European Journal of Therapeutics
pISSN: 2564-7784
eISSN: 2564-7040

Eur J Ther. 2024;30(2):125-135.
https://doi.org/10.58600/eurjther1907

Original Research

The Relationship Between Breast Volume and Thoracic Kyphosis Angle

Şenay Bengin Ertem [1], Ümit Ali Malçok [2]

[1] Department of Radiology, Çanakkale Onsekiz Mart University, Faculty of Medicine, Çanakkale, Türkiye.
[2] Department of Neurosurgery, Çanakkale Onsekiz Mart University, Faculty of Medicine, Çanakkale, Türkiye.

Received: 2023-10-23 **Accepted:** 2023-12/20 **Published Online:** 2023-12-20

Corresponding Author
Ümit Ali Malçok, MD, Associate Prof,
Address: Çanakkale Onsekiz Mart University, Faculty of Medicine, Department of Neurosurgery, 17100, Çanakkale, Türkiye.
E-mail: umalcok@gmail.com

ABSTRACT

Objective: It has been hypothesized that a disproportionate upper body weight caused by macromastia places abnormal stress on the spine, which may lead to skeletal abnormalities. To evaluate whether there is a relationship between breast volume and the thoracic kyphosis angle measured on thorax CT images.

Methods: A total of 448 female patients who underwent thoracic CT examinations were included in this study. Breast volume (ml), by using the "organ segmentation method"; thoracic kyphosis angles by using Cobb's method were made manually on the workstation.

Results: Mean right breast volume was 902.03 ± 376.47 (154.21 - 2366.20 ml), left breast volume was 911.01 ± 383.34 (167.93 - 2894.07 ml), total breast volume was 1810.09 ± 750.82 (354.39 - 5100.68 ml). The total breast volume ($p<0.001$) and thoracic kyphosis angle ($p=0.012$) in patients aged 50-69 years were significantly higher than those aged 17-29 years. Larger total breast volume [$p<0.001$] and thoracic kyphosis angle ($p<0.001$) values were associated with larger BMI intervals. A significant positive correlation was observed between the total breast volume and thoracic kyphosis angle ($r=0.771$, $p<0.001$).

Conclusion: Our results showed that the thoracic kyphosis angle significantly increased in parallel with a larger total breast volume, and that total breast volume was an independent risk factor for thoracic kyphosis angle. The manual organ segmentation method we used was found to be reliable and easy to apply, but time-consuming technique for calculating BV.

Keywords: Breast volume, thoracic kyphosis angle, organ segmentation technique, thorax computed tomography

INTRODUCTION

Women with a larger-than-normal breast volume (BV) experience cervical tension, head, back, and shoulder pain, and poor posture more often than women with normal or small breast volumes [1]. It has been hypothesized that a disproportionate upper body weight caused by macromastia places abnormal stress on the spine, which may lead to skeletal abnormalities [2]. Several studies have shown that high BV is one of the mechanisms leading to an increase in thoracic kyphosis and cervical lordosiss [3,4]. Improvements in pain, functional capacity, severity of additional symptoms, and thoracic kyphosis angle (TKA) after breast reduction surgery confirm these conclusions [3,5]. Furthermore, a cross-sectional study reported that women with large breasts had greater TKA and upper-trunk musculoskeletal pain than those with small breasts [1].

Although BV estimation is important for determining the amount of tissue to be removed before mastectomy and the approach to reconstructive surgery after mastectomy, there is still no standard method for measuring BV [6, 7]. Various techniques have been used for BV estimation, including anthropometric measurements, Archimedean procedure, Grossman-Rounder device, negative casting (plaster, paraffin, thermoplastic materials), 2D images such as mammography or ultrasound, 3D surface calculation, and Cavalieri principle [6-9].

Some of these methods have disadvantages such as being complex in terms of technical performance, causing discomfort to the patient or examiner, inadequate sensitivity, and high costs [7]. In existing studies assessing BV measurement methods, the participant count is either low or subjects only include certain groups (such as postmenopausesal patients with large breast). Therefore, a technique that can accurately measure BV in larger patient groups is needed.

The organ segmentation method using CT images is a technique developed for measuring organ volume. It has been used to measure the volume of intra-abdominal organs, such as the liver, spleen, and pancreas [10]. A few studies have used the same technique to measure breast volume [7, 11]. However, most of these studies were related to their use in breast reduction surgery.

Main Points;

- Our results showed that TKA was correlated with TBV and TBV was an independent risk factor associated with higher TKA
- TBV and TKA values in the 50-69 years age group were found to be significantly higher than those in the 17-29 years age group. But there was no significant correlation between age and TBV and TKA.
- Both TBV and TKA increased significantly as the BMI and weight increased.
- The Cobb angle method has subsequently been widely used in clinical practice to measure sagittal spine curves. We preferred the angle between T4 and T12, which is commonly used in TKA measurements.
- The manual organ segmentation method we used was found to be reliable and easy to apply, but time-consuming technique for calculating BV.

The aim of this study was to evaluate whether there is a relationship between BV and the TKA on thorax CT images.

MATERIALS AND METHODS

Study Design and Ethical Issues

This retrospective, single-center study was conducted at the Radiology Department of the University Hospital. Ethics committee approval was obtained (decision number: July 16, 2020, code:14-10) from the same location. This study was conducted in accordance with the ethical standards of the Declaration of Helsinki. Since the study was conducted retrospectively, informed consent was not obtained from the participants.

Study Population

This study included 448 female patients who underwent thorax CT (TCT) examination at our Radiology Department from 2019 to 2020.

The exclusion criteria were age <17 years; impaired image quality due to artifacts; scoliosis; thoracic vertebral fracture; osteoporosis; presence of tumor or abscess at the level where TKA measurement would be made; having spinal, thoracic or breast surgery history; and having received radiotherapy at the site of measurement.

