The Methods of Postural Assessment used for Breast Cancer: A Narrative Review

Meme Kanseri için Kullanılan Postüral Değerlendirme Yöntemleri: Bir Derleme

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ABSTRACT

Asymmetry and postural changes can be triggered after breast cancer treatment, which is the most common type of cancer among women. The posture disorders, which can often be ignored can cause different pathologies of the musculoskeletal system. Moreover, these may adversely affect psychology and body image. Cancer patients are a most sensitive group though cancer treatments have many side effects such as chemotherapy, radiotherapy, and surgery. One of the most common side effects is postural changes which needs to be assessed carefully and detailly in all individuals. There are several studies on postural changes in breast cancer survivors in the literature; thus, various postural evaluations and different treatment methods have been used. However, there is no consensus on the gold standard evaluation method or a comparison study of the reliability of the methods in this patient group. The aim of this narrative review is to contribute to the literature while discussing which method could be preferred by summarizing the methods of postural assessment used for breast cancer. In accordance with this purpose, comprehensive searches were made using different keywords in different electronic databases such as PUBMED, Google Scholar, and EBSCO. As a result of the search, evaluation and treatment studies using different evaluation methods for posture in breast cancer were determined and examined. In our study, the advantages and disadvantages of all these methods are summarized in order to contribute to clinical practice of this subject, owing to the fact that there are limited data in the literature.

Keywords: Biomechanics, breast cancer, mastectomy, methods, posture.

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Kadınlarda en sık görülen kanser türü olan meme kanseri tedavisi sonrası asimetri ve postüral değişiklikler tetiklenebilir. Çoğu zaman göz ardı edilebilen postür bozuklukları, kas-iskelet sisteminde farklı patolojilere neden olabilir. Ayrıca bunlar psikolojiyi ve beden imajını olumsuz etkileyebilir. Kanser hastaları hassas bir gruptur ve kemoterapi, radyoterapi, cerrahi gibi kanser tedavilerinin birçok yan etkisi vardır. En sık görülen yan etkilerden biri, tüm bireylerde dikkatli ve ayrıntılı olarak değerlendirilmesi gereken postür değişiklikleridir. Literatürde meme kanserinden sağ kalanlarda postüral değişikliklerle ilgili çeşitli çalışmalar bulunmaktadır; bunun için çeşitli postüral değerlendirmeler ve farklı tedavi yöntemleri kullanılmıştır. Ancak bu hasta grubunda altın standart değerlendirme yöntemi veya yöntemlerin güvenilirliğinin karşılaştırılması konusunda bir fikir birliği yoktur. Bu anlatı incelemesinin amacı meme kanserinde kullanılan postüral değerlendirme yöntemlerini özetleyerek hangi yöntemin tercih edilebileceğini tartışırken literatüre katkıda bulunmaktır. Bu amaç doğrultusunda PUBMED, Google Scholar, EBSCO gibi farklı elektronik veri tabanlarında farklı anahtar kelimeler kullanılarak kapsamlı aramalar yapılmıştır. Araştırma sonucunda meme kanserinde postür için farklı değerlendirme ve tedavi yöntemlerinin kullanıldığı çalışmalar belirlenerek incelenmiştir. Çalışmamızda literatürde sınırlı veri bulunan bu konunun klinik pratiğine katkı sağlamak amacıyla tüm bu yöntemlerin avantaj ve dezavantajları özetlenmiştir.

Anahtar Sözcükler: Biyomekanik, meme kanseri, mastektomi, yöntemler, postür.

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ÖZET

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INTRODUCTION

Breast cancer (BCa) is the most common type of cancer among women (1). According to the World Health Organization's 2020 data, more than 2.3 million people were diagnosed with BCa globally (2). Due to developing technology, medical innovations, and enchanced early diagnosis opportunities, survival rates after BCa is increasing day by day (3). BCa has such a global impact. It is often attempted to be controlled by surgery and subsequent adjuvant treatments. Breast-conserving treatments such as sentinel lymph node biopsy and radiotherapy can be applied. The primary treatment method is surgery, in which the surrounding tissues are removed as well as the breast tissue in different proportions based on needs (4, 5). Mastectomy or different reconstructive procedures can be inevitable (6). Although these methods to be applied often lead to variable contraindications (3).

