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RESEARCH

Analysis of somatotype on liver, spleen and kidney morphology in healthy children: an ultrasonographic anatomy study

Sağlıklı çocuklarda somatotipin karaciğer, dalak ve böbrek morfolojisi üzerindeki etkisinin analizi: bir ultrasonografik anatomi çalışması

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Abstract

Purpose: Somatotype is a quantitative expression of an individual's current morphological configuration and consists of three classifications: mesomorphy, endomorphy and ectomorphy. This study aimed to examine the relationship between somatotype and liver, spleen, and kidney morphometry in healthy children utilizing ultrasonographic (USG) methods.
Materials and Methods: One hundred healthy children between the ages of 7 and 10 participated in the study. The sizes of liver, spleen and kidney were measured using USG. The children's somatotypes were determined according to the Heath-Carter method by taking 10 anthropometric measurements.
Results: As a result of the measurements, it was determined that the highest value of liver length was 11.9 cm (9.9-13.6) in Mesomorph Endomorph somatotype and the smallest value was 10.9 (9-12.3) in central somatotype. The highest value of right kidney vertical length was 32 mm (25-45) in Mesomorph Endomorph somatotype and the lowest value was 29 mm (25-34) in central somatotype. According to the results of the Kruskall Wallis H test analysis, there was a statistically significant difference between liver length and right kidney vertical length measurements and somatotypes ($p<0.05$). Post-hoc analysis indicated that this difference was due to the central and mesomorph-endomorph somatotypes.
Conclusion: In conclusion, we believe that our results should be taken into consideration for clinical diagnoses. Additionally, we suggest that taking our measurement

Öz

Amaç: Somatotip, bireyin mevcut morfolojik durumunun nicel bir ifadesidir ve mezomorfi, endomorfi ve ektomorfi olmak üzere üç derecelendirmeden oluşur. Bu çalışmanın amacı sağlıklı çocuklarda somatotipin karaciğer, dalak ve böbrek morfometrisi ile ilişkisini ultrasonografik (USG) yöntem kullanarak incelemektir.
Yöntem: Çalışmaya yaşları 7 ile 10 arasında değişen 100 sağlıklı çocuk katıldı. Çalışmaya dahil edilen çocuklarda USG ile karaciğer, dalak ve böbrek boyutları ölçüldü. Çocukların somatotipleri 10 antropometrik ölçüm alınarak Heath-Carter yöntemine göre belirlendi.
Bulgular: Yapılan ölçüm sonucunda karaciğer uzunluğunun en yüksek değerinin 11.9 cm (9.9-13.6) ile mesomorph endomorph somatotipinde, en küçük değerinin 10.9 (9-12.3) ile santral somatotipinde olduğu belirlendi. Sağ böbrek vertikal uzunluğunun, en yüksek değerinin 32 mm (25-45) ile ile mesomorph endomorph somatotipinde, en küçük değerinin 29 mm (25-34) ile santral somatotipinde olduğu belirlendi. Yapılan Kruskall Wallis H testi analiz sonucuna göre karaciğer uzunluğu ve sağ böbrek vertical uzunluk ölçümleri ile somatotipler arasında istatistiksel olarak anlamlı fark bulundu ($p<0.05$). Yapılan Post-Hoc analizi sonucuna göre bu farkın santral ve mezomorf-endomorf somatotiplerinden kaynaklandığı belirlendi.
Sonuç: Sonuç olarak klinikte tanı konulurken bulduğumuz sonuçların dikkate alınması gerektiğini düşünmekteyiz. Ayrıca abdominal ultrason çekimlerinde ölçüm sonuçlarımızın göz önünde bulundurulmasının doğru bir

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results into consideration in abdominal ultrasound scans is necessary for an accurate evaluation. We think that clinicians evaluating the pathologies of diseases related to the organs we measured should not forget the size changes according to the somatotype results.
Keywords:. Somatotype in children, liver, spleen, kidney, ultrasonography

değerlendirme için gerekli olduğu kanaatindeyiz. Ölçüm yaptığımız organlarla ilgili hastalıkların patolojilerini değerlendiren klinisyenlerin somatotip sonuçlarına göre boyut değişimlerini unutmaması gerektiğini düşünmekteyiz.
Anahtar kelimeler: Çocuklarda somatotip, karaciğer, dalak, böbrek, ultrasonografi

INTRODUCTION

Knowing the normal sizes of the liver, spleen, and kidneys is important not only for radiologists but also for clinicians who evaluate these organs from a pathological perspective. This is especially significant in the pediatric age group, as organ size increases with age. It has been shown that organ sizes change under pathological conditions: some diseases cause an increase in size, while others lead to a decrease, and the direction of this change in organ size can be used to predict the prognosis of certain diseases[1]. Many studies have shown that the size and/or measurements of the liver, spleen, and kidneys are influenced by various factors such as age, ethnicity, race, gender, weight, and height. It is estimated that there is at least a tenfold increase in liver mass from birth to adulthood. Hepatomegaly is a common clinical finding in children and may result from intrinsic liver diseases or systemic changes. In cases of clinical suspicion, ultrasonography (US) is often the preferred method for examining pediatric patients[2].