Data Collection, Imaging and Measuring Techniques

Patient age, height (cm), weight (kg), and TCT images were obtained from the hospital's medical record database. The body mass index (BMI) was calculated as weight/height² (kg/m²). Patients were divided into 7 groups according to age (17-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-100 years) and 3 groups according to BMI (<25, 25–30, ≥30) [12]. Thorax computed tomography examination was performed with a 320-detectors, 640-section Toshiba Aquillion One TSX-301C 2016 (Canon Medical Systems, Tokyo, Japan) tomography device with the following settings: kV 120, mA 50, rotation time 350 ms, slice thickness 5 mm, and slice interval 5 mm.

Measuring Breast Volume

Axial TCT images of 448 patients were evaluated to ensure that both the breasts were in the field of view. Coronal and sagittal reformat images were obtained from axial sections of the TCTs. Breast volume (ml) measurements were made manually at the workstation (Vitrea version 6.8.0]) by an experienced radiologist, using the "organ segmentation method" in accordance with the

manufacturer's recommended protocol. By selecting the tissues within the breast boundaries, volume measurements were performed for each breast (right and left) separately, and the total breast volume (TBV) was calculated automatically by the device (Figure 1).

Measuring Thoracic Kyphosis Angle

In the same session, TKAs were measured manually at the workstation (Vitrea version 6.8.0) on the sagittal plane of the TCT images in the bone window (W:2500, L:480) by an experienced radiologist and neurosurgeon as follows: First, straight lines were drawn in the sagittal plane, tangent to the upper end plate of the T4 vertebra, and the lower end plate of the T12 vertebra. Subsequently, two separate perpendicular lines that intersected these two lines were drawn. Finally, TKA was determined by measuring the acute angle at the intersection of the last two lines drawn (Cobb's angle) (Figure 2) [13].

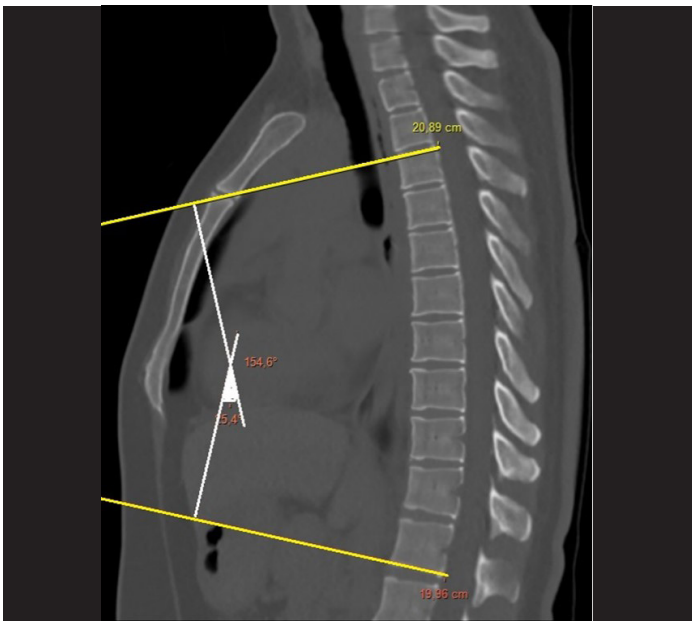

Figure 2. Thoracic kyphosis angle measurement technique on sagittal plane thorax CT image.