The removal of breast tissue at different rates according to the type of surgery adversely affects the body biomechanics. Especially in radical mastectomy, which is a less frequently preferred method today, the removal of muscle groups in the relevant region affects this biomechanics much more. The most important factor causing this biomechanical change is postural disorders due to complications such as marked asymmetry in soft tissue and changes in mass distribution on the chest wall. Apart from these, other complications that occur directly related to surgical and post-surgical treatments are pain, fibrosis and limitation of movement (7). Thus, in order to cope with post-treatment complications in addition to surgical revision techniques and adjuvant treatments, assessments and preventive-therapeutic rehabilitative interventions for postural changes are very important. However, these changes are often overlooked.

Radiotherapy can also be a secondary cause that leads to postural changes with some possible side effects. After radiotherapy, radiation fibrosis can be developed in the long term and cause changes on the tissue level (3). Studies in the literature have shown that radiotherapy affects functional parameters such as range of motion and muscle strength in the shoulder joint as the primary cause (8). Different potential causes have also been suggested for these dysfunctions, which are thought to be caused by radiotherapy in the long term, such as damage on nerves and muscle atrophy in this region (9, 10). In addition to radiotherapy side effects on posture and joint range of movement, it has been reported that pain, which can occur after mastectomy, can negatively affects individuals at the functional level by limiting shoulder joint movements (11).

In many studies, postural/biomechanical changes of upper body posture, shoulder and spinal alignment have been mentioned. These changes occur in the upper body, and this is introduced as "upper body morbidity" in the literature. (3, 8, 12-14). In addition to these, changes in foot posture after breast-conserving surgery and mastectomy have also been investigated in a few studies in the literature (15, 16).

Although there are many studies in the literature in which postural changes were evaluated from different perspectives after surgical interventions such as mastectomy, lumpetectomy, and breast-conserving surgery, no standardization has been achieved in terms of evaluation methods. Evaluations in these studies range from observational evaluation to biophotogrammetric methods in which different software were used (3, 12-14, 17-20). The aim of this narrative review is to investigate posture assessment methods used for BCa patients. For this purpose, comprehensive searches were made on different electronic databases including PUBMED, Google Scholar, EBSCO. Searches were performed using different keywords: "breast cancer" AND posture*mastectomy* AND posture* etc.

To analyze the postural assessment methods used in BCa in this narrative review, a total of 36 studies evaluating posture in BCa survivors were examined. Approximately 69% of the reviewed studies did not involve any intervention, and were based only on evaluation and comparisons. In approximately 80% of the studies, women undergoing unilateral surgery were evaluated, and in approximately 83% otf the studies there was no mention of dominance, a confounding factor that could greatly influence the interpretation of results. In addition, in most of the studies reviewed, only *mastectomy* was reported as the type of surgery, and the type of mastectomy were not specified.

Spinal posture was evaluated in approximately 53% of studies. Apart from these, there were also studies that performed the evaluation of the shoulder additional to the spine, general postural assessment, including the pelvis, shoulder and neck region, or specifically evaluated only foot posture. Photogrammetric assessment was mostly used as the evaluation method, followed by studies used other methods (Spinal Mouse, superficial electromyography (EMG), visual inspection, Moire apparatus, flexicurve, etc.) and examining radiography.

The studies on this subject, which are considered in this narrative review and the postural evaluation methods in them are given in Table 1.

Table 1. Methods used for postural assessment in the studies reviewed.

