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# NÖROLOJİK BELİRTİLERİ OLAN ÇOCUKLARIN VÜCUT KOMPOZİSYONLARININ AYAKTAN AYAĞA BİYOELEKTRİK EMPEDANS İLE DEĞERLENDİRİLMESİ

# ASSESSMENT OF BODY COMPOSITIONS BY FOOT-TO-FOOT BIOELECTRIC IMPEDANCE AMONG CHILDREN WITH NEUROLOGICAL MANIFESTATIONS

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**ÖZET**

**AMAÇ:** Klinik pratikte, vücut kompozisyonunun değerlendirilmesinde ayak-ayak biyoelektrik empedans analizinin (BIA) kullanımı artarak devam etmektedir. Taşınabilirliği, basitliği, hızı ve güvenilir olması tercih edilme nedenleri arasında sayılmaktadır. Bu çalışma nörolojik belirtileri olan çocukların BIA ile vücut kompozisyonunu değerlendirmeyi amaçlamaktadır.

**GEREÇ VE YÖNTEM:** Pediatrik nöroloji polikliniğine başvuran 406 çocuğun antropometrik ölçümleri ve vücut kompozisyonları incelendi ve tanıya göre cinsiyet ve gruplar karşılaştırıldı.

**BULGULAR:** Erkek çocuklar, kızlara göre daha düşük ağırlık, vücut yağ yüzdesi (%BF), yağ persantili, yağ kütlesi ve vücut kitle indeksi (BMI) değerleri gösterdi ancak toplam vücut su yüzdesi (%TBW) daha yüksek değerler gösterdi [ağırlık (p=0,015), %BF (p<0,001), yağ persantili (p=0,001), yağ kütlesi (p<0,001), BMI (p=0,006) ve %TBW (p<0,001)]. Ağırlık standart sapma skoru (SDS) ve boy SDS dışında gruplar arasında anlamlı farklılıklar saptandı (p<0,001).

**SONUÇ:** Ayaktan ayağa BIA ile vücut kompozisyonu değerlendirmesine dayanarak, pediyatrik popülasyondaki her nörolojik alt grubun belirli vücut kompozisyonunu gösterdiğini öne sürebiliriz. Vücut kompozisyonunun değerlendirilmesi de beslenme/hidrasyon durumu hakkındaki bilgilere katkıda bulunacaktır.

**ANAHTAR KELİMELER:** Vücut kompozisyonu, Ayaktan ayağa biyoelektrik empedans, Çocuklar, Nörolojik belirtiler.

**ABSTRACT**

**OBJECTIVE:** In clinical practice, the use of foot-foot bioelectrical impedance analysis (BIA) in the assessment of body composition continues to increase. Its preference is primarily defined by its portability, simplicity, speed, and reliability. The present study aimed to evaluate body composition by BIA among children with neurological manifestations.

**MATERIAL AND METHODS:** Anthropometric measurements and body composition of 406 children attending the pediatric neurology outpatient clinic were analyzed, and the gender and groups were compared based on the diagnosis.

**RESULTS:** Boys manifested lower values of weight, percentage body fat (%BF), fat percentile, fat mass, and Body mass index (BMI) but higher values of percentage total body water (%TBW) than girls [weight (p = 0.015), %BF (p<0.001), fat percentile (p = 0.001), fat mass (p<0.001), BMI (p = 0.006), and %TBW (p<0.001)]. Significant differences were determined among the groups except for weight standard deviation score (SDS) and height SDS (p<0.001).

**CONCLUSIONS:** Based on body composition evaluation by foot-to-foot BIA, We may suggest that each neurological subgroup within the pediatric population demonstrates a distinct body composition. Therefore, evaluation of body composition will contribute to obtaining information about nutritional/hydration status..

**KEYWORDS:** Body composition, Foot-to-foot bioelectrical impedance, Children, Neurological manifestation.

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**Etik Kurul / Ethical Committee:** İzmir Katip Çelebi Üniversitesi Etik Kurulu (06.02.2019/47).

## INTRODUCTION

Although assessment of nutritional status is the foundation and complement of the examination, pediatric nutritional screening may lag behind neurological assessment in clinical practice. In clinical practice, anthropometric parameters such as weight, height or skinfold thickness are frequently used to assess nutritional status (1). However, measurements are not sufficient for definitive evaluation (2). Bioelectrical impedance analysis (BIA) is now frequently approved alongside anthropometric measurements in the assessment of body composition (1, 3, 4). BIA facilitates the measurement of body impedance and provides distinct conductivities of multiple body parts (5). Traditional BIA provides accurate estimation of fat-free mass (FFM), total body water (TBW), percentage TBW (%TBW), percentage body fat (%BF), and body fat mass (FM) (1, 6). Currently, several studies have focused on these measurements with BIA in the pediatric population (2, 4, 7 - 9). The main purpose of this study was to compare measurements with foot-foot BIA in children with neurological findings.

