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# Assessment of body composition with bioelectrical impadence analysis in thalassemia major patients

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**ABSTRACT**

Beta thalassemias are the most common autosomal recessive disorders characterized by anomalies in the synthesis of the beta chains of hemoglobin and are often associated with varying degrees of growth and developmental retardation. In this study, we determined the body fat mass (FM), fat-free mass (FFM), muscle mass (MM), total body water (TBW), extracellular water (ECW), intracellular water (ICW) and body mass index (BMI) by bioelectrical impedance analysis (BIA) in thalassaemia major patients. The body composition and growth conditions of thalassaemia major patients were assessed. A total of 43 patients (22 women and 21 men) with thalassaemia major age of 4-36 years and 26 age- and sex-matched healthy control subjects were included in the study. Height and weight measurements were performed by SECA (Model 767; Germany) and BIA measurements were made by In Body 720. Differences in the height, weight, waist circumference, FFM, MM, TBW, and ICW parameters were also significant ($p<0.05$). No significance in the abdominal circumference, chest circumference, BMI, FM and ECW parameters ($p>0.05$) were noted. Our study indicated that body composition is different in thalassaemia major patients when compared with healthy subjects. Bioelectrical impedance analysis is an easy, non-invasive, relatively inexpensive, safe, reproducible and effective evaluation method of the body composition that can be conducted in clinics.



## 1. Introduction

Thalassaemia belongs to a heterogeneous group of diseases that is characterized by the absence or reduction in β-globin chain synthesis (Cao and Galanello, 2010). Thalassaemia major is the most severe form of thalassaemia; the patients with this disease have homozygotes or compound heterozygotes for beta$^0$ or beta$^+$ genesals have severe and progressive haemolytic anaemia (Brancaleoni et al., 2016) The treatment of this disease requires blood transfusions at regular intervals in order to prevent heart failure, which is associated with severe anaemia. In such cases, patient survival depends on the blood transfusions subsequent to the diagnosis that is performed at every 2$^{nd}$ or 3$^{rd}$ week over a lifetime, with the introduction of iron-binding treatment. Adolescent children who do not receive proper treatment develop several endocrine issues due to accumulation of iron (Oliver, 1999; Galanello and Origa, 2010).

Growth retardation in patients with thalassaemia major is multifactorial; it is accompanied by undernutrition, hypogonadism, hypothyroidism and other complications of thalassaemia such as the tissue hypoxia and side effects of chelating therapy with

desferrioxamine (Cappellini et al., 2000; Weatherall, 2001; Quirolo and Vichinsky, 2004).The role of general malnutrition as a cause of growth abnormalities has not yet been determined (Ertuğrul, 2002). One of the malnutrition detection methods includes the bioelectrical impedance analysis (BIA). BIA is an easy, non-invasive, relatively inexpensive, safe, and reproducible method. BIA allows determination of the body fat mass (FM), fat-free mass (FFM), muscle mass (MM), total body water (TBW), extracellular water (ECW), intracellular water (ICW) and body mass index (BMI) (Kyle et al., 2004a; Kyle et al., 2004b). In the current study, the body FM, FFM, MM, TBW, ECW, ICW, and BMI were determined by BIA in thalassaemia major patients. The patient's body composition and growth conditions were also assessed.

## 2. Materials and methods

The study protocol was approved by the Human Ethics Committee of Adnan Menderes University and by the Ministry of Health.

The thalassaemic group was 43 β-thalassaemia major patients (22 females and 21 males) their ages were ranging between 4-36 years; from the Paediatrics and Haematology Clinics of State Hospitals at Aydin, Turkey. All thalassemic patients were provided regular transfusion therapy and the necessary medical treatment during the first 6 month to 1 year of life. The control group were 26 subjects (12 females and 14 males); the two groups were matched in age, ethnicity, and social background. All participants or their parents/guardians were informed about the study and they signed informed consent complying with the regulations of the Ethical Committee.

Height and weight measurements were performed by using the SECA (Model 767; Germany). Circumference were measured at 3 sites (chest, abdomen and waist) using an inelastic tape measure by an investigator. All participant or their parents were informed about the BIA order to minimize errors. BIA was performed for the determination of body composition by using In Body 720. Each patient was asked to undress, except for their undergarments, and placed in an upright position on the body composition analyzer. All jewellery and wrist watches were removed before the analyzer started recording. Person-related data (age, sex, height) was included in the device. In Body 720 uses the segmental BIA method to examine the body as five cylinders (four limbs and a trunk) and measures impedance in these parts separately. It also uses electrical current at multi-frequency (5, 50, 250, 500 and 1000 kHz) in order to directly measure the amount of body FM, FFM, MM, TBW, ECW, ICW and BMI.