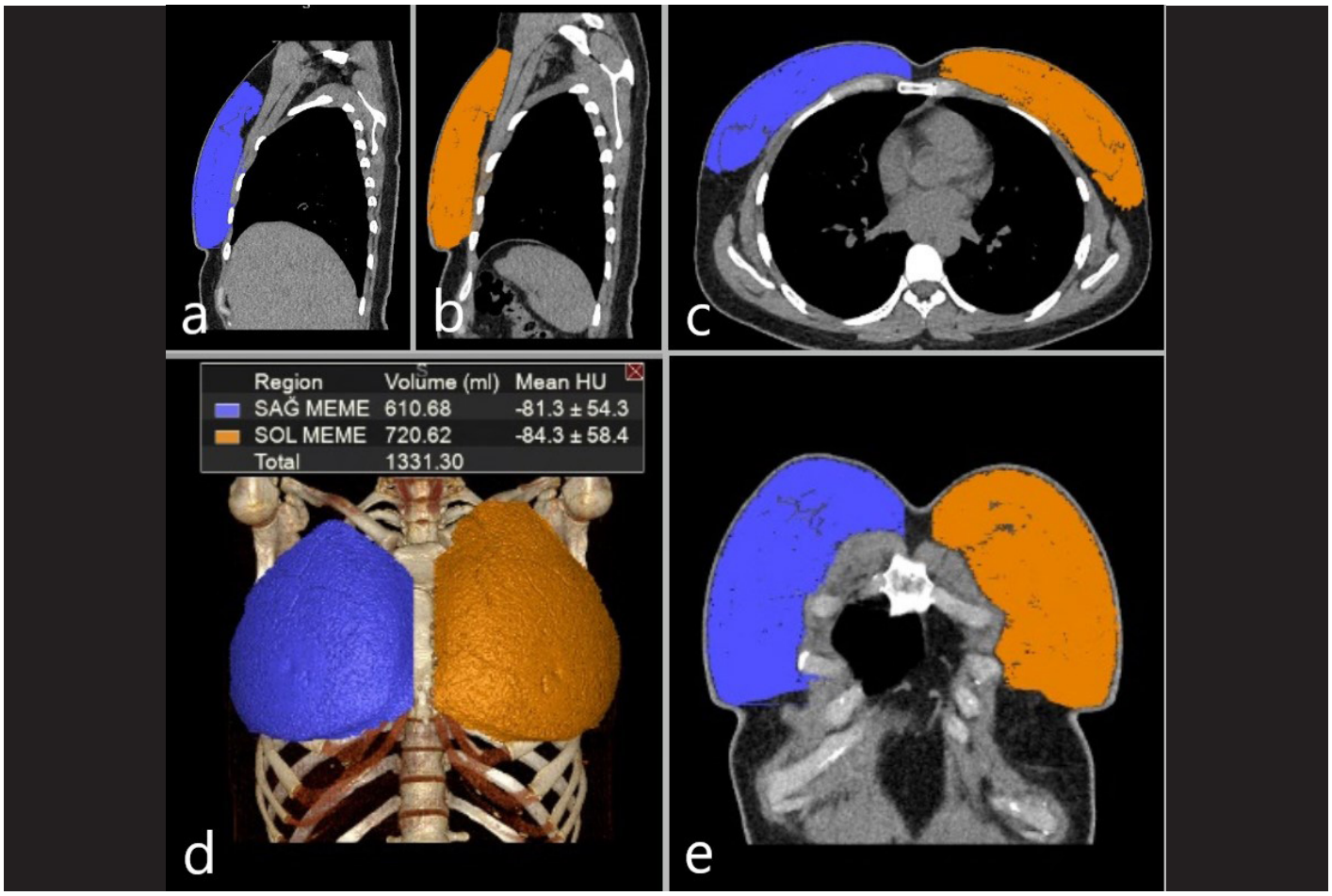

Figure 1. Sagittal (a, b), axial (c) 3-dimensional (d) and coronal (e) reformat images of breast volumes made with "organ segmentation method" on thorax CT images.

Statistical Analysis

Statistical analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA). For the normality check, histograms and Q-Q plots were employed. Continuous variables are described as mean ± standard deviation (minimum-maximum), and categorical variables are reported as frequency values (relative and absolute). Comparison of the right and left BVs was performed using the paired sample t-test. Comparisons between age and body mass index groups were performed using one-way analysis of variance (ANOVA). Pairwise corrections were performed using the Bonferroni method. Pearson correlation coefficients were calculated to evaluate the relationships between continuous variables. Multiple linear regression analysis was performed to determine significant factors associated with TKA. Two-tailed p-values of less than 0.05 were considered statistically significant.

RESULTS

The mean age in the study group was 56.09±16.35 (17-91) years, and the mean BMI was 28.46±5.76 [16.00-56.93]. The distributions of 448 female patients age and BMI groups are shown in Table 1 (Table 1). Mean right BV was 902.03±376.47 (154.21-2366.20 ml), mean left BV was 911.01±383.34 (167.93-2894.07 ml), mean total BV (TBV) was 1810.09±750.82 (354.39-5100.68 ml). There was no significant difference between the right and left BV (p=0.104). The mean TKA was 29.98±9.14 (5.4-73.6) degrees.

The total breast volume (p<0.001) and TKA (p=0.012) of the patients in the 50-69 age range were significantly higher than the corresponding values in the 17-29 age group, while values in the other groups were similar. In addition, both TBV (p<0.001) and TKA (p<0.001) increased significantly with higher BMI intervals (Table 2).

According to the results of the Pearson correlation calculations, a significant positive correlation was observed between the TBV and TKA (r=0.771, p<0.001) (Figure 3). A significant positive correlation was observed between weight and TBV (r=0.524, p<0.001) and TKA (r=0.406, p<0.001). There was also a significant positive correlation between BMI and TBV (r=0.520, p<0.001) and TKA (r=0.405, p<0.001) (Table 3).

Table 1. Summary of patients' characteristics and measurements.

Age range	**Mean (%)**
17-29	37 (8.3%)
30-39	38 (8.5%)
40-49	71 (15.8%)
50-59	96 (21.4%)
60-69	109 (24.3%)
70-79	67 (15.0%)
80-100	30 (6.7%)
Mean Age ± sd (range)	56.09 ± 16.35 (17 - 91)
Mean Height ± sd, cm	160.54 ± 5.80 (145 - 185)
Mean Weight ± sd, kg	73.25 ± 14.67 (42 - 155)
Mean Body mass index ± sd, kg/m^2	28.46 ± 5.76 (16.00 - 56.93)
Body mass index range	**Mean (%)**
<25.0	128 (28.6%)
25.0-<30.0	157 (35.0%)
≥30.0	163 (36.4%)

Data are presented as the mean ± standard deviation (minimum - maximum) for continuous variables. and as frequency (percentage) for categorical variables.

Table 2. Distribution of total breast volume and thoracic kyphosis angles according to age and body mass index.

	Total breast volume, ml	**Thoracic kyphosis angle**
Age		
17-29	1469.48 ± 652.09 ^{a}	26.11 ± 7.58 ^{a}
30-39	1719.78 ± 724.06 ^{ab}	28.83 ± 8.51 ^{ab}
40-49	1661.59 ± 638.21 ^{ab}	29.37 ± 7.89 ^{ab}
50-59	2036.07 ± 701.00 ^{b}	31.58 ± 8.85 ^{b}
60-69	1938.98 ± 830.74 ^{b}	31.45 ± 9.69 ^{b}
70-79	1776.85 ± 815.14 ^{ab}	30.00 ± 10.60 ^{ab}
80-100	1578.87 ± 561.28 ^{ab}	27.15 ± 8.06 ^{ab}
p	**<0.001**	**0.012**
Body mass index, kg/m^2		
<25	1269.36 ± 572.52 ^{a}	24.96 ± 7.88 ^{a}
25 to <30	1831.73 ± 658.01 ^{b}	30.00 ± 8.21 ^{b}
≥30.0	2213.88 ± 697.16 ^{c}	33.91 ± 9.02 ^{c}
p	**<0.001**	**<0.001**

Data are presented as mean ± standard deviation. The same letters denote a lack of statistically significant differences between groups.

Multiple linear regression analysis was performed to determine the significant risk factors associated with higher TKA rates. We found that a large TBV (p<0.001) was a significant risk factor for higher TKA after adjusting for age, height, weight, and body mass index. Other variables included in the model, such as age (P=0.876), height (P=0.966), weight (P=0.993), and BMI (P=0.998) were found to be non-significant (Table 4).

