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Original Article

# Impact of unilateral mastectomy on body posture: A prospective longitudinal observational study

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ABSTRACT

*Objective:* Unilateral mastectomy is known to induce postural alterations, yet the temporal development pattern of these changes remains elusive. This study aimed to explore the impact of unilateral mastectomy on body posture.
*Methods:* A prospective, longitudinal, observational study with a one-group repeated-measures design was conducted. Patients undergoing unilateral mastectomy were recruited from a university-affiliated hospital in Western China and monitored for 12 months post-surgery. A trained nurse assessed seven postural baseline parameters on the day of suture removal and at 3, 6, and 12 months after unilateral mastectomy. Two parameters were in the sagittal plane (forward head posture and trunk rotation angle), and five were in the coronal plane (neck tilt, shoulder asymmetry, scapular asymmetry, scapular asymmetry relative to the spine, and pelvic tilt).
*Results:* The final analysis included 159 patients. Baseline prevalence of most postural abnormalities ranged from 50.94% to 59.75%, with mean deviations between 2.74 and 4.51 mm. At 12 months post-mastectomy, prevalence and mean deviations increased by more than 30% and 3.50 mm, respectively, compared to baseline. Postural abnormalities increased gradually in the first 3 months, notably between the 3rd and 6th months, and slowed between the 6th and 12th months. On the mastectomy side, coronal plane abnormalities significantly increased within 12 months: earlobe to acromion distance (Wald $\chi^2 = 45.283$, $P < 0.001$), depressed shoulder height (Wald $\chi^2 = 42.253$, $P < 0.001$), depressed scapula height (Wald $\chi^2 = 31.587$, $P < 0.001$), scapula to spine distance (Wald $\chi^2 = 45.283$, $P < 0.001$), and elevated pelvic height (Wald $\chi^2 = 48.924$, $P < 0.001$).
*Conclusions:* Postural changes are common post-unilateral mastectomy, with prevalence and deviation increasing gradually, particularly between 3 and 6 months post-mastectomy. Early rehabilitation initiation is recommended to mitigate postural changes.
*Trial registration:* ChiCTR2000040897

## Introduction

According to statistics published by the International Agency for Research on Cancer, the global incidence of breast cancer was 11.7% in 2020, making it the most commonly diagnosed cancer worldwide.[1] Approximately 35.5% of breast cancer patients are treated by mastectomy because of tumor stage, financial problems, and tumor size.[2,3] Breast cancer is commonly regarded as a treatable disease, and the 5-year survival rate is more than 90% in patients undergoing unilateral mastectomy.[4–6] This prolonged postoperative survival time means that patients undergoing unilateral mastectomy will experience more surgery-related complications. Postural changes are a major complication after the unilateral mastectomy. Previous studies have demonstrated that, when compared to patients treated with breast-conserving surgery or immediate breast reconstruction, patients who undergo unilateral mastectomy are more often observed to present the following postural

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abnormalities: a greater trunk rotation angle, a greater change in spinal alignment, more prominent scapula and shoulder asymmetry, and a greater pelvic tilt angle.[7–11] Additionally, in previous studies, patients who underwent unilateral mastectomy had mean height differences of the acromion and the scapula of up to 4.01 and 7.06 mm, respectively, and a mean Cobb angle of up to 6.8° 12 months after unilateral mastectomy.[8,9] Postural abnormalities not only are associated with a worse self-image but also cause somatic symptoms such as back pain and neck pain,[12,13] which reduce quality of life in patients who have undergone unilateral mastectomy. To help medical staff plan targeted rehabilitation training programs to prevent and manage postural changes in unilateral mastectomy patients, it is imperative to have a comprehensive understanding of the impact of unilateral mastectomy on body posture.

The human skeleton is an interconnected whole, and abnormalities in one part will lead to compensatory changes in other parts to maintain body balance.[14] Previous studies have focused on assessing the changes in body posture based on the bony structure of the spine in unilateral mastectomy patients,[7,8,12,15] with less attention to the other skeletal areas and limited guidance for rehabilitation training. In addition, the occurrence and development of postural changes are dynamic processes. However, in most studies, postural assessment was only performed at a single time.[11,16–18] Such a postural assessment is equivalent to a static investigation, in which it is not possible to understand the pattern of the development of changes in body posture over time in patients who have undergone unilateral mastectomy. Although two studies have reported that the mean deviation of postural abnormalities increases over time within 12 months after unilateral mastectomy, more details of particular postural abnormalities,[9,10] such as their onset time and deviation direction, remain unclear.

Postural changes caused by unilateral mastectomy can be prevented with rehabilitation training.[19,20] It is important for medical staff to comprehensively understand the impact of unilateral mastectomy on body posture because it is the starting point for planning proper rehabilitation training programs for such patients. Therefore, we conducted this prospective, longitudinal, observational study with a postural assessment at baseline and at 3, 6, and 12 months after unilateral mastectomy. Our aim was to reveal patterns of the development of changes in body posture over time within 12 months after unilateral mastectomy and to provide multidimensional evidence for medical staff to plan rehabilitation training programs.