Statistical analyses were performed using the SPSS version 14.0. The Kolmogorov-Smirnov test was used to assess the normality of numeric variables. For the numeric variables that were normally distributed, comparison between two groups was made by the independent sample t test and results were given as mean±standard deviation. For the non-normally distributed variables, comparison between two groups was made by the Mann-Whitney U test and results were given median (25-75 percentiles). Significance was defined as $p<0.05$.

## 3. Results

Height, weight, abdominal circumference, chest circumference, waist circumference, BMI, FFM,FM, TBW, ECW and ICW values for patients with thalassaemia major, respectively, were 159.85(139.25-172.77) m, 51.5(32.7-65.1) kg, 73.5(66.75-81.0)cm, 73.13±15.06 cm, 67.38±12.90 cm, 19.45±4.22 kg/m$^2$, 28.80±13.58 kg, 10.75(6.7-17.7) kg, 15.88±7.16 kg, 21.65±9.47 L, 15.8(14.0-26.8) L, 10.54 (8.6-15.9) L (Table 1).

Differences in the height, weight, waist circumference, FFM, MM, TBW, and ICW parameters were also significant ($p<0.05$). No significance in terms

**Table 1**. Definitive statistics of the patient group

| Measurements | Mean±SD or Median (25-75 percentiles) | Min | Max |
|---|---|---|---|
| Height (m) | 159.85 (139.25-172.77) | 88.0 | 177.0 |
| Weight (kg) | 51.5 (32.7-65.1) | 13.0 | 80.0 |
| Abdominal circumference (cm) | 73.5 (66.75-81.0) | 46.0 | 95.0 |
| Chest circumference (cm) | 73.13±15.06 | 45.0 | 100.0 |
| Waist circumference (cm) | 67.38±12.90 | 45.0 | 98.0 |
| Body mass index (BMI) (kg/m$^2$) | 19.45±4.22 | 13.5 | 30.2 |
| Fat free mass(FFM) (kg) | 28.80±13.58 | 8.4 | 60.5 |
| Fat mass (FM) (kg) | 10.75 (6,7-17.7) | 1.8 | 33.6 |
| Muscle mass (kg) | 15.88±7.16 | 4.5 | 33.5 |
| Total body water (TBW) (L) | 21.65±9.47 | 6.2 | 44.4 |
| Intracellular water (ICW) (L) | 15.8 (14.0-26.8) | 2.7 | 24.9 |
| Extrecellular water (ECW) (L) | 10.54 (8.6-15.9) | 3.2 | 41.7 |

**BMI:** Body mass index; **FFM:** Fat free mass; **FM:** Fat mass; **MM:** Muscle mass; **TBW:** Total body water; **ICW:** Intra cellular water; **ECW:** Extra cellular water

**Table 2**. Comparison of measurements between the patients and the control group

| Measurements | Patient | Control | *p* |
|---|---|---|---|
| Height (m) | 145 (121-159) | 159.85 (139.25-172.77) | 0.009 |
| Weight (kg) | 43.5 (23-54) | 51.5 (32.7-65.12) | 0.021 |
| Abdominal Circumference (cm) | 69 (57-81) | 73.5 (66.75-81) | 0.313 |
| Chest Circumference (cm) | 73.13±15.06 | 79.94±14.72 | 0.071 |
| Waist Circumference (cm) | 67.38±12.90 | 76.5±13.77 | 0.007 |
| Body Mass Index (BMI) (kg/m$^2$) | 19.45±4.22 | 20.64±5.01 | 0.294 |
| Fat Free Mass (FFM) (kg) | 28.80±13.58 | 39.22±17.48 | 0.007 |
| Fat Mass (FM) (kg) | 7.5 (5.3-15.2) | 10.75 (6.7-17.72) | 0.086 |
| Muscle Mass (kg) | 15.88±7.16 | 22.11±9.93 | 0.004 |
| Total Body Water (TBW) (L) | 21.65±9.47 | 29.58±12.34 | 0.004 |
| Intracellular Water (ICW) (L) | 12.4 (6.4-15.8) | 15.8 (14.02-26.8) | 0.001 |
| Extrecellular Water (ECW) (L) | 10.1 (6-12.1) | 10.45 (8.67-15.95) | 0.156 |

**BMI:** Body mass index; **FFM:** Fat free mass; **FM:** Fat mass; **MM:** Muscle mass; **TBW:** Total body water; **ICW:** Intra cellular water; **ECW:** Extra cellular water

of the abdominal circumference, chest circumference, BMI, FM and ECW parameters were noted (p>0.05, Table 2). Statistically significant difference in the ICW values were noted between control patients and female thalassaemia major patients (p<0.05). No significant differences were noted in the values of other parameters (p>0.05, Table 3). All measurements showed statistically significant difference between the control and male patients with thalassaemia major (p<0.05, Table 4).