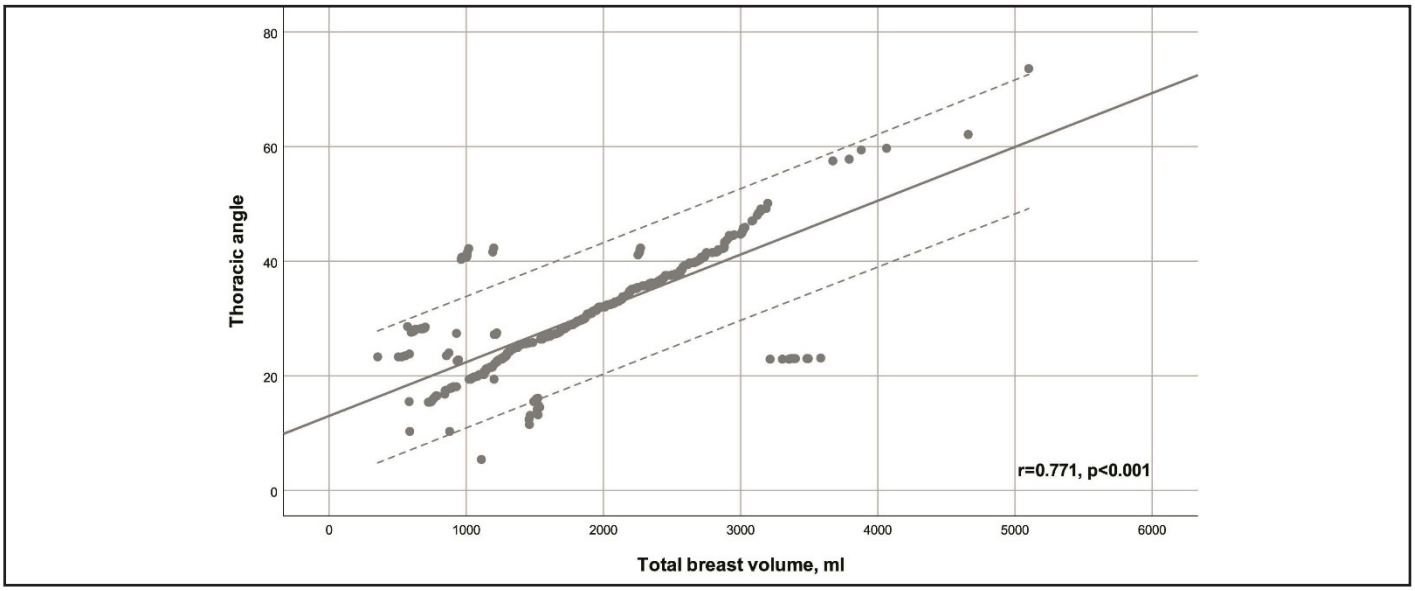

Figure 3. Scatter plot of total breast volume and thoracic kyphosis angle.

Table 3. Correlations between breast volume, thoracic kyphosis angle and patients characteristics.

		Total breast volume, ml	Thoracic kyphosis angle
Total breast volume, ml	r	-	**0.771**
	p	-	**<0.001**
Age	r	0.089	0.076
	p	0.060	0.110
Height, cm	r	0.012	0.003
	p	0.796	0.955
Weight, kg	r	**0.524**	**0.406**
	p	**<0.001**	**<0.001**
Body mass index, kg/m^2	r	**0.520**	**0.405**
	p	**<0.001**	**<0.001**

r: Pearson correlation coefficient

Table 4. Risk factors of the high thoracic kyphosis angle, multiple linear regression analysis.

	Unstandardized β	Standard Error	Standardized β	t	p	95.0% Confidence Interval for β	
(Constant)	14.341	36.803		0.390	0.697	-57.989	86.672
Age	0.003	0.018	0.005	0.157	0.876	-0.033	0.039
Height, cm	-0.010	0.229	-0.006	-0.043	0.966	-0.461	0.441
Weight, kg	0.002	0.252	0.004	0.009	0.993	-0.493	0.497
Body mass index, kg/m^2	-0.002	0.643	-0.001	-0.003	0.998	-1.266	1.262
Total breast volume, ml	0.009	0.000	0.770	21.486	**<0.001**	0.009	0.010

Dependent variable: Thoracic kyphosis angle; Adjusted R^2=0.590; F=129.769; p<0.001

DISCUSSION

In our study, TBV and TKA values in the 50-69 years age group were found to be significantly higher than those in the 17-29 years age group, but there was no significant correlation between age and TBV and TKA. In addition, both TBV and TKA increased significantly as the BMI and weight increased. Our study has an advantage over the literature in that the number of participants in the study population is relatively high, regardless of age and breast size.

Excessive BV causes biomechanical disorders such as back pain, avoidance of physical activity, and biopsychological problems such as cosmetic dissatisfaction [4, 14, 15]. In the present study, we showed a relationship between TBV and TKA, which may be associated with the development of back pain. In the correlation analysis, we found that a larger TBV was associated with a higher TKA, indicating an increased kyphosis angle. Multiple linear regression analysis showed that TBV was independently associated with higher TKA regardless of other factors. Notably, both weight and BMI were positively correlated with TBV and TKA.

Previous studies have shown that abnormal increases in BV that force the thoracic spine anteriorly are involved in the deterioration associated with sagital vertebral aksis (SVA). The increased load due to the large BV in the front side of the body can shift the body's center of gravity in the same direction [14, 16, 17]. Fındıkçıoğlu et al., showed that women with large breasts according to cup sizes had significantly greater TKA (measured by lateral radiography) than women with small breasts [3]. Similarly, in a cross-sectional study that included 300 women between the ages of 18-82, BV was measured using a hand-held three-dimensional scanner, and the participants were divided into four groups: small, medium, large and hypertrophic according to BV. TKA was measured using a flexicurve ruler. Although the hypertrophic group had the highest TKA value, breast size did not have a significant effect on TKA [5]. In a recent study from Türkiye, the BV of 60 women was measured using the Grossman-Rounder device. The cervical lordosis, thoracic kyphosis and lumbar lordotic Cobb's angles were calculated. The average cervical lordosis angle was significantly higher in patients with larger breasts than in those with smaller breasts [4].