## Methods

### *Design and setting*

This was a prospective, longitudinal, observational study with a one-group repeated-measures design. The primary purpose of this study was to investigate the impact of unilateral mastectomy on body postures. This study was conducted at the West China Hospital of Sichuan University, a 4500-bed university-affiliated hospital in Western China.

### *Ethical considerations*

The study was approved by the Institutional Review Board of the West China Hospital of Sichuan University [IRB No. 2019 (564)] and registered on the China Clinical Trial Registry (Registration No. ChiCTR2000040897). All patients provided written, informed consent for research purposes.

### *Participants*

Breast cancer patients admitted to the breast surgery ward and treated with mastectomy were recruited. The inclusion criteria were as follows: (1) age range of 18–80 years; (2) consciousness and ability to communicate orally or in writing; (3) women with a first diagnosis of unilateral breast cancer by imaging and histopathology; (4) treatment by unilateral mastectomy with or without lymph node dissection; and (5) no obvious abnormal spine morphology or postural abnormalities visible to the naked eye. The exclusion criteria were as follows: (1) diagnosis with a neurological, skeletal, or rheumatic disorder or other disease that seriously affects body posture; and (2) history of bodily injury such as a spinal, shoulder, or neck injury, resulting in permanent alteration of the normal body posture prior to the unilateral mastectomy. The elimination criteria were as follows: (1) nonoperative factors causing postural changes during the study such as fractures and bodily injuries; and (2) failure to complete follow-up for any reason over the course of the study.

### *Research procedure*

#### *Patient approach*

In our hospital, the average stay for breast cancer patients is 6–7 days, and they are usually discharged 3–4 days after unilateral mastectomy. In this study, the first dressing change for the wound was applied on the day of discharge, during which the patients received general information about the study from the nurse who was responsible for the dressing change. If a patient wanted to participate in the study, they would contact the nurse in charge of enrollment and be given detailed information about the study in person. Subsequently, written informed consent was provided by all participating patients.

#### *General requirements for postural assessment*

Each patient was instructed to tie up the hair, expose the earlobes, and remove the upper body clothing with no special limitations on lower body clothing when entering a warm, separate concealed room for the postural assessment. Furthermore, the patients were asked to stand with both arms hanging down naturally, the head in the natural straight position, the chin slightly extended, and the back against a body-posture-assessment wall chart with the eyes looking straight forward when conducting the postural assessment.

#### *Postural assessment instruments*

Assessment instruments included a posture-assessment wall chart, a soft ruler, a triangular ruler, writing pens, markers, an electronic scale, and a sociometer.

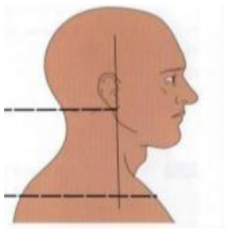
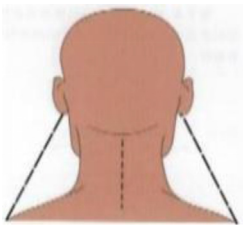
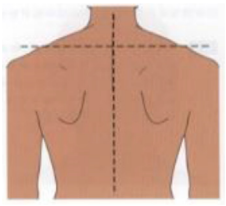
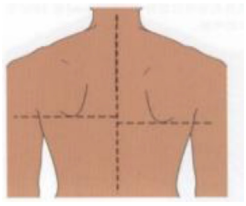
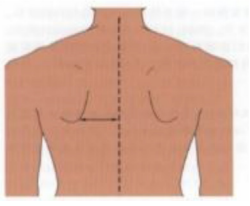
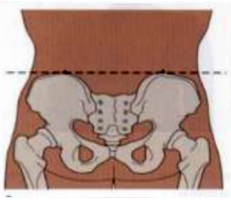
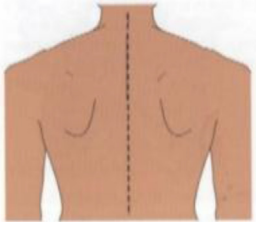
#### *Postural assessment methods*

Seven postural parameters were measured, two on the sagittal plane, i.e., forward head posture and trunk rotation angle, and the remaining five postural parameters on the coronal plane, including neck tilt, shoulder asymmetry, scapula asymmetry, scapula asymmetry relative to the spine, and pelvic tilt. The above-mentioned postural parameters were measured by a trained nurse using the human body-posture-assessment method described in *Postural Assessment* by Johnson, during which the operations of the nurse were closely observed by a rehabilitation physician.[21] First, the body weight and height of each patient were measured and used to calculate the body mass index (BMI). Next, anatomical points, usually located on the skin surface, were marked with the patient in the standing position; these points included the acromion, earlobe, inferior angle of the scapula, spinous process, and iliac crest. The postural assessment methods are detailed in Table 1.

#### *Data collection and follow-up*

Demographic and clinical information on the patients was collected from electronic medical records. Body posture was assessed at four time points, i.e., at baseline (the day of suture removal) and at 3, 6, and 12 months after unilateral mastectomy. If the patient was not available to return to the breast surgery ward at the necessary time, she was allowed to complete the postural assessment within one week before or after the specified time.