## MATERIALS AND METHODS

The study included 406 children from 4 years to 17 years. The study subjects were recruited from the pediatric neurology outpatient clinic in Tepecik Education and Research Hospital. All patients were ambulatory and had no swallowing dysfunction. The patients were divided into eight main groups according to their complaints at presentation and neurological findings and their diagnoses: Headache, epilepsy, syncope, developmental delay (DD), vertigo, seizure, neuropathy and others (paresthesia, gait disturbance, tremor, etc.). Demographic data were recorded.

The Tanita SC-330 Body Composition Analyzer (®) was used to estimate each patient's body composition by foot-to-foot BIA. Gender, age, and height were entered into the Tanita machine. Moreover, the predicting value of clothing weight (0.4 kg) was calculated. Patients were asked to climb onto the device. Then, a printout that exhibited the body weight, %BF, fat percentile, FM, FFM, muscle mass, TBW, and %TBW was obtained. The body composition was calculated using the manufacturer's in-built equation. Body mass index (BMI) was calculated as weight (kg) divided by the square of height ($m^2$).

### Ethical Committee

The informed consent form was signed by all the patients. The approval of Izmir Katip Celebi University ethics committee was obtained (approval number: 06.02.2019/47).

### Statistical Analysis

The descriptive statistics were used as a number, percentage, mean±sd, and min & max. ANOVA and Tukey post hoc test was engaged in comparing the anthropometric measurements and body composition among the different groups. The other variables did not satisfy normal distribution and, therefore, the Kruskal-Wallis test was used. Comparisons of the groups were evaluated by the Mann-Whitney U test, and Bonferroni correction was conducted. The student's t-test was used for the value of VA standard deviation score (SDS) and BMI SDS, and the non-parametric Mann-Whitney U test was used for other values in the comparison of the gender. Analyses were performed using the Statistical Package for the Social Sciences (SPSS) software version 21.0 (SPSS Inc., Chicago, Ill., USA), and a p-value < .05 was considered statistically significant.

## RESULTS

The present study included 146 with headache, 83 with epilepsy, 51 with developmental delay (DD), 28 with seizure, 26 with syncope, 18 with neuropathy, 13 with vertigo, and 41 with other neurological manifestations in children. The mean age was found 11.40 ±3.63 years (girls: 12.03 ±3.49 years, n = 230; boys: 10.57 ±3.65 years, n = 176).

In the comparison of the gender, male participants exhibited remarkably lower values of weight (p = 0.015), %BF (p<0.001), fat percentile (p = 0.001), body FM (p<0.001), and BMI (p = 0.006). In contrast, female subjects were found to have a significantly lower value of %TBW (p<0.001) **(Table1)**. The differences were statistically significant between the groups for anthropometric measurements and body compositions except for weight SDS and Height SDS (p<0.001).

Furthermore, significant differences ($p<0.05$) were obtained when comparing the groups. Moreover, only significant differences between-group comparisons are discussed in **Table 2**.