The measurement of these structures has increased the need for body composition analysis tools that account for fat mass, bone mass and muscle mass, such as somatotype. Somatotype is a quantitative expression of the individual's current morphological configuration. It consists of three components: mesomorphy, endomorphy and ectomorphy. These components correspond to the three primary germ cell layers, which lead to specific tissue clusters that define body composition[3]. Mesomorphy refers to the musculoskeletal structures of the body; endomorphy refers to the degree of adipose in the body, regardless of the region of adipose; and ectomorphy refers to the apparent linearity or fragility of limbs in the absence of any mass such as muscle, fat or other tissues[4,5].

Changes occur in morphological structures of organs in many diseases. Accurate evaluation of kidney, spleen and liver morphology is particularly crucial for the success of clinical diagnosis and treatment. Various imaging devices assist in the diagnosis and confirmation of changes related to these structures. Ultrasonography (USG) is commonly used, especially in children, due to its speed, safety, and portability[6]. The literature shows that organs have been examined using different imaging techniques based on age groups and gender. However, normative indicators related to the size of internal organs used in the diagnosis of USG are evaluated without considering the somatometric characteristics of the individual. Evaluating organ pathology in terms of somatotype characteristics is important, as it provides insights about what kind of change the disease causes in the structures of organs in individuals[7].

In this study, we aimed to compare the liver, spleen, and kidney measurements of primary school children using ultrasonography and somatotype analysis, a detailed method for determining body composition. Additionally, children were referred to the relevant department in case of any pathological condition observed in their organs. We aimed to examine the effect of the children's body composition on organ morphometry.

MATERIALS AND METHODS

Sample

The study was conducted on 100 healthy children between the ages of 7 and 10 who were referred to the radiology department of the state hospital due to various reasons between 2020 and 2021. Liver, spleen and kidney measurements were performed using ultrasonography (USG) on the children included in the study.

Power analysis was performed using the G*Power (v3.1.7) prior to the start of the study to determine the sample size. Based on the analysis, it was calculated that at least 14 children should be included in each group for 1 unit change in radiologic measurements taken from children with different somatotypes in order to obtain 80% power at $\alpha=0.05$ level.

To exclude hematological, infectious, malignant, congestive and chronic diseases that may affect organ size, a detailed medical history, including blood tests in the past 6 months, was obtained through the hospital system. Clinical exclusion criteria included: refusal to participate; jaundice; fever (T > 37.5 C); significant lymphadenopathy; limb deformity; chest wall deformity; and known liver, spleen, kidney, or systemic diseases. Imaging exclusion criteria included: liver, spleen, and kidney parenchymal mass lesions; abnormal parenchymal echostructure and echogenicity; liver, spleen, and kidney cysts; accessory spleens; and hydronephrosis.

Procedure

The study was initiated following the approval of the Malatya Turgut Özal University Clinical Research Ethics Committee, dated 30.12.2021 and numbered 2021/117. The study began in a primary school in Malatya province after the children's families signed a consent form. Personal information of the participants and study data were collected in accordance with the Declaration of Helsinki. Informed consent was obtained from the parents of all children participating in the study. Ultrasound imaging was performed by a radiologist with 15 years of experience.

After the children's families were informed about the study, they completed their consent forms. Sociodemographic information for each child was recorded on a patient information form.

The heights of the patients were measured in centimeters using a precision steel stadiometer on barefoot, and their ages were recored in years. The Tanita BC Segmental Body Analysis System (Tanita Corporation, Tokyo, Japan) was used to assess body weight in kilograms while the subjects stood barefoot and free of any metal accessories. BMI was calculated using the formula: weight (kg) divided by height squared (m^2)[8].

Data collection process

USG measurements

USG examination was performed with 5 MHz convex probe of Mindray DC-8 Exp. Liver size is routinely measured through longitudinal assessment at the midclavicular, particularly of the right lobe of the liver[9-11]. In this study, liver size was measured in the supine position using this method (Figure 1).