**Table 1**
Postural assessment methods.[21]

| Postural abnormalities | Method | Picture |
|---|---|---|
| Forward head posture | The patient's back and heels were placed closely against the body-posture-assessment wall chart in the standing position. The distance from the earlobe to the wall was measured, i.e., $d_1$, and the distance from the acromion to the wall was measured, i.e., $d_2$. The relative distance of the forward head posture was calculated using the following formula (mm): $d_{relative\ distance} = \lvert d_1 - d_2 \rvert$. |  |
| Neck tilt | The distance from the earlobe to the acromion was measured using a soft ruler, and the relative distance was calculated using the following formula (mm): $d_{relative\ distance} = \lvert d_{\ mastectomy\ side} - d_{\ nonmastectomy\ side} \rvert$. |  |
| Shoulder asymmetry | A triangular ruler was used to measure the relative height of the acromion (mm). |  |
| Scapular asymmetry | A triangular ruler was used to measure the relative height of the lower subscapula angle (mm). |  |
| Scapular asymmetry relative to the spine | A triangular ruler was used to measure the relative distance of the lower subscapula angle to the spine (mm). |  |
| Pelvic tilt | A triangular ruler was used to measure the relative height of the iliac crests (mm). |  |
| Trunk rotation angle | Adam's forward bending test (FBT) was performed with the patient's feet placed together and the knees straight, while bending at the hips to nearly 90° with the arms freely hanging forward and the palms together. The trunk rotation angle was measured with a scoliometer in Adam's FBT position (°). |  |

(*continued on next page*)

**Table 1** (*continued*)

| Postural abnormalities | Method | Picture |
|---|---|---|

Note: All pictures were taken from *Postural Assessment* written by Jane Johnson and have been approved by the author and publisher.[21]

### *Minimizing protocol breaches*

We developed numerous measures to minimize breaches of the study protocol because this research necessitated that patients regularly return to the hospital to complete the postural assessment. These measures included (1) encouraging family members to support the patient throughout the study; (2) recruiting patients who lived near the hospital as much as possible to reduce the difficulty of commuting; (3) establishing a group on WeChat, a very popular Chinese social media App, to address any potential barriers and motivate adherence to the protocol; (4) regularly contacting each patient by phone to determine how she had recovered after unilateral mastectomy and give appropriate advices; and (5) helping patients make appointments with the surgeon when needed.

### *Data analysis*

SPSS 26.0 software (IBM Corp., Armonk, NY, USA) was used to analyze the data. Descriptive statistics, such as frequencies and proportions, were used to describe the study sample. Generalized estimating equations were used to estimate the impact of unilateral mastectomy on body posture, where time was the main effect and postural parameters were the repeated measurement variables. All tests were two -tailed, and the α level was set at $P < 0.05$.

## Results

### *Study procedures*

This study was conducted from September 2020 to March 2021. Of the 726 patients recruited, 567 were excluded or eliminated, and 159 patients with complete data were included in the final analysis (Fig. 1).

### *Patient characteristics*

The mean age of the 159 patients was 48.91 years [standard deviation (SD) = 7.23], all patients were right-handed ($n$ = 159/159, 100.00%), and the mastectomy side was principally the right side ($n$ = 84/159, 52.83%). Detailed patient characteristics are presented in Table 2. Generalized estimating equations revealed no significant difference in BMI at the four time points (Wald $\chi^2 = 2.014$, $P = 0.569$).

### *Effect of unilateral mastectomy on body posture*

#### *Prevalence of postural abnormalities*

At baseline, the prevalence of postural abnormalities was 50.94%–59.75%, except for pelvic tilt (11.32%). At 12 months after unilateral mastectomy, the prevalence of postural abnormalities increased by more than 30% compared to baseline, except for the trunk rotation angle. In terms of the changing trajectory of the prevalence of postural abnormalities over time, the prevalence of postural abnormalities slowly increased within 3 months postmastectomy, followed by an obvious increase between 3 and 6 months postmastectomy, and finally demonstrated a relatively slow increase between 6 and 12 months postmastectomy, except for pelvic tilt. The changing trajectory of the prevalence of specific postural abnormalities over time is presented in Table 3 and Fig. 2.