Authors/Year	The Method of Postural Assessment [Device/Software]	Characteristics of Subjects
Rostkowska et al. 2006 (13)	Photogrammetric assessment used of Moiré topography [N/A]	Unilateral & bilateral M and Healthy control Adjuvant treatment (N/A)
Bąk, 2008 (21)	Photogrammetric assessment [N/A]	Unilateral RM Adjuvant treatment (N/A)
Bąk & Ciesla, 2009 (22)	Computerized photogrammetry [N/A]	Unilateral RM+IBR and RM+IBR using Becker-25 prosthesis Adjuvant treatment (N/A)
Malicka et al. 2010a (23)	Photogrametric assessment [N/A]	Unilateral & bilateral Patey RM or BCT Adjuvant treatment (Radiotherapy, chemotherapy or hormone therapy)
Malicka et al. 2010b (24)	Photogrammetric assessment [Computer-aided Posture Evaluation]	Unilateral & bilateral MRM or BCT Adjuvant treatment (Radiotherapy, chemotherapy or hormone therapy)
Ciesla & Polom, 2010 (14)	Photogrametric assessment [3 Dimensional (3D) body surface analysis]	Unilateral RM and IBR with expander-prosthesis Becker-25 Adjuvant treatment (Chemotherapy, hormone therapy)
Hanuszkiewicz et al. 2011 (25)	Photogrammetric assessment [N/A]	Unilateral & bilateral MRM/ BCT Adjuvant treatment (Radiotherapy, chemotherapy or hormone therapy)
Haddad et al. 2013 (3)	Photogrammetric assessment [Posture evaluation software: Posturograma Clinico, Fisiometer, version 2.8]	Unilateral Total, RM, MRM with ALND+Underwent radiotherapy
Barbosa et al. 2013 (26)	Biophotogrammetry [CorelDraw® Software]	Unilateral M/quadrantectomy Adjuvant treatment (Radiotherapy or chemotherapy)
Hanuszkiewicz et al. 2015 (18)	Photogrammetric assessment [Computer Body Posture Diagnosis Device: USB version with the 87 CQ-PostureUSB for Windows XP software]	Unilateral & bilateral M Adjuvant treatment (Radiotherapy, hormone therapy or chemotherapy)
Glowacka et al. 2015 (27)	Photogrammetric assessment [CAPS with Moiré fringe analysis]	Unilateral M/BCT with sentinel node dissection
Hojan et al. 2016 (28)	Electromyography activity of erector spinae muscles with four different weights of breast prosthesis using a 4-channel EMG device [No- raxon TeleMyo 400, Noraxon, Scottsdale, AZ, USA; MyoResearch Master Edition 1.06 XP software]	Unilateral MRM Adjuvant treatment (Radiotherapy)

Table 1. Methods used for studies postural assessment in the reviewed (continued)

