Body posture and biomechanics in women after mastectomy

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Abstract. Breast cancer is the most frequently diagnosed cancer among women. Breast cancer has shown survivorship rate improvements due to technology, early diagnosis and better treatments than before. As breast cancer survivors are living longer, there has been greater focus on understanding the side treatment effects. Women following mastectomy displayed several postural and biomechanical alterations. The major problem in women after mastectomy, besides upper limb dysfunction, are disorders in the trunk area, specially the thoracic kyphosis, which has an influence on the formation of functional disorders in the median part of the spine. The current research describes the postural and biomechanical alterations after mastectomy in breast cancer patients and review the evidence regarding the possible effect of external prosthesis in corporeal biomechanics and functionality. Results showed a tendency of muscle imbalance and shoulder and neck asymmetry.

1. Introduction

Breast cancer is the most frequently diagnosed cancer (excluding non-melanoma skin cancer) among women worldwide. Between 2008 and 2018 breast cancer incidence increased by 20\%, while mortality has increased by 14\% [1].

The term “breast cancer survivors” denotes women who have received a diagnosis of cancer, from the point of diagnosis, through and after treatment [1]. The cancer survivor statistics have changed for the last years. In the United States, there are 3.1 millions of breast cancer survivors. From 2007 to 2013, there were 90\% of breast cancer survivors [2]. This tendency of survivorship improvements is due to technology, early diagnosis and better treatments than before. Therefore, more women will need oncology rehabilitation [3].

As breast cancer survivors are living longer, there has been greater focus on understanding the side effects of treatment and taking steps to mitigate them during and after medical interventions. Women after mastectomy displayed several postural and biomechanical alterations. Such as altered patterns of scapular rotation in all planes of movement compared with controls. In particular, the scapula on the mastectomy side rotated upward to a greater extent than that on the non-mastectomy side, resulting in scapular excursion [4].

As demonstrated by Crosbie, et al. [4], the asymmetry in shoulder position due to surgery leads to disturbed kinematics of the spine. Individual elements of the human motor system are closely related to one another. Following mastectomy for breast cancer, many women experience impairment in shoulder movements that can substantially affect their everyday function and quality of life. Although some symptoms, such as arm swelling due to lymphedema, are easily accounted for, other symptoms, such as
chronic ache and pain, which women report in the shoulder and upper trunk months to years after surgery, are left untreated [4].

The asymmetry of both soft tissue motility and mass distribution across the chest wall that arises from the loss of a breast, potentially could affect upper limb movements and contribute to trunk or arm symptoms. Previous research has identified that there can be changes in the size and activation of muscles around the upper trunk consequential to surgery for breast cancer, and soft tissue contracture may result from protective posture and movement [5].

After the mastectomy, the provision of an appropriate breast prosthesis can help to improve body image and quality of life and reduce associated emotional distress [6]. Breast cancer patients experience physical symptoms and psychosocial distress that adversely affect their quality of life (QOL) [7].

The current research is about the postural changes and the study of the biomechanics associated with mastectomy. The physical and functional activity of female patients after surgical treatment is reduced. This may lead to adverse changes within the motor system such as disturbed symmetry of shoulders and reduced range of motion of the upper limb within the shoulder joint (also due to irradiation of the region). These effects may also be due to the reflexive pain-avoiding alignment of the limb. Disturbing range of motion within the shoulder joint is experienced by patients having undergone both lumpectomy and mastectomy [8]. Therefore, this study pretends to describe the postural and biomechanical alterations after mastectomy in breast cancer patients and review the evidence regarding the possible effect of external prosthesis in corporal biomechanics and functionality.

2. Experimental procedure
A descriptive correlational study was carried out, through which the main postural, muscular and balance alterations were identified in 10 women with unilateral mastectomy. By interpreting the results obtained in 4 tests applied to patients, which included: videography and photometry for posture analysis with Adibas posture software see Figure 1.

![Figure 1. Adibas posture.](image)

Measurement of the upper limb muscle strength with dynamometer biometrics datalife H500. Paravertral muscle activity and functional status with sEMG Biometrics Myon (Surface electromyography). Figure 2 and Figure 3. And balance measurement during the modification of the support base with plates pressure Ecosanit foot. Figure 4.