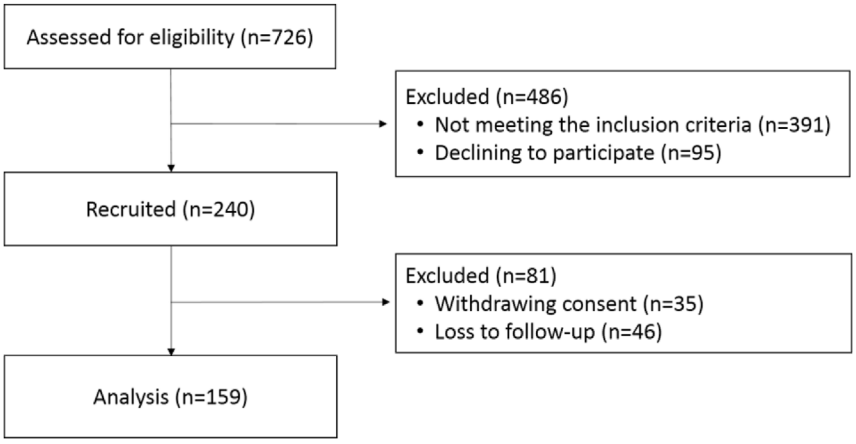



**Fig. 1.** Study flow diagram.

*Degree of deviation of postural abnormalities*

At baseline, the mean deviation of postural abnormalities was 2.74–4.51 mm, except for the trunk rotation angle (0.67°) and pelvic tilt (0.44 mm). At 12 months after unilateral mastectomy, the mean deviation of the postural abnormalities increased by more than 3.50 mm compared to baseline, except for the pelvic tilt and trunk rotation angle. Regarding the changing trajectory of the degree of deviation of the postural abnormalities over time, the degree of deviation of the postural abnormalities slightly increased within 3 months postmastectomy, followed by an obvious increase between 3 and 6 months postmastectomy, and this tendency to increase lasted until 12 months postmastectomy, except for pelvic tilt and trunk rotation. The changing trajectory of the degree of deviation of specific postural abnormalities over time is presented in Table 3 and Fig. 2.

*Deviation direction of postural abnormalities on the coronal plane*

On the mastectomy side, the prevalence of the following postural abnormalities showed a significant increase over time on the coronal plane within 12 months postmastectomy: increased distance from the earlobe to the acromion (Wald $\chi^2 = 45.283$, $P < 0.001$), depressed shoulder height (Wald $\chi^2 = 42.253$, $P < 0.001$), depressed scapula height (Wald $\chi^2 = 31.587$, $P < 0.001$), increased distance from the scapula to the spine (Wald $\chi^2 = 45.283$, $P < 0.001$), and elevated pelvic height (Wald $\chi^2 = 48.924$, $P < 0.001$), as shown in Fig. 3.

**Table 2**
Patient characteristics ($N = 159$).

| Characteristics | *n* (%) |
|---|---|
| Age (years, mean ± SD) | 48.91 ± 7.23 |
| Age | |
| < 40 years | 34 (21.38) |
| 40–50 years | 75 (47.17) |
| > 50 years | 50 (31.45) |
| Operative side | |
| Right | 84 (52.83) |
| Left | 75 (47.17) |
| Dominant hand | |
| Right | 159 (100.00) |
| Left | 0 (0.00) |
| Number of lymph nodes dissected (mean ± SD) | 14.84 ± 11.12 |
| Waist circumference (cm, mean ± SD) | 80.35 ± 7.23 |
| Mastectomy weight (g, mean ± SD) | 440.95 ± 216.61 |
| Mastectomy weight | |
| < 300 g | 47 (29.56) |
| 300–500 g | 56 (32.22) |
| > 500 g | 56 (32.22) |
| Body mass index (kg/m$^2$, mean ± SD) | |
| Baseline | 24.04 ± 0.25 |
| 3 months postmastectomy | 24.03 ± 0.25 |
| 6 months postmastectomy | 24.28 ± 0.25 |
| 12 months postmastectomy | 24.46 ± 0.25 |
| Level of education | |
| Junior high school and below | 59 (37.11) |
| High school | 45 (28.30) |
| College/university and above | 55 (34.59) |

*Subgroup analysis of the degree of deviation of postural abnormalities*

*Age stratification*

Among the three groups that were < 40 years versus 40–50 years versus > 50 years in age, there were no significant differences in the changes in the mean deviation of the postural abnormalities over time. However, at 12 months after unilateral mastectomy, the greatest increase was observed in those > 50 years of age, followed by those 40–50 years of age and those < 40 years of age compared with the baseline deviation of the postural abnormalities, except for scapula asymmetry relative to the spinal position and pelvic tilt, as shown in Supplementary Table S1 and Fig. 4.

*BMI stratification*

Among the three groups with BMI < 24 kg/m$^2$ versus 24–28 kg/m$^2$ versus > 28 kg/m$^2$, there was no significant difference in the changes in the mean deviation of postural abnormalities over time. However, at 12 months after unilateral mastectomy, the greatest increase was observed in the > 28 kg/m$^2$ group, followed by the 24–28 kg/m$^2$ group and the < 24 kg/m$^2$ group compared with the baseline deviation of postural abnormalities, except for scapula asymmetry, as shown in Supplementary Table S2 and Fig. 4.

*Mastectomy weight stratification*

Among the three groups with a mastectomy weight of < 300 g versus 300–500 g versus > 500 g, there was no significant difference in the changes in the mean deviation of postural abnormalities over time. However, at 12 months after unilateral mastectomy, the greatest increase was observed in the > 500 g group, followed by the 300–500 g and < 300 g groups compared with the baseline deviation value of postural abnormalities, as shown in Supplementary Table S3 and Fig. 4.