In another studies, found that a large BV is not only a cosmetic but also a functional problem and can lead to pathological conditions such as increased cervical lordosis and thoracic kyphosis and increased or decreased lumbar lordosis. They also reported that reduction mammoplasty can correct pathological angulation of the vertebral column [18-20].

Sanal et al. used a technique similar to the BV calculation method used in our study. They retrospectively screened patients who had undergone TCT for various reasons, and calculated TBV by adding the volumes of each breast separately calculated from the 3D breast reconstruction images obtained on the CT workstation [11]. By examining the midsagittal planes of the same CT images containing the 1st thoracic to 1st lumbar levels, they determined the degree of degeneration at each spinal level using the Kellgren-Lawrence degeneration scale. They found that both the total degeneration grade and total number of involved levels were significantly higher in women with large breasts than in those with normal and small breasts.

Thoracic kyphosis tends to increase with aging [21]. After the fourth decade of life, the kyphotic angle generally begins to worsen rapidly in women than in men [21,22]. Age related hyperkyphosis often occurs in older ages and is characterized by excessive forward curvature of the thoracic spine [23]. Currently, there is no well-defined threshold that distinguishes normal kyphosis from hyperkyphosis. The cut-off value for the hyperkyphosis angle has generally been used at a higher value such as greater than 40 degree or 50 degree in the literature [23-28]. The exact etiology of thoracic hyperkyphosis and its progression over time have not yet been determined. However, studies have examined various risk factors such as osteoporosis, vertebral fractures, degenerative changes, decreased mobility, reduced proprioception, spinal extansor musculature, and even heredity [29-32]. Osteoporosis is a systemic musculoskeletal disease that results in a decrease in bone mass and deterioration in bone microstructure. It causes bone fragility and an increase in the possibility of fractures [33]. It has been reported that 70% of all bone fractures in adults aged 45 and over and one –third of vertebral fractures in women the age of 65 are related to osteoporosis [34]. Postural kyphosis, one of the leading consequences of osteoporosis, develops due to vertebral fractures and causes physical and psychological damage [35]. Hyperkyphotic posture not only increases postural back pain, but also increases the risk of falls and therefore the risk of bone fractures [35,36]. Our study was conducted retrospectively. Since patient datas were obtained from our hospital's medical record database; bone densitometry results were not available

for each patient. Therefore, we could not examine the effect of osteoporosis on the TKA angle.

The Cobb angle method was originally proposed to evaluate the severity of scoliosis. However, it has subsequently been widely used in clinical practice to measure sagittal spine curves [37]. In this study, we chose to measure TKA using the Cobb angle method because it provides information about the anatomy of the vertebrae and spinal alignment. In addition, high inter- and intra-observer reliability has been defined for the use of the Cobb angle with well-trained inspectors. Owing to the superposition of the shoulder joints and bones, it is difficult to accurately assess the region from the fourth thoracic vertebra to cranial vertebra. Therefore, we preferred the angle between T4 and T12, which is commonly used in TKA measurements [13]. We obtained results consistent with those of previous studies. Thoracic kyphosis was positively correlated with TBV. Considering that age, weight, height and BMI may also affect TKA, we performed regression analysis and determined that TBV was an independent risk factor for TKA.

Many factors such as breast shape, the complex anatomy of the breast region, consistency, weight fluctuation, menstrual and hormonal effects, and position of the breast on the chest wall can affect the results of BV measurement; therefore, it is difficult to determine a standard BV measurement method [6]. In addition, because most of these methods cannot adequately measure the tissue lateral to the pectoral folds and/or the breast facing the chest wall, the results are often unreliable [7]. In addition to the advantages of most of the methods used to measure BV, there are also disadvantages, such as difficulty in implementation, costs, and not always being acceptable for patients [38]. The formula-related problems of anthropomorphic measurements, the inaccuracy of the Grossman-Roudner device for larger breasts, and the fact that the water displacement technique is reliable in medium or large breasts are specific disadvantages of previously reported methods [39-41].

It is difficult to automatically estimate breast volume because the breast consists of tissues of different densities, such as glands, fat, and skin [7, 42]. Along with technological developments, advances have been made in imaging systems and the three-dimensional detailing of these images [43, 44]. Today there are modern MRI, CT, mammography (MG), and ultrasound (US) devices containing special software that can automatically and accurately estimate the breast volume and benign or malignant mass volumes in the breast [7, 45- 50]. Magnetic resonance imaging (MRI) has excellent soft tissue resolution, is radiation-free, offers multiplanar and multi-sequence imaging; but is expensive and time consuming [51]. Computed tomography imaging (CT) has high spatial and intensity resolution. But it causes large amounts of radiation exposure and use of contrast agents that have negative side effects [52]. Mammography (MG) is the main diagnostic method in breast cancer screening and is the only imaging method that contributing to reducing breast cancer- related mortality [53]. But there is still radiation exposure in MG, although not as much as CT. Ultrasound (US) has advantages of being widespread, easily accessible, economical, easy to apply and does not contain radiation as CT or MG. It is considered the preferred imaging method for breast cancer [48,54]. But, volume measurement with two-dimensional ultrasound images is difficult; therefore 3D ultrasound (ABUS) which can perform automatic volume measurement of breast sould be used [49,55]. However, since automatic volume measurement softwares are expensive and not available on every devices, limits their clinical applications.

Studies have shown that the volume of various organs, such as the spleen [56], liver [57], and abdominal adipose tissue [58], can be measured with CT- and MRI-assisted manual organ segmentation. To the best of our knowledge, there are few publications in the literature on manual BV measurement utilizing the “organ segmentation method” over axial sections and coronal-sagittal reformat images in multislice CT. We preferred this method for TBV because it is objective and easily measurable. The comparison of these values with TKA values (measured using the objective Cobb method), allowed for an accurate assessment of the relationships between breast size and thoracic kyphosis.