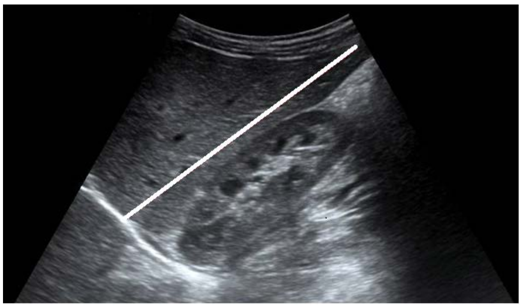

Figure 1. The measurement of liver length at the right midclavicular line in the longitudinal view.

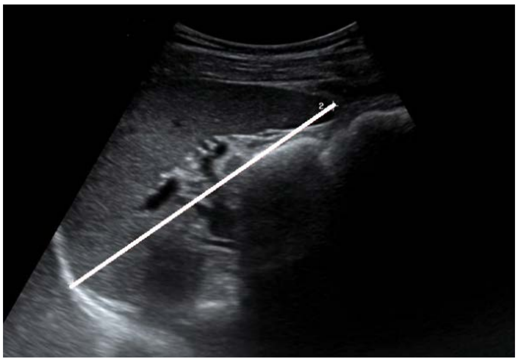

Figure 2. The measurement of spleen length is the greatest dimension -at the hilum- on the longitudinal coronal view, between the most superomedial and the most inferolateral points.

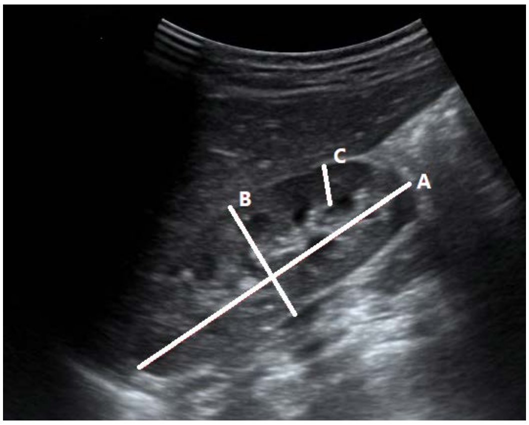

Figure 3. The measurement of kidney maximum vertical dimension (A), transverse dimension (B), and parenchymal thickness (C).

The spleen was measured longitudinally in the supine position. The measurement was taken between the most superomedial and the most inferolateral edges in the plane where the splenic hilum was visualized

(Figure 2). Both kidney were measured in the supine or mildly right/left decubitus positions. Maximum vertical and transverse measurements of both kidneys and parenchymal thickness were assessed in sagittal planes passing through the renal hilum (Figure 3).

To ensure measurement accuracy and consistency, attention was paid to confirm that all evaluated organs were in their anatomically normal positions and exhibited typical morphological features. In addition, all ultrasonographic examinations were conducted by a single experienced radiologist, thereby enhancing the methodological reliability and minimizing interobserver variability.

Somatotype determination

To determine somatotype, ten anthropometric measurements were taken from the volunteers who participated in the study. Length and weight were measured with a precision digital device. Skinfold thickness (SFT) measurements from four different regions (triceps, subscapular, supraspinale, and calf) were taken using skinfold caliper; bone diameter measurements from two regions (knee and elbow width) and circumference measurements from two different regions (contracted arm and calf) were taken usinga tape measure. Somatotypes were calculated using the Heath-Carter method[12].

Statistical analysis

The Kolmogorov Smirnov test was used to assess the normality of the data distribution, and the results showed that the data were not normally distributed. The median, minimum (min), and maximum (max) values of the data were reported. The characteristics of several somatotypes were compared using the Kruskall Wallis H test. To ascertain which group was responsible for the difference in parameters between the somatotypes, pairwise comparisons were performed using the Post-Hoc Mann- Whitney U test. The Model Viewer table was used for the post-hoc test. Values of $p<0.05$ were considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics 22.0 for Windows.

RESULTS

One hundred children with four different somatotypes were included in the study. Measurements were taken from 25 mesomorphic ectomorph children with a median age of 10 years, 33 endomorphic mesomorph children with a median age of 9 years, 25 mesomorphic endomorph children with a median age of 10 years, and 17 central-type children with a median age of 10 years.

The median (min-max) values of the variables used in the calculation of age and somatotype, along with the Kruskall Wallis H test analysis results, are presented in Table 1. According to the analysis results, a statistically significant difference was found among all variables except age across somatotypes ($p<0.05$) (Table 1).