Ribeiro et al. 2016 (29)	Computerized photogrammetry	Unilateral Late RM/RM+silicon prothesis
Karczewska et al. 2016 (30)	Photogrammetry assessment [MORA 4th Generation System]	Unilateral Total M Adjuvant treatment (Radiotherapy and/or chemotherapy)
Rahimi et al. 2016 (31)	A simple device [A 60-cm-long flexicurve]	Side of the surgery: N/A M Adjuvant treatment: N/A
Loudon et al. 2016 (32)	A video analysis software [Quintic™ Sports Biomechanics Video Analysis Software (9.03 version 14; Quintic Consultancy Limited; www.quintic.com)]	Unilateral M/BCT (Lumpectomy) Adjuvant treatment (Radiotherapy and chemotherapy) Stage 1 secondary lymphoedema
Lewis & Cunningham, 2016 (33)	Visual inspection [N/A]	Unilateral breast lumpectomy+5 weeks later M+SLND Didn't receive any adjuvant treatment (Radiotherapy or chemotherapy)
Serel et al. 2016 (34)	Chest radiography [Cobb Angle]	Unilateral M Adjuvant treatment: N/A
Glowacka et al. 2017 (35)	Posturometric examination [Moiré system]	Unilateral Patey M/BCT Adjuvant treatment (Radiotherapy, chemotherapy, hormone therapy)
Glowacka Mrotek et al. 2017 (16)	A non-invasive device for computer analysis of the plantar surface of the foot [CQ-ST device by CQ Electronic system]	Unilateral M Adjuvant treatment (Radiotherapy, chemotherapy, hormone therapy)
Hojan & Manikowska, 2017 (36)	SEMG for 7 posture tests: Trunk flexion, sagittal extension, extension/flexion ratio, rotation right, rotation left, lateral flexion right, lateral flexion left [A 4-channel SEMG device (Noraxon TeleMyo 400, Noraxon, Scottsdale, AZ, US)]	Unilateral MRM Adjuvant treatment: N/A
Jeong et al. 2018 (37)	Chest radiography [Cobb Angle]	Unilateral M and IBR Adjuvant treatment: N/A
ACAM Peres et al. 2017 (38)	A postural analysis software/software de análise postural [PAS/SAPO (version 0.68)]	Unilateral M alone/ M+IBR with abdominal flap Adjuvant treatment: N/A
Glowacka-Mrotek et al. 2018 (15)	A computer-based foot analysis tool as an extension of projection moiré (CQ Electronic)-based podoscopic examination [N/A]	Unilateral BCT surgery with SLNB or ALND Adjuvant treatment (Radiotherapy and/or chemotherapy)
Mangone et al. 2019 (12)	A device for spine postur evaluation [Formetric-4D rasterstereographic system (DIERS, International GmbH, Schlangenbad, Germany)]	Unilateral M Use of breast prostheses or tissue expanders after mastectomy Adjuvant treatment (Radiotherapy, chemotherapy)
Lang et al. 2019 (39)	An optoelectronic infrared cameras system [10 VICON MX20 (Vicon Motion Systems, Oxford, UK)]	Unilateral &bilateral M at least 6 months prior to participation Adjuvant treatment (Radiotherapy, chemotherapy)
Tan & Wilson, 2019 (40)	Visual inspection [N/A]	Unilateral lumpectomy + re-excision of the breast 4 weeks after lumpectomy Neoadjuvant chemotherapy Adjuvant treatment (Radiotherapy)
Lopera-Muñeton et al. 2019 (41)	Videography and photometry for posture analysis [Adibas posture software] Paravertral muscle activity with SEMG [SEMG Biometrics Myon]	Unilateral M Adjuvant treatment: N/A
Surmeli et al. 2019 (42)	A scale for posture evaluation [New York Posture Rating Chart]	Unilateral M/BCT with and without lymphedema Adjuvant treatment (Radiotherapy, chemotherapy)
Gutkin et al. 2020 (43)	Radiography [Cobb Angle]	Unilateral & bilateral M/IBR Diagnosis of scoliosis Adjuvant treatment (Radiotherapy, chemotherapy, hormone therapy)
Çelenay et al. 2020 (44)	A computer-assisted and non-invasive device [Spinal Mouse®(Idiag, Volkerswill, Switzerland)]	Unilateral RM with the diagnosis of secondary arm lymphoedema Adjuvant treatment (Radiotherapy and chemotherapy)
Tanrıverdi et al. 2020 (45)	Radiography [Cobb Angle]	Unilateral BCT/MRM Neoadjuvant chemotherapy Adjuvant treatment (Radiotherapy, chemotherapy, hormone therapy)
Kabala et al. 2020 (46)	A completely non- invasive device [DIERS formetric III 4D optoelectronic method]	Unilateral RM Adjuvant treatment (Radiotherapy, chemotherapy, hormone therapy)
Hanuszkiewicz et al. 2021 (47)	Posturometric examination [Moiré apparatus (CQ Electronic System, Wroclaw, Poland)]	Unilateral RM/BCT Adjuvant treatment (Radiotherapy, chemotherapy, hormone therapy)
Glowacka-Mrotek et al. 2021 (19)	Photogrammetric assessment [N/A]	Unilateral BCT+ALND/SLND Adjuvant treatment (Radiotherapy, chemotherapy)
Lee et al. 2021 (20)	Radiography [Cobb Angle using the Picture Archiving and Communication System (PACS, INFINITT®)] Photogrammetric assessment CT using the PACS An 3D scanner [Artec 3D scanner using the PACS]	Unilateral M alone/IBR with Latissimus Dorsi flap Adjuvant treatment (Radiotherapy, chemotherapy, hormone therapy)

N/A: No answer; M: Mastectomy; RM: Radical mastectomy; MRM: Modified radical mastectomy; BCT: Breast-conserving therapy; IBR: Immediate breast reconstruction; SLND: Sentinel lymph node dissection; ALND: Axillary lymph node dissection; 3D: three dimensional; CAPS: Computer-assisted postural assessment system; ROM: Range of motion; SEMG: Surface electromyography; CT: Computed tomography.

