male (n=11)		p
Parameters	Mean	SD	Mean	SD	
Age (year)	39.2	11.6	32.0	9.1	0.428
Body Mass Index (kg/m^2)	29.9	5.7	31.4	4.0	0.134
Fasting Blood Glucose (mg/dL)	97.3	12.4	104.9	17.2	0.175
Thyroid-Stimulating Hormone (μU/mL)	3.1	6.3	2.3	0.9	0.348
Total Cholesterol (mg/dL)	199.4	35.3	197.6	38.0	0.569
Alanine Aminotransferase (U/L)	19.1	11.7	49.5	33.1	0.000*
White Blood Cell (10^9/L)	7.0	1.8	8.2	0.9	0.060
Red Blood Cell (10^9/L)	4.6	0.3	5.3	0.3	0.593
Hemoglobin (g/dL)	13.1	1.1	15.3	0.8	0.513
Hematocrit (%)	38.9	2.92	44.7	2.64	0.643
Platelet (10^9/L)	270.8	52.3	266.0	46.0	0.706
Daily Boron Intake (mg/day)	1.4	0.4	1.5	0.6	0.067

*p<0.05
SD: standard deviation

Table 3. The dietary boron levels in the present study and in other studies.

Countries	Daily Boron Intake (mg/day)	
	Female	Male
Turkey[a]	1.4	1.5
United States[b]	0.89	1.11
Germany[b]	1.62	1.72
Mexico[b]	1.75	2.12
Kenya[b]	1.80	1.95
Australia[c]	2.28	2.16

[a]This study.
[b]Rainey and Nyquist (1998).
[c]Pieczyńska et al. (2003).

Table 4 shows the mean values of all the parameters when the patients were divided into groups, such as normal, overweight, obese, and morbidly obese, according to BMI. The only significant difference between the groups was found for fasting blood glucose levels (p=0.041). There was no significant difference in daily boron intake levels between the groups.

However, when patients were divided into two groups as having boron intake ≤1.5 mg/day or >1.5 mg/day, the only significant difference was found for BMI values (p=0.011) (Table 5). Moreover, a significant and negative correlation between BMI and daily boron intake between the groups was also found (p=0.05, r=−0.3555).

Table 5. The mean values of all the parameters according to daily boron intake.

Parameters	**Daily dietary boron intake (mg/kg)**				
	≤1.5		**>1.5**		**p (t-test)**
	Mean	**SD**	**Mean**	**SD**	
Age (year)	37.5	11.8	37.9	11.2	0.909
BMI (kg/m^2)	31.8	5.1	27.9	5.1	0.011*
Fasting Blood Glucose (mg/dL)	100.8	15.4	96.3	10.7	0.253
Thyroid-Stimulating Hormone (μU/mL)	2.3	1.4	3.8	8.7	0.341
Total Cholesterol (mg/dL)	200.0	34.5	197.5	37.9	0.806
Alanine Aminotransferase (U/L)	27.4	24.5	23.4	18.5	0.529
White Blood Cell (10^9/L)	7.3	1.7	7.2	1.7	0.897
Red Blood Cell (10^9/L)	4.7	0.4	4.7	0.5	0.810
Hemoglobin (g/dL)	13.7	1.2	13.5	1.7	0.640
Hematocrit (%)	40.5	3.3	39.8	4.3	0.506
Platelet (10^9/L)	272.1	49.2	266.3	53.7	0.695

*p<0.05.
SD: standard deviation; BMI: body mass index.

Table 4. The mean values of all the parameters according to BMI groups.

	BMI (kg/m^2)								
BMI classification	Normal (n=8)		Overweight (n=17)		Obese (n=23)		Morbidly obese (n=2)		p (ANOVA)
Parameters	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Age (year)	33.0	9.5	36.2	10.7	39.6	11.8	46.0	21.2	0.354
Fasting Blood Glucose (mg/dL)	91.6	4.3	96.0	14.0	102.0	13.0	118.0	28.3	0.041*
Thyroid-Stimulating Hormone (μU/mL)	1.9	0.6	4.2	9.5	2.4	1.6	1.9	0.0	0.716
Total Cholesterol (mg/dL)	195.4	42.2	200.0	41.2	197.1	28.9	226.0	46.7	0.737
Alanine Aminotransferase (U/L)	21.0	9.5	20.8	17.6	30.0	27.3	39.0	26.9	0.434
White Blood Cell (10^9/L)	6.7	2.2	6.9	1.9	7.8	1.2	6.2	0.4	0.196
Red Blood Cell (10^9/L)	4.6	0.4	4.7	0.4	4.8	0.4	4.9	0.2	0.564
Hemoglobin (g/dL)	13.1	1.5	13.5	1.5	13.7	1.4	14.0	0.8	0.743
Hematocrit (%)	39.0	3.7	39.7	3.9	40.9	3.7	42.0	0.9	0.486
Platelet (10^9/L)	287.4	52.4	258.2	52.3	272.6	50.5	265.5	34.6	0.596
Daily Boron Intake (mg/day)	1.7	0.4	1.4	0.4	1.4	0.5	1.3	0.1	0.328

*p<0.05.
SD: standard deviation; BMI: body mass index.