Table 1. Median (min-max) values of somatotype variables and analysis results

Parameter	Mesomorphic ectomorph(n=25)	Endomorphic Mesomorph (n=33)	Mesomorph Endomorph (n=25)	Central (n=17)	p
Age (years)	10 (7-10)	9 (7-10)	10 (8-10)	10 (7-10)	.133
Length (cm)	137 (120-152)	130 (113-147)	138 (124-150)	131 (120-156)	.000
Weight (kg)	28 (18-52)	30 (20-54)	37 (22-57)	25 (19-41)	.004
Triceps SFT (mm)	14 (7-30)	21 (9-42)	21 (10-33)	14 (10-25)	.005
Subscapular SFT (mm)	11 (7-28)	12 (6-32)	15 (9-24)	10 (6-18)	.000
SuprailiacSFT(mm)	11 (6-35)	15 (7-31)	18 (10-39)	10 (6-25)	.000
Calf SFT (mm)	18 (10-25)	18 (8-42)	20 (15-28)	16 (8-22)	.004
Contracted arm circumference (cm)	22 (18-26)	23 (18-31)	23 (20-30)	20 (18-24)	.000
Calf circumference (cm)	28 (24-36)	30 (24-38)	31 (26-39)	27 (15-32)	.006
Elbow width (cm)	6.7 (5.9-8.2)	7.1 (5.6-9)	7.3 (6.1-8.5)	6.8 (5.8-7.5)	.005
Knee width (cm)	8.1 (6.9-9.4)	8.8 (7.2-10.7)	8.8 (6.9-10.7)	7.9 (7.2-9.4)	.031

SFT: Skinfold thickness

Table 2 presents the median (min-max) values and Kruskall Wallis H test analysis results for the parameters liver, spleen, right kidney length, right kidney width, right parenchyma, left kidney length, left kidney width, and left parenchyma obtained from different somatotypes. According to the analysis results, the liver and right kidney width variables showed statistically significant differences among somatotypes ($p<0.05$) (Table 2).

Table 2. Median (min-max) values and analysis results of the variables measured from somatotypes

Parameter	Mesomorphic ectomorph	Endomorphic Mesomorph	Mesomorph Endomorph	Central	p
Length of liver (cm)	11.1 (9.5-14.4)	11.5 (9.8-14.4)	11.9 (9.9-13.6)	10.9 (9-12.3)	.020
Length of spleen(cm)	8.7 (7.3-10.2)	9.3 (6.1-13)	8.9 (6.6-12.7)	8.5 (6.8-11.6)	.405
Right kidney transverse length (mm)	86 (76-105)	84 (75-97)	89 (74-108)	83 (72-100)	.145
Right kidney vertical length (mm)	30 (24-37)	31 (24-37)	32 (25-45)	29 (25-34)	.006
Right kidney parenchymal thickness (mm)	10 (8-13)	10 (8.5-11.5)	11 (10-13)	10 (8.5-12)	.065
Left kidney transverse length (mm)	86 (77-106)	86 (69-99)	88 (72-110)	85 (75-110)	.329
Left kidney vertical length (mm)	35 (26-43)	36 (27-45)	37 (28-47)	36 (28-44)	.591
Left kidney parenchymal thickness (mm)	11 (9.5-13.5)	11.5 (9.5-14)	12 (10.5-14)	11 (10-13)	.130

Pairwise comparisons were conducted using the post-hoc Mann-Whitney U test to determine which somatotypes accounted for the differences in liver and right kidney transverse length—variables that exhibited statistically significant differences across somatotypes. The post-hoc results were presented in the Model Viewer table. According to the analysis results, the differences in liver and right kidney transverse size was found to be between central and mesomorph-endomorph somatotypes (Table 3).

Table 3. Post- Hoc test Model Viewer table

Pairwise Comparisons	Length of Liver	Right kidney width
Central- Mesomorphicectomorph	.424	.1000
Central-Endomorphicmesomorph	.054	.239
Central- Mesomorphendomorph	.019	.005
Mesomorphic ectomorph - Endomorphic mesomorph	.1000	.1000
Mesomorphic ectomorph - Mesomorph endomorph	.1000	.081
Endomorphic mesomorph - Mesomorph endomorph	.1000	.572

DISCUSSION

This study was conducted with the hypothesis of evaluating the effect of somatotype a detailed body composition analysis on ultrasonographic (USG) measurements of the liver, spleen, and kidneys in pediatric individuals. A statistically significant difference was found between somatotypes in the craniocaudal measurement of the liver. Post-hoc analysis revealed that this difference occurred between the central and mesomorph-endomorph somatotypes.