Besides the cancer population, some studies evaluates the effects of breast reduction surgery on posture and gait in women with large breasts have focused on spinal posture and, interestingly, on pelvic tilt angle. More improvement in anterior pelvic tilt and anterior spine flexion was observed in women who underwent more resections, but it was reported that these results could not be statistically demonstrated due to the small number of patients (48). Apart from this, in another similar study, significant improvements were observed only at the pelvic level. However, improvements were also reported especially at the level of the shoulders and trunk as a result of the effect size analyses (49). This improvement can actually be attributed to a more symmetrical posture in women after resection, and the pathomechanics of postural changes can be understood more clearly when the cancerous population who often undergo mandatory asymmetric/unilateral surgery are considered.

In addition to many different surgical procedures applied in the cancerous population, reconstruction with the latissimus dorsi flapper formed in a short time after mastectomy is a frequently preferred method in recent years. In a recent study examining the postural changes and functional results that may occur with this method, postural parameters have been evaluated with four different methods (Cobb angle, photometry, computed tomography (CT), and 3D scanning) for three times: preoperatively, 6 and 12 months after surgery. Besides biomechanical evaluations, individuals were also evaluated in terms of some functional parameters, and it was reported that there was more improvement in spinal asymmetry in the frontal plane in the group that underwent reconstruction after mastectomy compared to the group that underwent only mastectomy (20).

The methods frequently used for postural assessment in different studies in the literature are as follows; biophotogrammetry, 4D raster stereographic system, radiography, etc. Some details of the assessment methods are given in the following sub-sections.

1- Biophotogrammetry (Photogrammetric assessment)

'Photogrammetric assessment' or *'biophotogrammetry'* were used for postural evaluation in 42% of the studies we have examined. Biophotogrammetry is a method that includes biomechanical analysis by taking an image of the static posture and using different softwares today. In fact, this method was used in a simplier version and has been used quite frequently, especially in recent publications on posture. The reason for this may be its high validity and reliability (50, 51). The most important advantages of this method are as follows:

1. It enables whole body analysis by using the same photograph
2. It increases the reliability of inter-rater measurements with the same landmarks determined in the relevant photograph (52).
3. It is harmless compared to direct radiography containing X-rays for postural evaluation in the sensitive group of BCa survivors who have undergone different adjuvant treatments in addition to surgery (19).

Therefore, it can be shown as the best alternative to radiography, which is the gold standard in spinal evaluation. However, for a good and reliable assessment;

- Equipment's and the individual's position should be correct,
- The subject should maintain her/his position during the analysis,
- The evaluation should be carried out properly,
- Illuminated environment should be provided,
- The photo quality should be high and distorsion-free,
- Patient privacy should be considered (24, 53).

2- 4D immersional raster stereographic system (4D immersional optoelectronic method)

In addition to biophotogrammetry, analysis with a *'4D raster stereographic system'* or *'4D optoelectronic method'* is similar to this method but creates a 3D model of the image. This method is an alternative method that can be preferred for postural evaluation (54). It is possible to calculate especially spinal curvatures and anatomical landmarks, while taking into account the anatomical-biomechanical assumptions of the 3D models created by this method. It is based on the analysis of data obtained from a photogrammetric video recording of the posterior of the body (55). Simply, after the parallel light beam emanating from a projector light source is projected onto the patient's back. This 3D modeling is performed as a result of recording and analyzing the image of these strips on the body surface by a camera. These models can be performed with different surface analysis methods (12). Just like biophotogrammetry, this method does not contain X-rays and this may be the reason for preference as an ideal method for posture analysis in the cancer population. However, the most important disadvantages of this complicated system are that it is quite expensive and requires expert personnel for its use (56, 57).