Our study has some limitations. The retrospective and single-center design of our study limited the addition of new data and the generalizability of the results. The fact that the proposed BV measurement method requires CT imaging means both radiation exposure and additional cost. In addition, the manual measurement of BV with organ segmentation requires a relatively long time.

In conclusion, our results showed that TKA was correlated with TBV and TBV was an independent risk factor associated with higher TKA. It was observed that the increase in TBV and TKA values was especially evident in the 50-69 age group. The

manual organ segmentation method we used was found to be reliable and easy to apply, but time-consuming technique for calculating BV.

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical Approval: Ethical approval for the study was granted by the Clinical Research Ethical Committee of Çanakkale Onsekiz Mart University (Approval number: 2020-07-16/14-10).

ŞB Ertem and *ÜA Malçok*: Contributed significantly to understanding and designing or obtaining data, or analyzing and interpreting data, drafting the manuscript or critically reviewing it for important intellectual content, and approving the final version to be published. They also agree to be responsible for all aspects of the work if questions arise regarding the accuracy or completeness of the work.

REFERENCES

[1] McGhee DE, Coltman KA, Riddiford-Harland DL, Steele JR (2018) Upper torso pain and musculoskeletal structure and function in women with and without large breasts: A cross sectional study. Clin Biomech. 51:99-104. https://doi.org/10.1016/j.clinbiomech.2017.12.009

[2] Elowitz EH (2014) Does Reduction Mammaplasty Revert Skeletal Disturbances in the Vertebral Column of Patients With Macromastia? A Preliminary Study. Aesthetic Plast Surg. 38(1):113-4. https://doi.org/10.1007/s00266-013-0215-0

[3] Fındıkcıoğlu K, Fındıkcıoğlu F, Bulam H, Sezgin B, Ozmen S (2013) The impact of breast reduction surgery on the vertebral column. Ann Plast Surg. 70(6):639-42. https://doi.org/10.1097/sap.0b013e31823fac41

[4] Tunçkale T, Gürdal SÖ, Çalışkan T, Topçu B, Yüksel MO (2021) The impact of various breast sizes of women on vertebral column and spinopelvic parameters. Turk Neurosurg. 31(5):699-703. https://doi.org/10.5137/1019-5149.jtn.30936-20.2

[5] Coltman CE, Steele JR, McGhee DE (2019) Effect of breast size on upper torso musculoskeletal structure and function: a cross-sectional study. Plast Reconstr Surg. 143(3):686-95. https://doi.org/10.1097/prs.0000000000005319

[6] Kovacs L, Eder M, Hollweck R, Zimmermann A, Settles M, Schneider A, Endlich M, Mueller A, Schwenzer- Zimmerer A, Papadopulos NA, Biemer E (2007) Comparison between breast volume measurement using 3D surface imaging and classical techniques. The Breast. 16(2):137-45. https://doi.org/10.1016/j.breast.2006.08.001

[7] Erić M, Anderla A, Stefanović D, Drapšin M (2014) Breast volume estimation from systematic series of CT scans using the Cavalieri principle and 3D reconstruction. Int Surg. 12(9):912-7. https://doi.org/10.1016/j.ijsu.2014.07.018

[8] Lee WY, Kim MJ, Lew DH, Song SY, Lee DW (2016) Three-dimensional surface imaging is an effective tool for measuring breast volume: a validation study. Arch Plast Surg. 43(5):430-7. https://doi.org/10.5999/aps.2016.43.5.430

[9] Choppin SB, Wheat JS, Gee M, Goyal A (2016) The accuracy of breast volume measurement methods: a systematic review. The Breast. 28:121-9. https://doi.org/10.1016/j.breast.2016.05.010

[10] Ma J, Zhang Y, Gu S, Zhu C, Ge C, Zhang Y, An X, Wang C, Wang Q, Liu X, Cao S, Zhang Q, Liu S, Wang Y, Li Y, He J,Yang X (2021) Abdomen CT-1K: Is abdominal organ segmentation a solved problem?. IEEE Trans. Pattern Anal Mach Intell. 27:1-19. https://doi.org/10.1109/tpami.2021.3100536

[11] Sanal B, Korkmaz M, Nas OF, Can F, Hacikurt K (2017) The effect of gigantomasty on vertebral degeneration: a computed tomography study. J Back Musculoskelet Rehabil. 30(5):1031-5. https://doi.org/10.3233/bmr-169600

[12] Quesada O, Lauzon M, Buttle R, Wei J, Suppogu N, Kelsey SF, Reis SE, Shaw LJ, Sopko G, Handberg E, Pepine CJ, Merz CNB (2022) Body weight and physical fitness in women with ischaemic heart disease: does physical fitness contribute to our understanding of the obesity paradox in women? Eur J Prev Cardiol. 4;zvac046. https://doi.org/10.1093/eurjpc/zwac046

[13] Koelé MC, Lems WF, Willems HC (2020) The clinical relevance of hyperkyphosis: A narrative review. Front Endocrinol [Lausanne]. 11:5. https://doi.org/10.3389/fendo.2020.00005

[14] Kruse M, Thoreson O (2021) The prevalence of diagnosed specific back pain in primary health care in Region Västra Götaland: a register study of 1.7 million inhabitants. Prim Health Care Res Dev. 22:e37. https://doi.org/10.1017/s1463423621000426

[15] Schinkel-Ivy A, Drake JDM (2016) Breast size impacts spine motion and postural muscle activation. J Back Musculoskelet Rehabil. 29(4):741-8. https://doi.org/10.3233/bmr-160680

[16] Shimizu M, Kobayashi T, Chiba H, Senoo I, Ito H, Matsukura K, Saito S (2020) Adult spinal deformity and its relationship with height loss: a 34-year longitudinal cohort study. BMC Musculoskelet Disord. 21(1):1-7. https://doi.org/10.1186/s12891-020-03464-2