Discussion

It is generally known that foods of plant origin are usually rich sources of boron in contrast to meat and fish. The daily boron intake levels are highly variable based on food groups in the diet (25). Kim et al., using the associated database, estimated the boron intake in food that the Korean population frequently consumed (26). It has been reported that contributions of various foods to the daily boron intake are 35.00% for the vegetable group, 17.40% for the fruit group, and 9.32% for the grain group. Boron intake through vegetables, fruits, and cereals has accounted for 61.72% of the overall boron intake. The average daily intake of boron is 0.93 mg/day. These levels are slightly different from those in the present study. The contributions of vegetables, fruits, and grains were 23%, 35%, and 8% respectively, and the total contribution was approximately 66%.

In a study of multicountry (USA, Germany, Mexico, and Kenya) estimation of dietary boron intake, a boron nutrient database was created to include boron concentrations for foods consumed in each country. It incorporates boron analytical data from various sources in the US, Finland, UK, Italy, Japan, and China. Each individual's average daily boron intake has been estimated by linking the boron database with the survey food records (2). The daily average boron intake levels in these countries had been calculated as 1.6 mg/day. This level was found to be higher than that of our results. Pieczynska et al. have found the average daily consumption of boron for Australians as 2.23 mg/day according to their boron database (27). Similarly, they have reported that major sources of boron are nuts, dried fruits, legumes, fresh vegetables, and fruits.

To our knowledge, our retrospective study is the first study in Turkey that examines boron intake levels through diet. Therefore, there are no data that we can compare in Turkey. According to daily dietary boron levels based on studies performed in the United States, Germany, Mexico, Kenya, Korea, and Australia and values obtained in the present study, there were differences between countries with regard to boron consumption (Table 3). The reason may be due to differences in plant growth conditions, consumption of different amounts of boron-containing foods, different methodologies used to determine food boron concentration, differences in food consumption, and different eating habits.

In the literature, in boron-related clinical trials, boron supplements were given to individuals in place of dietary modification to increase daily boron intake. Many positive results, such as decrease level of fasting blood sugar and increase level of hemoglobin and triiodothyronine, have been obtained by the amount of daily boron that is increased via boron supplements (28-31). In the present study, no significant difference was found between boron intake levels and biochemical and hematological parameters. The only significant difference was found for ALT levels according to sex. This was an expected result according to the literature since ALT levels are normally different between males and females (32). Furthermore, the absence of a significant difference between clinical parameters and daily boron intake may be due to the low daily boron intake and its inability to affect clinical parameters. Daily boron intake was between 1.05 and 1.85 mg/day. According to WHO, these values were not high enough to change clinical parameters significantly. When patients were divided into two groups according to their boron intake as ≤1.5 mg/day or >1.5 mg/day, the only significant difference was found for BMI values, and a significant and negative correlation between BMI and daily boron intake was also present. In the literature, there are several experimental studies conducted on the weight-reducing effect of boron (5, 10). It has been reported that boron inhibits adipogenesis in progenitor cells through the Wnt/β-catenin pathway and suggested that boron may be a new hope for obesity management (33). According to the result of the present study, it was found that the BMI decreased when the dietary boron intake increased.

Conclusion

To the best of our knowledge, this is the first study in Turkey where the amount of boron consumed in the diet is calculated. The average daily boron intake was 1.45 ± 0.4 mg/day and was mostly found in fruits. A significant and negative correlation was found between BMI and daily boron intake. The present study may provide useful information about boron intake. Further studies are necessary to assess whether daily intake of boron is adequate in Turkey.

Ethics Committee Approval: Ethical approval was obtained from the Marmara University Health Sciences Institute Ethics Committee (06.03.2017-85).

Informed Consent: None. The authors did not receive informed consent because this research is a retrospective study.

Peer-review: Externally peer-reviewed.

Author contributions: Concept – A.Y.; Design – A.Y., R.K.; Supervision – A.Y., R.K.; Resource – A.Y., R.K., E.K.M., E.C., S.B.C.; Materials – R.K., E.K.M., E.C., S.B.C.; Data Collection and/or Processing – R.K., E.K.M., E.C., S.B.C.; Analysis and/or Interpretation – A.Y., R.K., S.B.C.; Literature Search – R.K., A.Y.; Writing – R.K., A.Y.; Critical Reviews – A.Y., R.K., E.K.M., E.C., S.B.C.

Conflict of Interest: No conflict of interest was declared by the authors .

Financial Disclosure: The authors declared that this study has received no financial support.

Etik Komite Onayı: Etik onayı, Marmara Üniversitesi Sağlık Bilimleri Enstitüsü Etik Kurulu'ndan alınmıştır (06.03.2017-85).

Hasta Onamı: Bu araştırma retrospektif olduğundan hasta onamı alınmamıştır.

Hakem Değerlendirmesi: Dış Bağımsız.

Yazar Katkıları: Fikir – A.Y.; Tasarım – A.Y., R.K.; Denetleme – A.Y., R.K.; Kaynaklar – A.Y., R.K., E.K.M., E.C., S.B.C.; Malzemeler – R.K., E.K.M., E.C., S.B.C.; Veri Toplanması ve/veya işlemesi – R.K., E.K.M., E.C., S.B.C.; Analiz ve/veya Yorum – A.Y., R.K., S.B.C.; Literatür taraması – R.K., A.Y.; Yazıyı Yazan – R.K., A.Y.; Eleştirel İnceleme – A.Y., R.K., E.K.M., E.C., S.B.C.

Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Finansal Destek: Yazarlar bu çalışmanın gerçekleştirilmesinde mali destek almadıklarını beyan etmişlerdir.

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