3- Radiography

Direct radiography is still frequently used in the postural evaluation of individuals with BCa although it is known to be a sensitive group (34, 37, 43, 45). In the direct radiography method, spinal posture was evaluated by calculating the *'Cobb angle'* on chest radiographs or scoliosis radiographs, often retrospectively.

Cobb angles were retrospectively examined in chest radiographies before and 12 months after mastectomy in the study conducted by Serel et al., which investigated the physical effects of unilateral mastectomy on spinal deformity. As a result of the study, it has been shown that long-term spinal deformations can develop in women with unilateral mastectomy. It has been suggested to inform patients about these changes that may be limited by physiotherapy (34).

In another study examining chest radiographs retrospectively, the effect of immediate breast reconstruction after unilateral mastectomy on thoracic spinal alignment was examined (37). Preoperative and two-year postoperative chest radiographs of patients were reviewed. In the scope of this study, the direction of the spinal curvature, its upper and lower ends, the length of the curve as well as the Cobb angle were measured and compared between mastectomized individuals with and without reconstruction. It was reported that the amount of change in spinal alignment was less in the group that underwent immediate reconstruction in addition to mastectomy compared to those who underwent mastectomy alone. Based on these data, it was stated that the reconstruction had a positive effect on the spinal alignment.

In a recent study; the medical records of mastectomized individuals diagnosed with scoliosis have been retrospectively reviewed. Just like other studies, Cobb angle was measured in this study on chest radiographs or scoliosis radiographs taken before and up to 6 months after mastectomy in medical records. As a result of the study, it has been reported that Cobb angle increased significantly after mastectomy. In addition, unlike many studies in the literature conducted on only unilateral mastectomized individuals, bilateral mastectomized individuals were also examined in this study. Although not significant, it has been stated that the difference in Cobb angles was greater in patients who underwent unilateral mastectomy compared to those of patients with bilateral mastectomy. It was also reported that the change in Cobb angle was higher in proportion to the size of the breast mass removed in this group (43). In terms of the known biomechanical effects of mastectomy, especially on the spine, it can be stated that individuals who have had a previous spinal deformity are at a higher risk.

4- Computed Tomography

In a quite current retrospective analysis (45) dated 2021, the effect of breast surgery on body posture after cancer treatment in patients with early-stage BCa has been investigated. In order to determine the thoracic kyphosis angle and other changes in body posture due to the primary affected region, the "*Cobb Method*" was used in this study, similar to those in the literature. However, in the analyses, unlike the literature, CT images performed for routine follow-up were used, not direct radiography. A significant increase in thoracic kyphosis angle in relation to age and body mass index was reported within 2 years after treatment.

5- Other Assessment Methods

In addition to all these objective and gold standard methods, different methods have been used in postural-biomechanical evaluations in the literature. Here, these methods and studies using these methods will be mentioned.

- **Flexicurve:** A study that compared thoracic kyphosis and lumbar lordosis in BCa survivors and healthy controls used a 60-cm-long flexicurve for biomechanical assessments.

According to the results of the study, it has been reported that BCa survivors have a greater angle of thoracic kyphosis than healthy subjects. Appropriate rehabilitative interventions, diet, and physical activity have been recommended to cope with this complication, which is correlated with the increase in age and body mass index and necessary to achieve postural improvement (31).