[17] Oxland TR (2016) Fundamental biomechanics of the spine-what we have learned in the past 25 years and future directions. J Biomech. 49(6):817-32. https://doi.org/10.1016/j.jbiomech.2015.10.035

[18] Fındıkcıoğlu K, Fındıkcıoğlu F, Özmen S, Güçlü T (2007) The impact of breast size on the vertebral column: a radiologic study. Aesthetic Plast Surg. 31(1):23-7. https://doi.org/10.1007/s00266-006-0178-5

[19] Berberoğlu Ö, Temel M, Türkmen A (2015) Effects of reduction mammaplasty operations on the spinal column: clinical and radiological response. Aesthetic Plast Surg. 39 (4):514-22. https://doi.org/10.1007/s00266-015-0516-6

[20] Karabekmez FE, Gökkaya A, Işık C, Sağlam I, Efeoğlu FB, Görgü M (2014) Does reduction mammaplasty revert skeletal disturbances in the vertebral column of patiensts with macromastia? A preliminary study. Aesthetic Plast Surg. 38(1):104-12. https://doi.org/10.1007/s00266-013-0194-1

[21] Fon GT, Pitt MJ, Thies AC Jr. Toracic kyphosis: range in normal subjects. Am J Roentgenol 134:979-83 https://doi.org/10.2214/ajr.134.5.979

[22] Ensrud KE, Black DM, Harris F, Ettinger B, Cummings SR (1997) Correlates of kyphosis in older women. The fracture intervention trial research group. J Am Geriatr Soc 45:682-7 https://doi.org/10.1111/j.1532-5415.1997.tb01470.x

[23] Katzma WB, Wanek L, Shepherd JA, Sellmeyer DE (2010). Age- related hyperkyphosis: its causes, consequences, and management. J Orthop Sports Phys Ther 40(6): 352-60 https://doi.org/10.2519%2Fjospt.2010.3099

[24] Roghani T, Zavieh MK, Manshadi FD (2017) Age-related hyperkyphosis: update of its potential cuses and clinical impacts- narrative review. Aging Clin Exp Res 29: 567-77 https://doi.org/10.1007/s40520-016-0617-3

[25] McDaniels-Davidson C, Davis A, Wing D, Macera C, Lindsay SP, Schousboe JT, Nichols JF and Kado DM (2017) Kyphosis and incidental falls among community-dwelling older adults. Osteporos Int 29:163-9 https://doi.org/10.1007/s00198-017-4253-3

[26] van der Jagt-Willems HC, de Groot MH, van Campen JP, Lamoth CJ, Lems WF (2015) Associations between vertebral fractures, increased thoracic kyphosis, a flexed posture and falls in older adults: a prospective cohort study. BMC Geriatr. 15:34 https://doi.org/10.1186/s12877-015-0018-z

[27] Kado DM, Miller- Martinez D, Lui LY, Cawthon P, Katzman WB, Hillier TA, Fink AH (2014) Hyperkyphosis, kyphosis progression, and risk of non-spine fractures in older community dwelling women: the study of osteoporotic fractures (SOF). J Bone Miner Res. 29: 2210-6 https://doi.org/10.1002/jbmr.2251

[28] Sinaki M, Brey RH, Hughes CA, Larson DR, Kaufman KR (2005) Balance disorder and increased risk of falls in osteoporosis and kyphosis: significance of kyphotic posture and muscle strength. Osteoporos İnt. 16:1004-10 https://doi.org/ 10.1007/s00198-004-1791-2

[29] Milne JS, Lauder IJ (1976) The relationship of kyphosis to the shape of vertebral bodies. Ann Hum Biol 3:173-9 https://doi.org/10.1080/03014467600001281

[30] Anderson DE, D'Agostino JM, Bruno AG, Demissie S, Kiel DP, Bouxsein ML (2013) Variations of CT- based trunk muscle attenuation by age, sex, and specific muscle. J Gerontol A Biol Sci Med Sci 68:317-23 https://doi.org/10.1093/gerona/gls168

[31] Kamel HK (2003) Sarcopenia and aging. Nutr Rev 61:157-67 https://doi.org/10.1301/nr.2003.may.157-167

[32] Van der Klift M, De Laet CE, McCloskey EV, Hofman A, Pols HA (2002) The incidence of vertebral fractures in men and women: Rotterdam Study. J Bone Miner Res 17: 1051-6 https://doi.org/10.1359/jbmr.2002.17.6.1051

[33] Bonner FJ, Lindsay R (2005). Osteoporosis. İn: Delisa JA (ed) Physical medicine and rehabilitation, 4th edn. Lippincott Wiliams and Wilkins, Philadelphia, pp 699-719.

[34] Hall SE, Criddle RA, Comito TL, Price RL (1999). A case-control study of quality of life and functional impairement in women with long-standing vertebral osteoporotic fracture. Osteoporos Int 9(6): 508-15 http://dx.doi.org/10.1007/s001980050178

[35] Sarıdoğan ME (2005) Osteoporoz Epidemiyolojisi. Gökçe Kutsal Y (ed) Osteoporoz, Ankara, pp 5-36.

[36] Sinaki M (1998) Musculoskeletal challenges of osteoporosis. Aging 10(3): 249-62 https://doi.org/10.1007/bf03339659

[37] Gölpınar M, Komut E (2022) The reliability of the projection area per length squared for measuring lumbar lordosis an lateral radiographs: A comparison with Cobb Method. Eur J Ther. 28(4):285-91. https://doi.org/10.58600/eurjther-28-4-0091

[38] Hussain Z, Roberts N, Whitehouse GH, Garcia-Finana M, Percy D (1999) Estimation of breast volume and its variation during the menstrual cycle using MRI and stereology. BJR. 72(855):236-45. https://doi.org/10.1259/bjr.72.855.10396212

[39] Bulstrode N, Bellamy E, Shrotria S (2001) Breast volume assessment: comparing five different techniques. The Breast. 10(2):117-23. https://doi.org/10.1054/brst.2000.0196