## Discussion

The occurrence and development of changes in body posture is a dynamic process. It is difficult to understand the pattern of development of changes in body posture over time with a single postural assessment. Through a postural assessment at four time points, this study revealed that postural changes were common in patients after unilateral mastectomy. The prevalence and degree of deviation of postural abnormalities progressively increased over time after unilateral mastectomy, especially between 3 and 6 months postmastectomy.

**Table 3**
Prevalence and degree of deviation of postural abnormalities ($N = 159$).

| (A) Prevalence of postural abnormalities | | | | | | |
|---|---|---|---|---|---|---|
| Postural abnormalities | Baseline, *n* (%) | 3 months, *n* (%) | 6 months, *n* (%) | 12 months, *n* (%) | Wald $\chi^2$ | *P* |
| Forward head posture | 87 (54.72) | 90 (56.60) | 150 (94.34) | 152 (99.60) | 61.491 | < 0.001 |
| Scapula asymmetry relative to spine | 95 (59.75) | 96 (60.38) | 134 (84.28) | 154 (96.86) | 67.926 | < 0.001 |
| Shoulder asymmetry | 83 (52.20) | 86 (54.09) | 119 (74.84) | 143 (89.94) | 44.150 | < 0.001 |
| Neck tilt | 91 (57.23) | 95 (59.75) | 118 (74.21) | 141 (88.68) | 61.423 | < 0.001 |
| Scapular asymmetry | 84 (52.83) | 85 (53.46) | 130 (81.76) | 139 (87.42) | 92.796 | < 0.001 |
| Trunk rotation angle | 81 (50.94) | 84 (52.83) | 96 (60.38) | 107 (67.30) | 55.872 | < 0.001 |
| Pelvic tilt | 18 (11.32) | 21 (13.21) | 34 (21.38) | 70 (44.03) | 12.230 | 0.007 |
| (B) Degree of deviation of postural abnormalities | | | | | | |
| Postural abnormalities | Baseline (mean ± SD, mm) | 3 months (mean ± SD, mm) | 6 months (mean ± SD, mm) | 12 months (mean ± SD, mm) | Wald $\chi^2$ | *P* |
| Forward head posture | 2.74 ± 0.24 | 2.77 ± 0.24 | 6.71 ± 0.32 | 9.63 ± 0.42 | 301.665 | < 0.001 |
| Scapula asymmetry relative to spine | 4.51 ± 0.38 | 4.53 ± 0.38 | 6.93 ± 0.40 | 8.73 ± 0.40 | 80.944 | < 0.001 |
| Shoulder asymmetry | 2.81 ± 0.25 | 2.86 ± 0.25 | 4.33 ± 0.25 | 7.63 ± 0.32 | 179.120 | < 0.001 |
| Neck tilt | 3.48 ± 0.32 | 3.53 ± 0.31 | 5.46 ± 0.33 | 6.98 ± 0.32 | 51.706 | < 0.001 |
| Scapular asymmetry | 2.86 ± 0.24 | 2.88 ± 0.24 | 5.95 ± 0.39 | 6.91 ± 0.36 | 133.681 | < 0.001 |
| Trunk rotation angle | 0.67 ± 0.73 | 0.69 ± 0.60 | 0.86 ± 0.66 | 0.97 ± 0.73 | 14.307 | 0.003 |
| Pelvic tilt | 0.44 ± 0.13 | 0.64 ± 0.15 | 0.79 ± 0.15 | 2.33 ± 0.26 | 44.495 | < 0.001 |

Note: *P* values were derived from generalized estimating equations, where time was the main effect and postural parameters were the repeated measurement variables.

Correct posture is fundamental for maintaining body balance and performing many daily life activities. Our study showed that the prevalence of most postural abnormalities increased by more than 30%, and the mean deviation of most of the postural abnormalities increased by more than 3.50 mm at 12 months after unilateral mastectomy compared to baseline among the 159 patients. This study indicated that postural changes are common in patients who undergo unilateral mastectomy, which is consistent with previous studies.[7,9,11,22] This phenomenon can be explained by the impact of the unilateral loss of a breast on the center of gravity in women. The symmetrical distribution of breast weight across the chest wall plays an important role in maintaining the balance of the center of gravity in women.[23,24] Unilateral mastectomy directly alters the center of gravity, which results in postural changes to maintain body balance.

In terms of the trajectory of the development of postural changes over time after unilateral mastectomy, the prevalence and degree of deviation of most of the postural abnormalities slowly increased from the baseline to the 3rd month postmastectomy, followed by an obvious increase from the 3rd to the 6th month postmastectomy, and finally a relatively slow increase from the 6th to the 12th month postmastectomy. This finding seems difficult to explain. However, a study showed that nearly 50% of breast cancer patients returned to work at 3 months postmastectomy.[25] The breast is regarded as a symbol of femininity. Thus, when "returning to work", patients may adopt a particular posture, for example, forward leaning of the trunk, head bowing, and back arching, to hide the absence of a breast.[26] This particular posture further accelerates changes in body posture. This may help explain why the largest postural change was observed from 3 to 6 months postmastectomy, rather than from baseline to 3 months postmastectomy, as we previously expected.