- **Electromyographic Activity of Spine Muscles:** In the study by Hojan et al., dated 2016, examining the effects of external breast prosthesis on the posture of women after mastectomy, electromyographic activities of bilateral erector spinal muscles were determined using a 4-channel EMG device for postural evaluation. Muscle activity was recorded using surface EMG in an unloaded standing position whilsewearing four different weights of breast prostheses during a standardized posture task. Also, the evaluations were made without shoes in order to eliminate the possible effects of the shoe type. As a result of the study, it was reported that the activation of the muscles on the operated and non-operated sides differed significantly, and the muscle activation on the non-operated side was higher. In addition, muscle activation imbalance between the two sides was measured less in those operated on the left side. However, it has been stated that the weight of the external breast prosthesis is not effective on this muscle imbalance (28).
- **Balance Board System:** A recent pilot study has examined dynamic body posture after mastectomy. The Balance Board System used in this study is actually a hemispheric unstable board consisting of an accelerometer and photosensor for measuring the inclination angles of the body in the sagittal and frontal axes. In addition, during this evaluation, the activation of the thoracic and lumbar erector spinae and lumbar multifidus muscles has also been measured using superficial EMG. Results of the study indicated that, in right-dominant women with BCa, right unilateral mastectomy caused more postural changes in dynamic sitting position compared to left mastectomy. For this reason, the importance of appropriate postoperative exercise programs was emphasized in order to maintain posture and trunk balance after unilateral mastectomy (17).
- **3 Dimensional Scanner:** In a study, along with Cobb Method, computed tomography, and photometry for postural assessment 3D scanner was also used. In this study, it was emphasized that the use of a 3D scanner is an adequate tool to determine the effects of reconstruction on posture (20).
- **New York Posture Rating Chart:** In another study, the relationship between upper extremity function, posture, and quality of life in women with and without lymphedema after BCa were examined. The New York Posture Rating Chart, in which 13 different body regions are scored according to 3 different degrees of postural change, was used for posture assessment in the study. Accordingly, 5 points are given if the posture is good, 3 points if it is moderately impaired, 1 point if it is severely impaired, and the total score that the subject can achievesvaries between 13 and 65. High scores indicate good posture. According to the results of the study, it was reported that women with lymphedema after BCa surgery had worse posture, quality of life and upper extremity functions than those who did not develop lymphedema. It has also been stated that the severity of postural changes is associated with poor quality of life (42).
- **Moiré Apparatus:** In a study the effect of nordic walking on isokinetic trunk muscle strength and sagittal spinal curvatures in women after BCa treatment were investigated. For the evaluation of sagittal spinal curvatures, the Moiré apparatus, which is based on direct observation with the use of a camera, was used in this study. As a result of the study, it has been reported that Nordic Walking has positive effects on both trunk muscle endurance and sagittal spinal curvatures in women. It has also been stated that this exercise significantly reduces thoracic kyphosis in middle-aged women following BCa treatments (47). Another study using the Moiré system also evaluated postural changes in the sagittal plane after different surgical techniques in female patients with BCa. It has been reported that women undergoing breast-conserving surgery have less postural deviations compared to women with mastectomies. However, the necessity of physical therapy for the postural alignment of both groups has been emphasized (35).
- **Spinal Mouse:** A recent study compared the spinal alignment and mobility in healthy controls and women with unilateral lymphedema after mastectomy. A spinal mouse which is a computer-assisted non-invasive device was used for postural evaluation. As a result of the study, it was reported that women with unilateral lymphedema after mastectomy had a greater thoracic kyphosis angle and inclination towards the unaffected side in the frontal plane compared to healthy controls. Inclination to the healthy side may have developed due to the asymmetry after mastectomy and the weight of the existing breast tissue. It has been emphasized that possible changes in spinal alignment and mobility in both sagittal and frontal planes should be considered after mastectomy (44).
- **Visual Inspection:** In a case report, clinical results after physiotherapeutic treatments for secondary lymphedema developing after BCa were examined. A 64-year-old woman with stage 2A BCa underwent neoadjuvant chemotherapy, lumpectomy with 18 lymph nodes were removed, and radiation therapy was performed. After this treatment process, a number of physiotherapeutic interventions were applied for secondary lymphedema developing in the right breast and upper extremity. In addition to objective evaluations such as joint range of motion (goniometer), anthropometric measurements (tape measure) for the evaluation of clinical effectiveness, and postural evaluation were performed subjectively by observation. As a result of the study, the importance of early diagnosis and physiotherapy interventions was emphasized (40). Furthermore, in another case report, dynamic angular petrissage was used in the treatment of axillary web syndrome after BCa surgery. The postural evaluation of the case was made with visual inspection in this study (33).

Besides these, there are studies in the literature that evaluated posture from different perspectives using many different evaluation methods. A recent study published in 2021, in which 4 different evaluation methods (Cobb's angle assessment in spine X-rays, protogrammetry, CT and 3D scanning) (20).