**Table 1:** Comparison of body composition between gender by bioelectrical impedance analysis (BIA)

| Variables | Gender | mean±sd | min&max | z | p |
|---|---|---|---|---|---|
| Weight | Female | 44.78±16.83 | 14.00&101.00 | | |
| (kg) | Male | 40.88±17.63 | 12.00&93.10 | -2.427 | **0.015** |
| | Total | 43.09±17.27 | 12.00&101.00 | | |
| Weight SDS | Female | 0.00±1.53 | -4.80&4.80 | | |
| | Male | -0.04±1.30 | -2.88&3.86 | -0.282* | 0.778 |
| | Total | -0.02±1.43 | -4.80&4.80 | | |
| Height | Female | 149.00±15.90 | 105.00&174.00 | | |
| (cm) | Male | 146.31±21.05 | 98.00&188.00 | -1.403 | 0.161 |
| | Total | 147.83±18.34 | 98.00&188.00 | | |
| Height | Female | 0.11±1.35 | -8.60&3.53 | | |
| SDS | Male | 0.41±1.38 | -2.49&4.34 | -1.666 | 0.096 |
| | Total | 0.24±1.37 | -8.60&4.34 | | |
| %BF | Female | 21.25±9.49 | 3.00&47.40 | | |
| | Male | 14.74±6.63 | 3.00&35.30 | -7.546 | **<0.001** |
| | Total | 18.43±8.96 | 3.00&47.40 | | |
| Fat percentile | Female | 37.07±36.98 | 2.00&98.00 | | |
| | Male | 26.38±33.15 | 2.00&98.00 | -3.411 | **0.001** |
| | Total | 32.43±35.73 | 2.00&98.00 | | |
| Body FM | Female | 10.95±8.30 | 0.50&42.40 | | |
| (kg) | Male | 6.24±4.65 | 0.70&31.60 | -6.380 | **<0.001** |
| | Total | 8.90±7.32 | 0.50&42.40 | | |
| Muscle mass | Female | 32.19±9.45 | 11.70&55.70 | | |
| (kg) | Male | 32.80±13.88 | 9.60&64.80 | -0.234 | 0.815 |
| | Total | 32.46±11.57 | 9.60&64.80 | | |
| FFM | Female | 33.90±10.11 | 11.60&58.70 | | |
| (kg) | Male | 34.66±14.67 | 10.00&69.60 | -0.177 | 0.859 |
| | Total | 34.23±12.29 | 10.00&69.60 | | |
| TBW | Female | 24.92±7.27 | 9.10&43.00 | | |
| (kg) | Male | 25.38±10.72 | 7.50&50.90 | -0.260 | 0.795 |
| | Total | 25.11±8.92 | 7.50&50.90 | | |
| %TBW | Female | 57.90±7.62 | 38.60&86.00 | | |
| | Male | 62.27±4.92 | 47.40&71.00 | -7.072 | **<0.001** |
| | Total | 59.79±6.92 | 38.60&86.00 | | |
| BMI | Female | 19.43±4.78 | 11.10&34.30 | | |
| ($kg/m^2$) | Male | 18.04±3.95 | 11.60&32.60 | -2.831 | **0.005** |
| | Total | 18.82±4.49 | 11.10&34.30 | | |
| BMI SDS | Female | -0.19±1.59 | -6.00&3.37 | | |
| | Male | -0.44±1.41 | -3.78&2.86 | 1.653* | 0.099 |
| | Total | -0.30±1.52 | -6.00&3.37 | | |

* The student's t-test was used.

%BF: percentage body fat, BMI: Body mass index, DD: Developmental delay, FM: Fat mass, FFM: Fat-free mass, TBW: Total body water, sd: standard deviation, SDS: Standard deviation score.

**Table 2:** Body composition and comparison of the groups with neurological manifestations in children by bioelectrical impedance analysis (BIA)