Through postural assessments at four time points, we found that on the mastectomy side, the prevalence of the following postural abnormalities showed a significant increase over time on the coronal plane within 12 months after unilateral mastectomy: distance from the earlobe to the acromion (Wald $\chi^2 = 45.283$, $P < 0.001$), depressed shoulder height (Wald $\chi^2 = 42.253$, $P < 0.001$), depressed scapula height (Wald $\chi^2 = 31.587$, $P < 0.001$), increased distance from the scapula to the spine

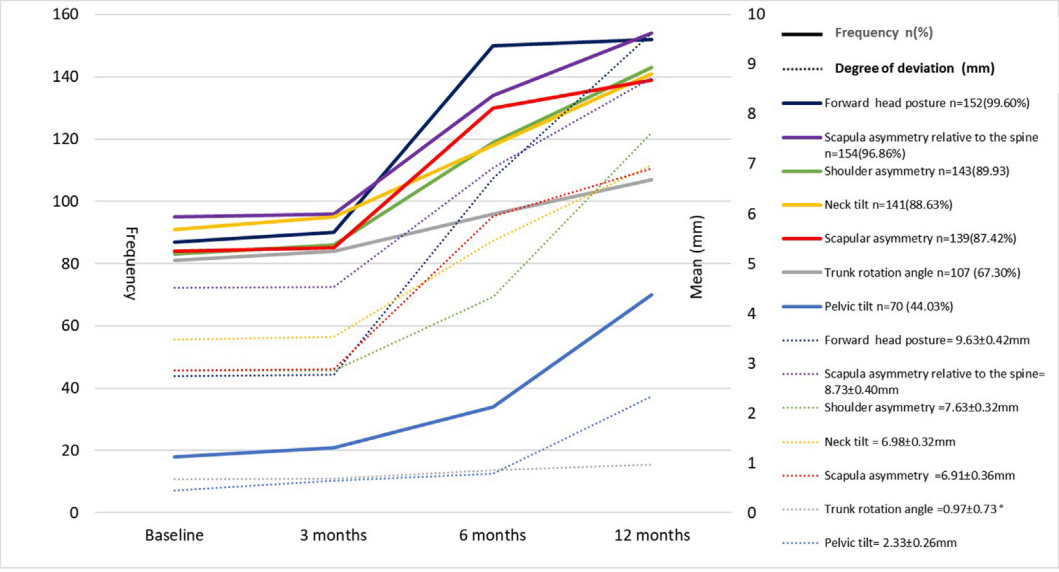



**Fig. 2.** The changing trajectory of the prevalence and degree of deviation of postural abnormalities over time ($N = 159$).