Gunas et al. reported that the craniocaudal measurement of the liver was higher in individuals with endo-mesomorphic somatotype, comparing the ultrasonographic measurement of the liver with somatotype characteristics[13]. In our study, we obtained higher values in craniocaudal measurement in individuals with meso-endomorph somatotype. This discrepancy may be attributed to our study's larger sample size compared to that in the literature. Size and morphology of the liver are influenced by various diseases. For this reason, establishing normal organ parameters is essential for accurate evaluation of pathological changes[14]. Although storage diseases, infiltrative diseases, and infectious causes are the leading causes of hepatomegaly in childhood, nutritional disorders such as Kwashiorkor are also significant contributors[15]. These factors support the idea that the correlation between somatotype and visceral organ parameters may reveal important clinical insights.

Clinical evaluation of visceral organ sizes through palpation and percussion is insufficient and the most accurate results are obtained through radiological imaging. To our knowledge, there are no studies in the literature evaluating the relationship between somatotype and USG parameters of the liver, spleen, and kidneys. However, there are many studies evaluating the parameters such as length, weight, surface area and organ size or volume[14-18]. However, it can be seen that, besides the use of radiological methods, stereological methods are also frequently used in these studies. Among radiological methods, USG is a fast, practical, radiation-free, anaesthesia-free and easily adaptable method for evaluating visceral organ size in pediatric populations.

Dittrich et al. [16] and Rocha et al.[17] reported that liver size measured by USG correlated best with body height and found no gender-related differences. Konuş et al.[10] reported that body length showed the best correlation with the vertical lengths of the kidney and spleen in addition to liver.

Sarac et al. [18] evaluated liver vertical length using USG and they found average values of 12.18 cm in boys and 11.99 cm in girls. Dhingra et al.[19] found liver vertical length as 9.59±1.98 cm (9.63 cm in boys, 9.54 cm in girls). In our study, the mean liver length was found to be 11.35 cm. We found that the statistically significant difference between somatotypes was between central and mesomorph endomorph somatotypes.

Şafak et al.[20] examined liver, spleen, and kidney sizes using USG in 712 children aged 7-15 and found that organ sizes did not differ by gender. They reported the strongest correlation was between weight and liver length (20kg: 76 10.5±1.4 cm, 30kg: 11.2±1.3 cm, 40kg: 11.6±1.2 cm, 50kg: 11.9±1.5 cm, 60kg: 12.3±1.4 cm).

Doğan et al.[14] evaluated liver, spleen and kidney measurements using USG in 506 children (267 male, 239 female) between the ages of 0 and 14. They found that organ sizes increased proportionally with age. In a study they conducted with CT on normal spleen, Schlesinger et al.[21] concluded that body weight and spleen volume correlated positively. Christophe et al.[22] also reported a linear correlation between body surface area and kidney length. In our study, no statistically significant difference was found between somatotypes in any of the parameters taken from spleen and kidney.

Although somatotype analysis is mostly used in sports sciences, it has been gaining popularity in health-related fields. A literature review shows that the importance of somatotype evaluation is increasing across various areas of health[22].

Determining normal parameters is critical for identifying potential pathological changes. Although morphometric studies that enable the determination of pathological states related to visceral organs are frequently encountered in literature, it is noteworthy that these organs affected by body composition are not associated with somatotype. While the present study being the first in this area limits the scope of discussion, it also lays the groundwork for future research in this field. Another limitation may be the small sample size. Studies with larger sample size may be able to reach more somatotype subgroups. We think that a study with children from different age categories would be more valuable, and we acknowledge this as a limitation.

As a result of our study, it was found that somatotype analysis, which is a detailed determinant of body composition, revealed a statistically significant difference between somatotypes in liver craniocaudal measurement in pediatric individuals. We recommend that these measurements be taken into account when interpreting abdominal ultrasound examination data. Thus, when deciding whether there is an increase or decrease in the investigated organs related to the somatotype, diagnosticians should first of all pay attention not to the average standards of their sizes, but to the dimensional characteristics of the organs and the body composition of the individual. These results bring us closer to understanding the concept of "population norm" for the parameters used in the study. Based on the experience we gained from our study, our recommendation would be that a somatotypic assessment should also be taken into account before detecting the pathologies of these organs, whose dimensions change even in the preclinical stage of the disease.

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