| Variables | Groups | mean±sd | min&max | $X^2$ | p | group comparison |
|---|---|---|---|---|---|---|
| Weight | Headache | 49.37±17.07 | 15.40&101.00 | | | Headache-epilepsy |
| (kg) | Epilepsy | 45.97±15.93 | 14.80&85.00 | | | Headache-DD |
| | syncope | 42.30±14.81 | 19.70&74.00 | | | Headache-seizure |
| | DD | 33.35±16.18 | 12.00&81.00 | 50.066 | <0.001 | DD-neuropathy |
| | Vertigo | 47.49±12.04 | 31.20&68.80 | | | |
| | Seizure | 33.67±14.63 | 14.00&67.50 | | | |
| | Neuropathy | 47.51±15.82 | 17.60&71.40 | | | |
| | Others | 41.26±18.05 | 16.40&89.00 | | | |
| Weight SDS | Headache | 0.19±1.49 | -3.40&4.80 | | | |
| | Epilepsy | -0.10±1.44 | -3.38&3.14 | | | |
| | syncope | -0.29±0.93 | -1.86&1.88 | | | |
| | DD | -0.33±1.62 | -4.80&3.86 | 1.816* | 0.083 | |
| | Vertigo | 0.01±0.84 | -1.36&1.40 | | | |
| | Seizure | -0.56±1.28 | -3.81&1.57 | | | |
| | Neuropathy | 0.35±1.05 | -2.00&2.33 | | | |
| | Others | 0.16±1.49 | -2.71&3.88 | | | |
| Height | Headache | 153.39±15.59 | 110.00&188.00 | | | Headache-DD |
| (cm) | Epilepsy | 146.13±17.60 | 110.00&182.00 | | | Headache-seizure |
| | syncope | 152.00±17.49 | 117.00&179.00 | | | Syncope-DD |
| | DD | 135.73±19.07 | 98.00&186.00 | 44.143 | <0.001 | DD-vertigo |
| | Vertigo | 156.62±12.11 | 135.00&185.00 | | | |
| | Seizure | 140.71±19.14 | 105.00&173.00 | | | |
| | Neuropathy | 150.39±19.32 | 114.00&180.00 | | | |
| | Others | 144.88±20.09 | 100.00&180.00 | | | |
| Height | Headache | 0.21±1.14 | -2.76&3.59 | | | |
| SDS | Epilepsy | 0.19±1.69 | -8.60&3.53 | | | |
| | syncope | 0.44±0.69 | -1.17&1.81 | | | |
| | DD | 0.10±1.72 | -6.06&4.34 | 2.873 | 0.896 | |
| | Vertigo | 0.34±1.47 | -2.20&3.04 | | | |
| | Seizure | 0.46±1.14 | -1.69&3.00 | | | |
| | Neuropathy | 0.14±1.24 | -2.08&2.39 | | | |
| | Others | 0.32±1.46 | -2.46&3.79 | | | |
| Fat (%) | Headache | 21.54±9.60 | 3.00&47.40 | | | Headache-epilepsy |
| | Epilepsy | 16.38±8.46 | 3.00&41.20 | | | Headache-seizure |
| | syncope | 16.25±7.88 | 6.00&32.50 | | | Headache-DD |
| | DD | 17.21±8.47 | 7.10&42.90 | 44.719 | <0.001 | Seizure-neuropathy |
| | Vertigo | 17.62±5.80 | 8.60&30.20 | | | |
| | Seizure | 11.65±5.36 | 3.00&23.00 | | | |
| | Neuropathy | 21.17±7.93 | 6.50&33.00 | | | |
| | Others | 18,09±7.94 | 7.20&45.90 | | | |
| Fat | Headache | 43.31±37.59 | 2.00&98.00 | | | Headache-epilepsy |
| percentile | Epilepsy | 25.12±33.43 | 2.00&98.00 | | | Headache-seizure |
| | syncope | 23.19±31.40 | 2.00&95.00 | | | Seizure-neuropathy |
| | DD | 29.02±36.21 | 2.00&98.00 | 43.852 | <0.001 | |
| | Vertigo | 34.00±29.46 | 2.00&90.00 | | | |
| | Seizure | 6.89±11.08 | 2.00&50.00 | | | |
| | Neuropathy | 52.83±33.20 | 2.00&95.00 | | | |
| | Others | 26.59±33.93 | 2.00&98.00 | | | |
| Fat mass | Headache | 11.66±8.35 | 0.50&42.40 | | | Headache-epilepsy |
| | Epilepsy | 7.20±5.96 | 0.50&32.60 | | | Headache-DD |
| | syncope | 8.13±5.97 | 0.80&23.10 | | | Headache-seizure |
| | DD | 6.61±6.47 | 1.20&34.70 | 53.192 | <0.001 | Seizure-neuropathy |
| | Vertigo | 8.54±3.91 | 2.90&17.70 | | | |
| | Seizure | 5.24±6.18 | 0.70&32.70 | | | |
| | Neuropathy | 10.10±5.32 | 2.20&20.30 | | | |
| | Others | 8.02±7.05 | 1.80&40.90 | | | |

*F skorudur (Anova testi), only significant differences were shown between group comparison

DD: Developmental delay, sd: standard deviation, SDS: Standard deviation score.

Among the group comparisons, it was showed significant difference between headache-DD, headache-seizure, syncope-DD, DD-vertigo according to the height; headache-epilepsy, headache-seizure, headache-DD, seizure-neuropathy according to the %BF; headache-epilepsy, headache-seizure, seizure-neuropathy according to the fat percentile; headache-epilepsy, headache-DD, headache-seizure, seizure-neuropathy according to the body FM; headache-DD, headache-seizure, DD-vertigo according to the muscle mass; headache-DD, headache-seizure, DD-vertigo, DD-neuropathy according to the FFM; headache-DD, headache-seizure, DD-vertigo according to the TBW; headache-epilepsy, headache-seizure, headache-syncope, headache-DD, seizure-neuropathy according to the %TBW; headache-epilepsy, headache-DD, headache-seizure, DD-neuropathy, seizure-neuropathy according to the BMI; seizure-headache, seizure-neuropathy, seizure-others according to the BMI SDS ($p<0.001$).

## DISCUSSION

This study aimed to evaluate body composition parameters related to various neurological findings in children. As expected, remarkable differences were highlighted between groups and the gender. Various aspects in the particular sample highlight the nutritional status.