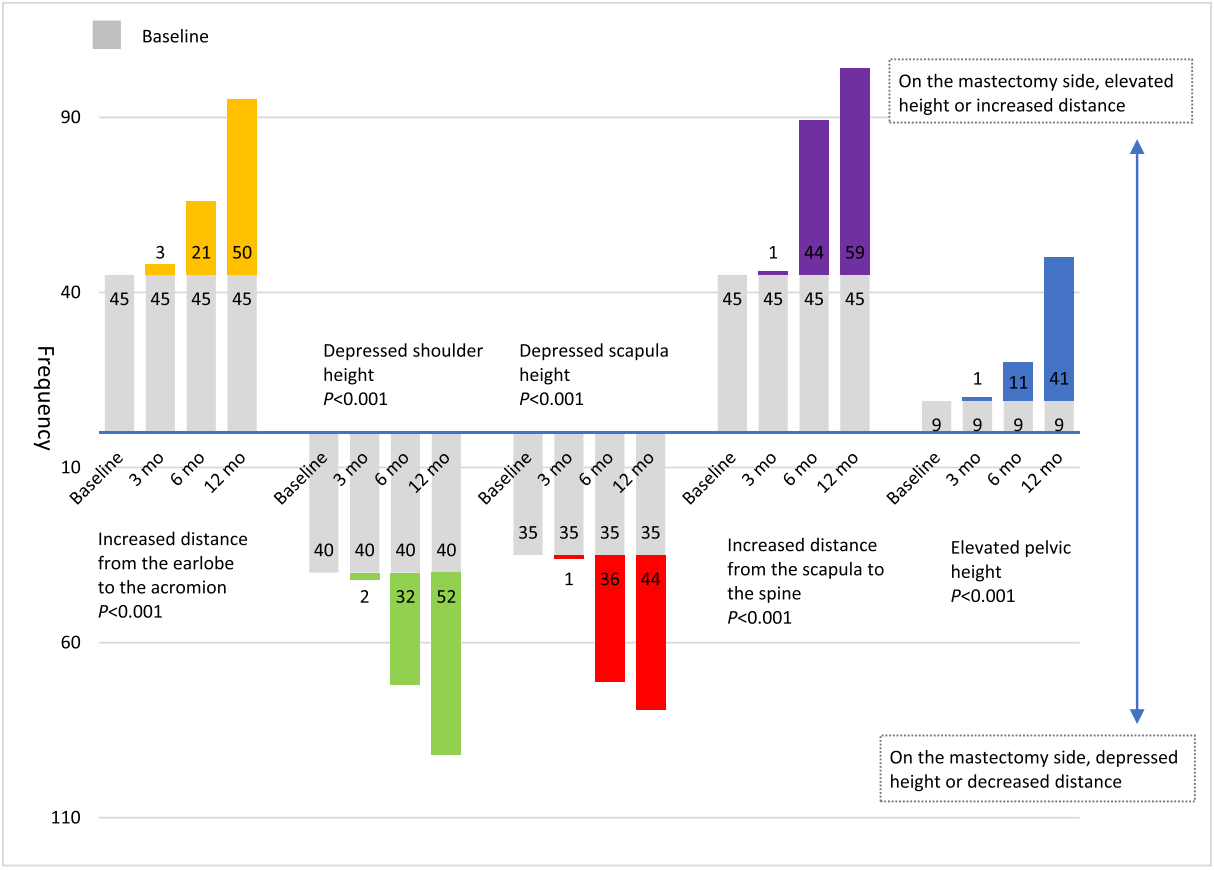



**Fig. 3.** Deviation direction of postural abnormalities on the coronal plane ($N = 159$). Note: The upward arrow denotes elevated height or increased distance on the mastectomy side. The downward arrow indicates depressed height or decreased distance on the mastectomy side.

(Wald $\chi^2 = 45.283$, $P < 0.001$), and elevated pelvic height (Wald $\chi^2 = 48.924$, $P < 0.001$). Yan et al., and Lv et al., developed prediction models for scoliosis using multiple logistic regression models and machine learning-based models, respectively. These results suggest risk predictors for scoliosis, including shoulder asymmetry, scapula asymmetry, scapula asymmetry relative to the spine, pelvic tilt, and the trunk rotation angle measured by a scoliometer.[27,28] Moreover, the accuracy of these prediction models is more than 80%.[27,28] This suggests that most postural abnormalities measured in our study are strongly related to the deterioration of spinal alignment. Additionally, Serel et al. demonstrated a significant shift of the thoracic spine toward the mastectomy side between before and 12 months after unilateral mastectomy.[22] Therefore, we speculate that on the mastectomy side, the above-described postural abnormalities gradually increase over time within 12 months postmastectomy, likely caused by a shift of the thoracic spine toward the mastectomy side within 12 months postmastectomy.

Age, BMI, and mastectomy weight are considered risk factors for postural change. We performed a subgroup analysis, as described above. The findings of the study showed that greater postural changes were observed with increasing age, BMI, and mastectomy weight. The normal aging population of women will experience a deterioration of muscle strength, which leads to significant deterioration of spinal alignment and thus changes in body posture.[29] BMI and mastectomy weight are usually strongly correlated indicators because obese patients generally have larger breasts than nonobese patients.[30] This means that the mastectomy weight is always heavier in obese patients than in others. A heavier mastectomy weight leads to a more serious change in the center of gravity, resulting in a more drastic change in body posture to maintain body balance. Jeong et al., reported that the heavier the mastectomy weight, the greater the increase in the Cobb angle.[7] Our study adds to that conducted by Jeong et al., and shows that mastectomy weight can also affect the change in the degree of deviation of postural abnormalities.

Our study has multiple advantages. First, the sample size of this study is the largest of the published series to date, which enhances the reliability and stability of the findings. Moreover, by assessing body posture at four time points, we were able to show the trajectory of the development of postural change over time from multiple angles in patients who had undergone unilateral mastectomy, including the prevalence and degree of deviation of postural abnormalities. Such a clear demonstration will help medical personnel develop more targeted rehabilitation training programs for patients undergoing unilateral mastectomy.

Our study also has limitations. First, body posture was assessed by a trained nurse using the human body-posture-assessment method, which may have led to measurement errors. Second, only seven postural parameters were measured in this study. Such selective measurements limited the reflection of the full profile of postural changes after unilateral mastectomy. Finally, although such postural changes are reversible, this study did not assess individual variability in rehabilitation training and its potential impact. However, despite these limitations, we believe our study is valuable for its purpose, which is to reveal the impact of unilateral mastectomy on body posture. The changing trajectory of the prevalence and degree of deviation of postural abnormalities are consistent from baseline to 12 months after unilateral mastectomy, which indicates that the limitations of the study did not shake its foundational conclusions.