The effect of the breast absence on the posture and conditions of biomechanics of women undergoing this type of procedure was established through a comparative statistical analysis between the healthy side and the affected side. The variables were analyzed through SPSS statistical software such as weight, height, joint angles, center of gravity displacement, load vectors and dynamic movements.
Figure 2. Dynamometer biometrics.  
Figure 3. sEMG biometrics myon.  
Figure 4. Plates ecosanit foot.

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3. Results and discussion

3.1. Participants characteristics
Ten patients with a history of breast cancer were included in the study. All the patients had undergone a mastectomy. The baseline characteristics are described in Table 1.

| Baseline characteristics of the participants | Volunteers |
|---------------------------------------------|-------------|
| Parameters                                 | %           |
| Age (years)                                | Mean (SD)   |
| Min-Max                                    | 54.10 (12.087) |
| Socio-economic level                       | 10%         |
| 1                                          | 10%         |
| 2                                          | 30%         |
| 3                                          | 60%         |
| Stage                                      | 10%         |
| I                                          | 10%         |
| II                                         | 30%         |
| IIIA                                       | 40%         |
| IIIB                                        | 20%         |
| IV                                         | 0%          |
| Surgery side                               | 50%         |
| Right                                      | 50%         |
| Left                                       | 50%         |
| Time after mastectomy                      | 50%         |
| 1-3 Months                                 | 50%         |
| 9-12 Months                                | 30%         |
| 13 Months or more                          | 10%         |
3.2. Postural analysis
The mean level of the neck angle in the non operated side was higher (110.63°) compared to the mastectomy side (99.16°), which suggests lateralization of the neck towards the operated side. Analysis showed statistical significant difference between those angles \((p< 0.05)\). Likewise, distance between shoulder and costal flank is higher on the operated side, these results show shoulder elevation. Postural alteration is also observed in the rib cage where the costal flank angle is greater in the operated side.

3.3. Dynamometry
Strength between the non operated side (mean 34.75 lb) and the operate side (mean 35.47 lb) were very similar; this may be due to laterality.

3.4. Surface electromyography
We compared both sides of the trunk (non operated and operated side) at several locations (lumbar, dorsal and cervical). There were some changes in the activity of spine muscles between sides, locations and position tests. For trunk flexion and extension, the lumbar operated zone shows less activation, contrary to the dorsal and cervical location where the operated side activated the most. For the cervical flexion the difference was statistical significant \((p < 0.05)\).

3.5. Baropodometry
Static and mean pressure in the anatomical position showed higher load on the operated side. However, when feet were together load leaned towards the non operated side. All the Tests results are showed in Table 2.

3.6. Discussion
The literature describes several postural and biomechanical alterations in patients with mastectomy due to breast cancer, which articulate with the results of the current study. Numerous studies \([9-12]\) have reported abnormalities in the sagittal plane (thoracic hyperkyphosis) and in the frontal plane (shoulder elevation, asymmetrical position of the scapulae, rib cage alterations and scoliosis). These modifications aggravate symptoms such as postoperative pain, weakness of muscles and involuntary protraction of the shoulder on the operated side, as an attempt to hide the aesthetic defect. The problems are usually greater in patients with more prominent functional deficits. Therefore, psychological tension transfers to the spine via muscles. The resultant overload is transferred onto the vertebrae and onto intervertebral discs, contributing to overload disease and back pain and underlying the development of postural defects. Resulting in a vicious circle \([11]\).

The major problem in women after mastectomy, are disorders in the trunk area, especially the thoracic kyphosis neck lateralization and shoulder asymmetry, which has an influence on the formation of functional disorders in the median part of the spine. Due to the deepening of this curvature pectoralis major and pectoralis minor as well as the abdominal muscles and hip extensors undergo shortening. The pathological alteration of the thoracic kyphosis has an influence on the reduction of muscular flexibility and endurance and, as such, the muscles demonstrate less ability to develop tone, and these may cause functional impairment and pain. From the biomechanics viewpoint, spinal curves in the sagittal plane are particularly important for spinal function. Changes in the degree of curve angles affect the body posture, at the same time impairing the ability of the spine to transfer loads and its normal functioning \([12]\). These changes were observed in our results.