Previous studies with foot-to-foot BIA in children revealed different results. In a large cohort of 203 healthy children (mean age 8.9 years), no significant difference in weight and height was reported; however, BMI was lower in boys than girls ($p = 0.03$) (5). Moreover, we found that weight and BMI were lower in boys, respectively ($p = 0.015$, $p = 0.05$). It may be explained the collection of different groups with neurological manifestations in the study. Furthermore, most of the patients among the groups complained of a headache, and also, the group with the highest weight and BMI comprised of the patients with headache. Childhood obesity suggested the cause of pathology is excess fat mass. Percentage body fat (%BF) is an indirect parameter to assess adipose tissue and is accepted as superior to BMI in many studies. Moreover, BMI fails to distinguish body FM from other tissue forms (10, 11). In a study encompassing 5850 students (9–17.9 years), boys had higher BMI values than girls but lower %BF by BIA (12). Hosking et al. reported body FM and %BF estimated by BIA were higher in girls as compared to boys in their study, respectively (p = 0.001, p<0.001) (5). In accordance with that, González-Ruíz et al. reported boys had a lower measurement of %BF than girls in the children and adolescents with an excess of adiposity (p<0.001) (11). On the other hand, various conditions like nutritional status, medical treatment, underlying diseases, and physical activity affect the TBW. Furthermore, TBW reflects body hydration status (13). Golec et al. reported a higher TBW and FFM among the male participants than the females; however, girls demonstrated a higher body FM and %BF (p<0.001) (14). In the present study, we found that boys had a higher TBW but a lower weight, %BF, fat percentile, body FM, and BMI than girls. The gender difference can be contributed by several factors. González-Jiménez et al. proposed that higher values %BF could be attributed to sexual maturation, socioeconomic level, dietary patterns, physical activity levels, neurohormonal factors, or ethnic factors (15).

When the groups were compared, significant differences were observed. While the average weight and BMI were the highest in the headache group, the lowest values were seen in the DD and seizure group. In a study on headaches, Hershey et al. found a relationship between obesity and headaches (16). In another study, Ravid suggested that the interpretation of weight measurement and BMI calculation attributed to obesity affecting migraine in children (17). While the lowest weight was found in the group of DD, the groups of seizure and DD revealed lower BMI values as compared to the other groups in the present study. It can be explained children with DD suffer from malnutrition and feeding difficulties. Malone et al. reported 48.6% nutritional risk and identified 7.7% of children as underweight (18). Moreover, the age distribution among the groups could affect the mean weight. On the other hand, the use of various antiepileptic drugs for epilepsy may be responsible for the main difference in BMI values between the epilepsy and seizure groups. Although no difference was found between the groups in terms of height SD, the highest values in mean height were found in vertigo, syncope, and headache groups. As predicted, the lowest height was determined in the DD group. According to the body FM, fat percentile, and %BF, groups with headache and neuropathy had the highest values between the comparisons. As is known, overweight and obesity can be explained by the accumulation of excess fat in the body (11). Childhood obesity and overweight are risk factors for metabolic and cardiovascular disorders and are also associated with primary headaches in children (11, 19). Several studies have specifically supported %BF for assessing body fat (8, 12). We can also suggest the association of excess body fat with headache in accordance with the literature. One of the remarkable measurements of BIA is FFM, which is presumed to include conducting electrolytes of nearly all body. Various outcomes about the water ingredient of FFM have been documented (20, 21). Bray et al. suggested a higher FFM hydration situation in children with excess FM rather than children with lower body fat (22). Leone et al. also reported that excess body fat is associated with being more hydrated than lower body fat (23). Furthermore, a significant correlation between FM and all body muscle mass has been proposed (24). However, the present study highlighted the higher values of FFM and muscle mass in the vertigo and headache group, while the lower values were determined in the DD group. Therefore, we can suggest that the results between muscle mass and FFM are more similar than in group comparisons. As mentioned before, TBW exhibits individual hydration status, too. We found TBW values higher in vertigo and lower in DD among the groups. However, the values in %TBW were found to be quite close among the groups. However, seizures and syncope revealed higher values of %TBW, while headache revealed lower values. The various outcomes may be explained by multiple factors, including nutritional/hydration status, medical treatment, underlying diseases, and physical activity.

In summary, BIA provides beneficial knowledge about body composition in addition to anthropometric measurements. In the present study, lower values of weight, %BF, fat percentile, body FM, and BMI, whereas higher values of %TBW were observed in the boys than girls. Although many distinct outcomes between-group comparisons were detected, there was no difference according to weight SDS and Height SDS. It may be explained that each group with specific neurological findings includes its own unique body composition so that the consequences by BIA will help to interpret nutritional/hydration status. Therefore, further studies could characterize the body composition of each particular group with neurological manifestations in children.

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