## Conclusions

Postural changes are common in patients after unilateral mastectomy. The prevalence and degree of deviation of postural abnormalities

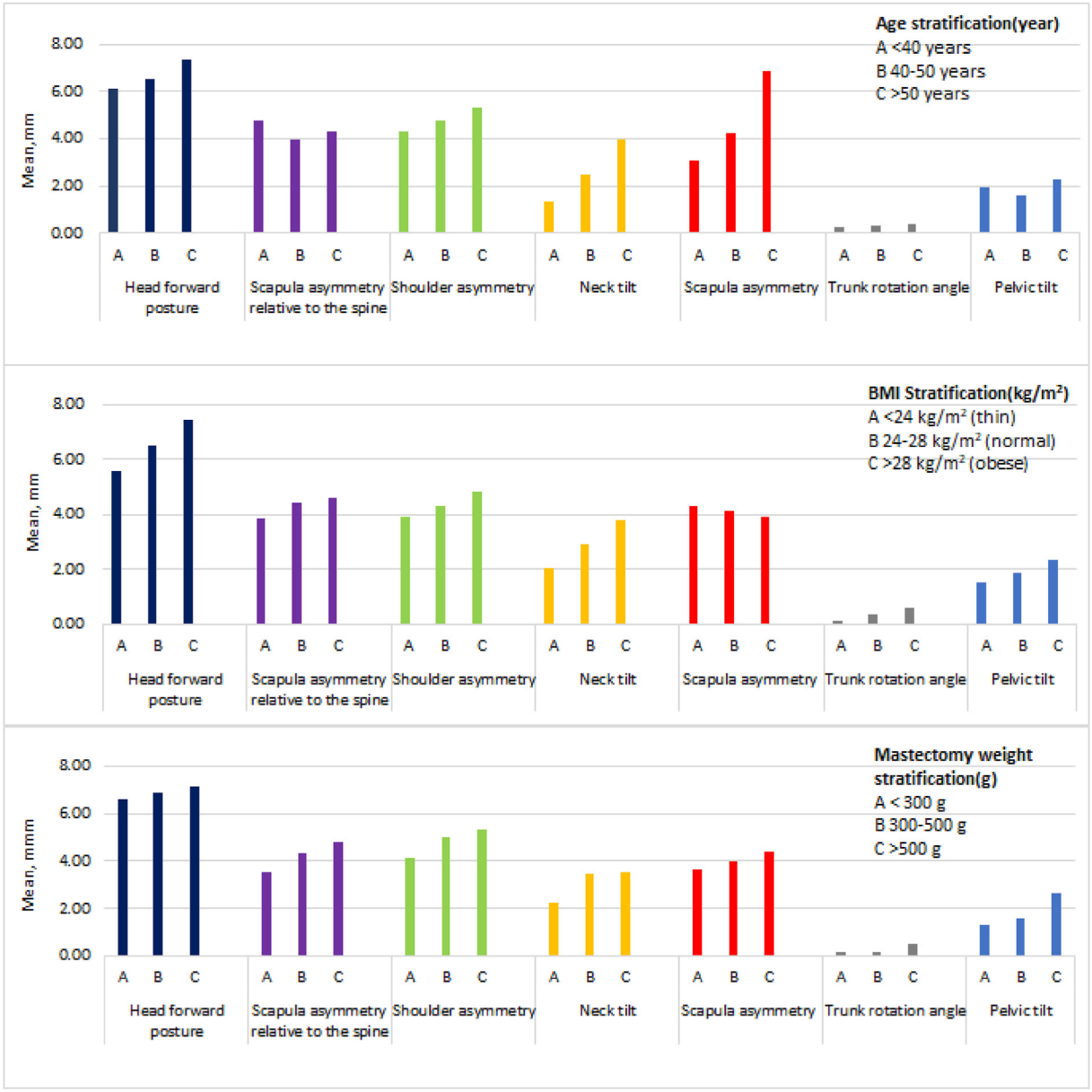



**Fig. 4.** Subgroup analysis of changes in the degree of deviation of postural abnormalities at 12 months postmastectomy compared with baseline ($N = 159$). Note: BMI was measured at baseline, and stratification was based on the Chinese standard.

progressively increase over time after unilateral mastectomy, especially from 3 to 6 months postmastectomy. We therefore recommend that patients initiate rehabilitation as early as possible after unilateral mastectomy to avoid postural changes.

## CRediT author statement

Ruixia Liu: Writing, original draft, formal analysis. Hongmei Xie: Writing, original draft, formal analysis. Yuehua Wang: Investigation and data collection. Qiuzhou Wang: Investigation, data collection. Xiaofeng Xie: Reviewing and editing. Xiaoxia Zhang: Conceptualization, supervision, methodology, writing, reviewing and the final approve of the draft. All authors had full access to all the data in the study, and the cor responding author had final responsibility for the decision to submit for publication. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

## Declaration of competing interest

All authors have none to declare. The corresponding author, Professor Xiaoxia Zhang, is a member of the editorial board of the Asia-Pacific Journal of Oncology Nursing. The article underwent the journal's standard review procedures, with peer review conducted independently of Professor Zhang and their research groups.

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## Ethics statement

The study was approved by the Institutional Review Board of the West China Hospital of Sichuan University [IRB No. 2019 (564)] All participants provided written informed consent.

## Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Declaration of Generative AI and AI-assisted technologies in the writing process

No AI tools/services were used during the preparation of this work.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.apjon.2023.100336.

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