In the present study study, the parameters such as height, weight, abdominal circumference, waist circumference, chest circumference, BMI, FM, FFM, MM, TBW, ICW and ECW were determined between the control group and thalassaemia major patients. No significant differences were noted in parameters such as abdominal circumference, chest circumference, BMI, FM and ECW between thalassaemia major patients and control (p>0.05).

**Table 3**. Comparison of measurements between the female patients and the control group

| Measurements | Patient | Control | *p* |
|---|---|---|---|
| Height (m) | 138.0 (117.3-158.0) | 155.7 (136.25-159.92) | 0.171 |
| Weight (kg) | 43.0 (21.9-55.8) | 46.25 (32-51.75) | 0.759 |
| Abdominal circumference (cm) | 71.0 (56.8-82.3) | 70.5 (59-78.5) | 0.516 |
| Chest circumference (cm) | 79.5 (58.0-88.5) | 79.5 (62.5-84.5) | 0.745 |
| Waist circumference (cm) | 67.4±13.39 | 70.25±9.4 | 0.520 |
| Body mass index (BMI) (kg/m$^2$) | 20.35±4.69 | 19.15±3.36 | 0.444 |
| Fat free mass(FFM) (kg) | 14.65 (6.1-21.3) | 12.1 (7.92-16.72) | 0.871 |
| Fat mass (FM) (kg) | 26.65 (14.6-36.5) | 33.45 (22.67-35.4) | 0.377 |
| Muscle mass (kg) | 16.1 (8.7-20.7) | 17.8 (14.4-18.92) | 0.304 |
| Total body water (TBW) (L) | 21.2 (11.1-27.4) | 24.5 (19.95-26.17) | 0.377 |
| Intracellular water (ICW) (L) | 11.9 (5.8-15.1) | 15.2 (12.9-15.95) | 0.043* |
| Extrecellular water (ECW) (L) | 9.01±3.6 | 8.72±9.01 | 0.803 |

**BMI:** Body mass index; **FFM:** Fat free mass; **FM:** Fat mass; **MM:** Muscle mass; **TBW:** Total body water; **ICW:** Intra cellular water; **ECW:** Extra cellular water

## 4. Discussion

Development of different disciplines of medical clinical sciences and of different and effective methods for the evaluation of body compositions is important toward contributing to important decision-making in health (Utter et al., 1999; Guida et al., 2004). BIA is frequently used to consider the body compositions of patients in clinic as it is safe, indirect, relatively inexpensive and an effective method of evaluation (Kyle et al., 2004b; Kaya and Özçelik, 2009; Karakaş et al., 2012).

BMI [measured by dividing the length dimension (m$^2$) by the body weight] is an effective indicator for the assessment of nutrition and growth in different age groups (Eto et al., 2004; Yılmaz et al., 2012).

In their study, Asadı-Pooya and Karamıfar (2004) calculated the BMI (weight/height$^2$) in individuals of different ages (<18 years) and compared the results with those of children and adolescents with standard curves. When the BMI is <10%, the ratio in children aged <10 years is 12.4% and the ratio in children aged >10 years is 46.5% (p<0.000001). The reasons of BMI reduction in children aged >10 years can be multiple