In addition, after the unilateral mastectomy, the removed tissue breaks the body weight distribution. Thus, the trunk had the tendency of lateral bending toward the operated side. As a result, the erector spinae muscle on the non-operative side must increase the static activity to pull the trunk back to the upright midline, possibly causing overloads \([10]\). Authors as Malicka, \emph{et al}, \([12]\) on a randomized control trial found that 82.3% of post-mastectomy women had faulty body postures, compared to only 35.1% of the healthy controls.
Table 2. Tests results: Postural analysis, surface electromyography, dynamometer and baropodometry.

| Frontal plane postural analysis          | Side            | Mean    | Standard deviation (SD) | P value |
|------------------------------------------|-----------------|---------|-------------------------|---------|
| Head flexion                              | Non operated side| 47.7400 | 14.6881                 | 0.500   |
| Head extension                            | Non operated side| 159.0900| 66.3248                 | 0.565   |
| Head flexion                              | Operated side   | 87.3200 | 35.8228                 | 0.367   |
| Head extension                            | Operated side   | 63.5100 | 28.4334                 | 0.705   |
| Right head flexion                        | Non operated side| 181.3200| 53.8443                 | 0.274   |
| Right head extension                      | Non operated side| 158.7600| 33.2633                 | 0.274   |
| Left head flexion                         | Operated side   | 158.5100| 36.7133                 | 0.212   |
| Left head extension                       | Operated side   | 159.0900| 66.3248                 | 0.565   |
| Static load                               | Non operated side| 47.7400 | 14.6881                 | 0.500   |
| Static load                               | Operated side   | 52.2600 | 14.6881                 | 0.500   |
| Mean pressure                             | Non operated side| 178.0900| 66.3248                 | 0.565   |
| Mean pressure                             | Operated side   | 196.7100| 75.5042                 | 0.174   |
| Static load Feet together                 | Non operated side| 52.2900 | 7.24162                 | 0.174   |
| Static load Feet together                 | Operated side   | 47.7100 | 7.24162                 | 0.174   |
| Mean pressure feet together               | Non operated side| 181.3200| 53.8443                 | 0.274   |
| Mean pressure feet together               | Operated side   | 158.7600| 33.2633                 | 0.274   |
| * Statistical significance.              |                 |         |                         |         |

This highlight the proportion of postural alterations caused by the surgery and the oncology treatments. These results are similar to ours, were the erector spinae at the lumbar location showed increased activation at the non-operated side.

In addition to the physical alterations, mastectomy causes a major effect on women’s self-image and a decreased sense of femininity that can lead to anxiety and depression. Therefore, most of the women
select breast restoration and symmetry through breast reconstruction or external breast prosthesis (EBP). A systematic review conducted by Liang and Xu [13] identified that six factors impact EBP use among postmastectomy patients. This includes comfort, appearance, cost of EBP, as well as the survivors’ mental status, fear of reconstructive surgery, and availability of supportive information about EBP. According to Jetha, et al. [14] the patients revealed several reasons of using EBP including sense of incompleteness, staring by others, and shape and symmetry of the breasts. They thought that losing a breast had distorted their body image and affected their womanhood.

Therefore, the prosthesis plays an important role in balance, posture, shape, self-appearance and appearance to others as well as providing a sense of wellbeing, self-confidence and femininity [15]. It has been estimated that about 90% of women undergoing mastectomy use a breast prosthesis permanently or during the waiting time preceding breast reconstruction [11]. Hence, good quality and appropriated fitting of the external breast prosthesis are crucial for women after mastectomy. However, research in this area is very limited. It is still unclear whether the weight of the breast prosthesis affects posture, biomechanics and daily life activities of women after mastectomy [9].

Several authors [16-18] emphasize the role of rehabilitation group in providing support and information to the patients for making decisions about EBP. However, further randomized studies are required with larger sample size.

4. Conclusions
The postural and biomechanical alterations after mastectomy in the sagittal and frontal plane are well described in the current research. The most prevalent modification was shoulder elevation, neck lateralization and muscle imbalance. Likewise, the review showed that the use of EBP is not only important for cosmetic purposes but also for a balanced body posture, increased confidence, and improved quality of life.

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