All these evaluation methods have different advantages and disadvantages (Table 2). These advantages and disadvantages may determine which method will be preferred in individuals undergoing BCa treatment. For example, the photogrammetric method is the most commonly used method in the postural evaluation of this population in many studies in the literature due to its important advantages such as not containing X-rays and reproducibility. In other words, the most important and sensitive point when choosing the evaluation method is to protect and not tire the individuals who have already gone through a long and radical treatment process as much as possible.

Table 2. Clinical advantages and disadvantages of different postural assessment methods used in BCa survivors.

Assessment Method	Advantages	Disadvantages
Biophotogrammetry (Photogrammetric assessment)	✓ Does not contain X-rays (harmless) ✓ It enables whole body analysis by using the same photograph ✓ Increases the reliability of inter-rater measurements with the same landmarks determined in the photograph ✓ Repeatability	⊗ Expensive ⊗ Complex ⊗ Not portable
4D raster stereographic system (4D optoelectronic method)	✓ Does not contain X-rays (harmless) ✓ Makes a map of the spine ✓ Repeatability	⊗ Quite expensive ⊗ Requires expert personnel ⊗ Complex ⊗ Not portable
Radiography	✓ Gold standard method in the detection and evaluation of spinal curvatures	⊗ Contain X-rays ⊗ Not portable ⊗ Less repeatable
Computed Tomography	✓ Another gold standard method other than radiography	⊗ Contain X-rays ⊗ Not postable ⊗ Less repeatable
Flexicurve	✓ Simple ✓ Practical ✓ Low cost ✓ Portable ✓ It has the capacity to provide assessment of spinal curvature in a continuous line and not only specific points ✓ It has a flexible structure that can be molded to the back of the subject to replicate the shape of the spine.	⊗ Limited in spinal curvature measurement at isolated levels ⊗ Less inter-rater validity than other methods
Electromyographic Activity of Spine Muscles (sEMG)	✓ Does not contain X-rays ✓ Showing muscle activations ✓ Repeatability	⊗ Does not directly assess postural parameters
Balance Board System	✓ With the EMG integrated into the system, it offers the opportunity to evaluate both muscle activations and the angular parameters of the trunk.	⊗ Expensive ⊗ Complex
3D Scanner	✓ Does not contain X-rays (harmless) ✓ Sufficient to show the effects of reconstruction on spine posture ✓ Repeatability	⊗ Expensive ⊗ Not portable
New York Posture Rating Chart	✓ Simple ✓ Practical ✓ Portable ✓ Repeatability	⊗ A method based on subjectıve data compared to other methods
Moiré Apparatus	✓ Does not contain X-rays (harmless) ✓ Repeatabilitiy	⊗ Expensive ⊗ Complex ⊗ Not portable
Spinal Mouse	✓ It provides the evaluation of the spine in static posture. ✓ It also provides the opportunity to measure the dynamic mobility of the trunk. ✓ Simple use ✓ Portable ✓ PrRepeatability	⊗ Expensive ⊗ It allows to evaluate the spine posture only in the sagittal and frontal planes.

CONCLUSION

In this study, attention was drawn to the issue of postural evaluation in BCa, which has limited information in the literature and is often overlooked. The methods used for postural assessment of BCa survivors in the literature were visual evaluation and the New York Posture Rating Chart; imaging methods such as radiography and CT; small devices such as flexicurve and spinal mouse, as well as much more complex and computer-based devices such as Moiré Apparatus, Balance Board System, photogrammetric assessment, 3D scanners, 4D raster stereographic system. The most commonly used methods were radiographic Cobb Angle measurement and photogrammetric methods.

Although the Cobb angle measurement seems to be the most practical method with high objectivity in clinical use, in fact, some of the photogrammetric methods are also very practical approaches. It should be decided which of the methods to be used, taking into account their advantages and disadvantages. There is a neccessarity for further research on this subject and for the development of different methods, especially for this sensitive patient group. In conclusion, posture and biomechanical factors should not be ignored in BCa. With a holistic perspective, it should be considered as a part of the evaluation and treatment process.

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

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