**Table 4**. Comparison of measurements between the male patients and the control group

| Measurements | Patient | Control | *p* |
|---|---|---|---|
| Height (m) | 145.0( 121.5-162.0) | 171.05 (140-178.2) | 0.016 |
| Weight (kg) | 43.5 (23.5-49.5) | 63.4 (32.7-80.4) | 0.007 |
| Abdominal circumference (cm) | 68.19±13.32 | 79.14±17.02 | 0.041 |
| Chest circumference (cm) | 71.42±13.62 | 83.6±16.28 | 0.023 |
| Waist circumference (cm) | 67.35±12.70 | 81.85±14.94 | 0.004 |
| Body mass index (BMI) (kg/m$^2$) | 18.51±3.52 | 21.92±5.92 | 0.040 |
| Fat free mass (FFM) (kg) | 6.0(4.2-8.8) | 7.95 (5.87-19.92) | 0.049 |
| Fat mass (FM) (kg) | 32.17±15.37 | 47.51±19.03 | 0.013 |
| Muscle mass (kg) | 17.19±7.81 | 26.94±10.98 | 0.004 |
| Total body water (TBW) (L) | 23.57±10.57 | 35.79±13.09 | 0.005 |
| Intracellular water (ICW) (L) | 13.17±5.79 | 22.06±8.62 | 0.001 |
| Extrecellular water (ECW) (L) | 11.0(6.05-12.2) | 14.6 (9.1-17.62) | 0.024 |

**BMI:** Body mass index; **FFM:** Fat free mass; **FM:** Fat mass; **MM:** Muscle mass; **TBW:** Total body water; **ICW:** Intra cellular water; **ECW:** Extra cellular water

endocrine disorders and nutritional differences. Owing to these reasons, the authors emphasized that growth monitoring is essential at regular intervals and that reduction in BMI should be treated (Asadi-Pooya and Karamifar, 2004). In our study, no significant differences in the BMI of patients and healthy control were noted. The patients included in this study were treated regularly, which is probably the reason for normal BMI in our patients. Patient survival depends on the blood transfusions subsequent to the diagnosis and performed at every 2$^{nd}$ or 3$^{rd}$ week for a lifetime, and the iron binding treatment is introduced approx. at 2-2.5 years of age. Sert et al. reported that thalassaemia major patients with a mean age of 9.56±5.59years had a BMI of 16.4±2.3 kg/m$^2$ (Sert et al, 2009). According to Patıroğlu et al. (2010) thalassemic patients aged 6 and 22-24 years, BMI value was 17.8±2.1kg/m$^2$. Cece et al. (2012) reported that for 50 children with thalassaemia β major from the Harran University School of Medicine with a mean age of 7.2±5.3, BMI was 16.9±2.1 kg/m$^2$. Nasr et al. (2012) reported BMI of 16.3±2 kg/m$^2$ in 33 children with thalassaemia β major with a mean age of 10.2±3.3 years. In our study, patients with thalassaemia major showed BMI values of 19.45±4.22 kg/m$^2$. On comparing these results with those of recent studies, BMI was found to be higher in our study. This difference could be attributed to the high average age of the patients in the study group (mean age=18.62±8.60 years) (Nasr et al, 2012). Acar et al. (2012) reported BMI of 22 thalassaemia β major patients (mean age=25±8 years) as 22±2.0 kg/m$^2$. Shahramian et al. (2015) reported that for 70 children (the mean age of participants was 13.75± 5.91, 12.63±1.12 for boys and 14.70±0.88 for girls). BMI were 17.41±2.39 (age<5), 15.1±1.89 (5< age< 10), 16.88±2.37 (age≥10). Our results are true under the consideration that weight and height parameters increases with age.

Kalef-Ezra et al. (2000) measured the BMI of 45 patients with homozygous β thalassaemia (mean age=18-30) at the Department of Medical Physics, Medical School, University of Ioannina, by bioelectrical impedance spectroscopy (BIS) method and found that only male patients had lower values in comparison with controls in male and female patients. TBW, ECW and ICW concentrations were lower and, lower concentration of ICW, showed lower TBW concentration (TBV/M). These results supports our results.

According to the study by Fung et al. (2010) the author considered fat, FFM and bone mineral density (BMD) by Dual Energy X-ray Absoptiometry (DEXA) at 257 transfused thalassaemia patients (23.7±11 years) and 113 transfusion non-patients (21.3±13 years). According to the data 1999-2000 NHANNES, the average population of adult patients with thalassaemia were weaker as compared to the American population and thalassemic subjects had significantly lower fat content.

The participants' height and average weight were lower than expected because of the wide age range. In comparison with the healthy subjects, patients with thalassaemia had reduced amount of ICW and TBW, indicating that body water imbalance has occurred. Lower values of MM and lean tissue mass points malnutrition and the normal values of body fat and BMI in the thalassaemia patients in this study suggested that this treatment method had a better prognosis.Body composition evaluation by the BIA method could contribute to the determination of malnutrition in thalassaemia major patients at the early stages.Bioelectrical impedance analysis is an easy, non-invasive, relatively inexpensive, safe, reproducible and effective evaluation method of the body composition that can be conducted in clinics.

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