[40] Kayar R, Civelek S, Cobanoglu M, Gungor O, Catal H, Emiroglu M (2011) Five methods of breast volume measurement: a comparative study of measurements of specimen volume in 30 mastectomy cases. Breast Cancer: Basic and Clinical Research. 5:43-52. https://doi.org/10.4137/bcbcr.s6128

[41] Sigurdson LJ, Kirkland SA (2006) Breast volume determination in breast hypertrophy: an accurate method using two anthropomorphic measurements. Plast Reconstr Surg. 118(2):313-20. https://doi.org/10.1097/01.prs.0000227627.75771.5c

[42] Yip JM, Mouratova N, Jeffery RM, Veitch DE, Woodman RJ, Dean NR (2012) Accurate assessment of breast volume: a study comparing the volumetric gold standard [direct water displacement measurement of mastectomy specimen] with a 3D laser scanning technique. Ann Plast Surg. 68(2):135-41. https://doi.org/10.1097/sap.0b013e31820ebdd0

[43] Ratib O, Valentino DJ, McCoy MJ, Balbona JA, Amato CL, Boots K (2000) Computer-aided design and modeling of workstations and radiology reading rooms for the new millennium. Radiographics. 20(6):1807-16. https://doi.org/10.1148/radiographics.20.6.g00nv191807

[44] Lenchik L, Heacock L, Weaver AA, Boutin RD, Cook TS, Itri J, Cristopher GF, Gullapalli RP, Lee J, Zagurovskaya M, Redson T, Godwin K, Nicholson J, Narayana PA (2019) Automated segmentation of tissues using CT and MRI: a systematic review. Acad Radiol. 26(12):1695-706. https://doi.org/10.1016/j.acra.2019.07.006

[45] Ortiz CG, Martel AL (2012) Automatic atlas-based segmentation of the breast in MRI for 3D breast volume computation. Med Phys. 39(10):5835-48. https://doi.org/10.1118/1.4748504

[46] Kim YS, Cho HG, Kim J, Park SJ, Kim HJ, Lee SE, Yang JD, Kim WH, Lee JS (2022) Prediction of implant size based on breast volume using mammography with fully automated measurements and brest MRI. Ann. Surg. Oncol 29(12): 7845-54. https:// doi.org/10.1245/s10434-022-11972-9

[47] Nara M, Fujioka T, Mori M, Agura T, Tateishi U (2022) Prediction of breast cancer risk by automated volumetric breast density measurement. Jpn J Radiol. 41(1): 54-62. https://doi.org/10.1007/s11604-022-013-y

[48] Ma JJ, Meng S, Dang SJ, Wang JZ, Yuan Q, Yang Q, Song CX (2022) Evaluation of a new method of calculating breast tumor volume based on automated breast ultrasound. Front Oncol. 13:12:895575. https://doi.org/10.3389/fonc.2022.895575.eCollection 2022

[49] Lagendijk M, Vos EL, Ramlakhan KP, Verhoef C, Koning AHJ, Lankeren WV, Koppert LB (2018) Breast and tumour volume measurements in breast cancer patients using 3-D automated breast volume scanner images. World J Surg.

42(7): 2087-93 https://doi.org/10.1007/s00268-017-4432-6

[50] Schmachtenberg C, Fischer T, Hamm B, Bick U (2017) Diagnostic performance of automated breast volume scanning (ABVS) compared to handheld ultrasonography with breast MRI as the gold standard. Acad Radiol. 24(8):954-61 https://doi.org/10.1016/j.acra.2017.01.021

[51] Kim JS, Bae K, Lee EJ, Bang M (2021) Mammography with a fully automated breast volumetric software as a novel method for estimating the preoperative breast volüme prior to mastectomy. Ann Surg Treat Res. 100(6):313-19 https://doi.org/10.4174/astr.2021.100.6.313

[52] Li H, Yao L, Jin P, Hu L, Li x, Gua T, Yang K (2018) MRI and PET-CT for evaluation of the pathological response to neoadjuvant chemotherapy in breast cancer: A systematic review and meta- analysis. Breast 40:106-15 https://doi.org/10.1016/j.breast.2018.04.018

[53] Li J, Gao W, Yu B, Wang F, Wang L (2018) Multi-slice spiral CT evaluation of breast cancer chemotherapy and correlation between CT results and breast cancer specifik gene1. J BUON 23(2):378-83

[54] Dobruch-Sobczak K, Piotrkowska- Wroblewska H, Klimonda Z, Roszkowska- Purska K, Litniewski (2019) J Ultrasound echogenity reveals the response of breat cancer to chemotherapy. Clin Imaging 55:41-6 https://doi.org/10.1038%2Fs41598-021-82141-3

[55] Vourtis A (2019) Three-dimensional automated breast ultrasound: Technical aspects and first results. Diagn Interv Imaging 100:579-92 https://doi.org/10.1016/j.diii.2019.03.012

[56] Xu Z, Gertz AL, Burke RP, Bansal N, Kang H, Landman BA, Abramson RG (2016) Improving spleen volume estimation via computer-assisted segmentation on clinically acquired CT scans. Acad Radiol. 23(10):1214-20. https://doi.org/10.1016/j.acra.2016.05.015

[57] Gotra A, Sivakumaran L, Chartrand G, Vu K-N, Vandenbroucke-Menu F, Kauffmann C, Kadoury S, Gallix B, de Guise JA, Tang A (2017) Liver segmentation: indications, techniques and future directions. Insights into Imaging. 8(4):377-92. https://doi.org/10.1007%2Fs13244-017-0558-1

[58] Hu HH, Nayak KS, Goran MI (2011) Assessment of abdominal adipose tissue and organ fat content by magnetic resonance imaging. Obes Rev. 12(5):e504-15. https://doi.org/10.1111/j.1467-789x.2010.00824.x

How to Cite;

Ertem ŞB, Malçok ÜA (2024) The Relationship Between Breast Volume and Thoracic Kyphosis Angle. 30(2):125-135. Eur J Ther. https://doi.org/10.58600/eurjther1907