Objective Integrated Assessment of Functional Outcomes in Reduction Mammaplasty

Giovanni Nicoletti, MD
FEBoPRAS*
Ilaria Passaro, MD†
Alberto Malovini, PhD‡
Angela Faga, MD, FICS*
Elena Dalla Toffola, MD†

**Background:** The aim of our study was an objective integrated assessment of the functional outcomes of reduction mammaplasty.

**Methods:** The study involved 17 women undergoing reduction mammaplasty from March 2009 to June 2011. Each patient was assessed before surgery and 2 months postoperatively with the original association of 4 subjective and objective assessment methods: a physiatric clinical examination, the Roland Morris Disability Questionnaire, the Berg Balance Scale, and a static force platform analysis.

**Results:** All of the tests proved multiple statistically significant associated outcomes demonstrating a significant improvement in the functional status following reduction mammaplasty. Surgical correction of breast hypertrophy could achieve both spinal pain relief and recovery of performance status in everyday life tasks, owing to a muscular postural functional rearrangement with a consistent antigravity muscle activity sparing. Pain reduction in turn could reduce the antalgic stiffness and improved the spinal range of motion. In our sample, the improvement of the spinal range of motion in flexion matched a similar improvement in extension. Recovery of a more favorable postural pattern with reduction of the anterior imbalance was demonstrated by the static force stabilometry. Therefore, postoperatively, all of our patients narrowed the gap between the actual body barycenter and the ideal one. The static force platform assessment also consistently confirmed the effectiveness of an accurate clinical examination of functional impairment from breast hypertrophy.

**Conclusions:** The static force platform assessment might help the clinician to support the diagnosis of functional impairment from a breast hypertrophy with objectively based data. (Plast Reconstr Surg Glob Open 2013;1:e61; doi: 10.1097/GOX.0000000000000004; Published online 24 October 2013.)

---

A large number of studies focused on the benefits of a reduction mammaplasty on breast hypertrophy-related functional impairments are reported in the literature.1–12 Nevertheless, the vast majority of these reports are actually supported by subjectively based data from quality of life questionnaires. The only exception in such a homogeneous context is a study where the pulmonary function was objectively evaluated before and after surgical correction of breast hypertrophy with a reduction mammaplasty.13

**Disclosure:** The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.
Recently, a new method was introduced to objectively analyze postural variations after a breast reduction by means of static stabilometry.\textsuperscript{14}

The aim of our study is an integrated assessment of the functional outcomes of reduction mammoplasty. Evaluation was carried out with the integration of 4 different subjective and objective methods: a full clinical physiatric examination, the Roland Morris Disability Questionnaire (RMDQ) for low back pain, the Berg Balance Scale (BBS), and a new static force platform.

**MATERIALS AND METHODS**

The study was carried out in cooperation with the Plastic Surgery Unit, University of Pavia, Salvatore Maugeri Research and Care Institute and the Physical Medicine and Rehabilitation Unit, University of Pavia, San Matteo Research and Care Institute, Pavia, Italy.

Seventeen women undergoing reduction mammoplasty for breast hypertrophy were enrolled in the study over a period of 2 years, from March 2009 to June 2011. The mean age was 43.7 years (minimum 15, maximum 59, and median 46). The average body mass index (BMI) was 29 (minimum 23, maximum 36, and median 28). Each patient was assessed before surgery and 2 months postoperatively. A formal informed written consent was obtained from all of the patients.

**Physiatric Clinical Examination**

All of the clinical signs and symptoms were scored as in a binary system (0–1).

- Kyphosis: normal = 0, pathological = 1
- Lordosis: normal = 0, pathological = 1
- Range of motion (ROM) of the lumbar spine:
  - Flexion $> 40^\circ$ = 0, flexion $< 40^\circ$ = 1;
  - Extension $> 15^\circ$ = 0, extension $< 15^\circ$ = 1
- Sensitivity alterations in lower and upper limbs:
  - No alterations = 0, sensitivity alterations = 1
- Reported cervical and lumbar pain: no pain = 0, pain = 1

Variations of the postoperative status vs the preoperative one were expressed using a semiquantitative scale:

$-1 = \text{improved (less disability)}$

$0 = \text{stable}$

$+1 = \text{worsened (more disability)}$.

**Roland Morris Disability Questionnaire**

The RMDQ is one of the most popular tools for clinical evaluation of pain-related lumbar spine disability. It assesses the low back pain through 24 items providing a numerical score ranging from 0 (no disability) to 24 (severe disability). A previously validated, translated, and culturally adapted version of the original RMDQ was used for our sample of Italian patients.\textsuperscript{15}

**Berg Balance Scale**

The BBS is one of the most reliable tools for clinical assessment of balance ability. The scale is performance oriented and consists of 14 movements common in everyday life with quantitative scores ranging from 0 (severe disability) to 56 (no disability).\textsuperscript{16}

**ARGO Static Force Platform**

The ARGO (R.G.M. Medical Devices S.p.A., Genoa, Italy) static force platform is designed to measure the instantaneous position of the center of pressure which, by balancing the couple produced by the force of weight, ensures maintenance of the upright position.

It has a large platform surface area ($600 \times 600 \text{ mm}^2$) for execution of circular kick and a high sampling frequency (100 Hz) that allows analysis of sway density parameters and provides data for obtaining a reliable harmonic analysis even with short measurement times (Fig. 1).

All test parameters are relative to the path followed by the center of pressure:

- Sway area (extent of the area covered by the center of pressure, in $\text{mm}^2$)
- Ellipse area (elliptic section of the sway area including 95% of the centers of pressure, in $\text{mm}^2$)
- Anteroposterior (AP) maximum oscillation, in mm
- Side maximum oscillation, in mm

![Fig. 1. The static force platform.](image-url)
Sway path (oscillation speed, in mm/s)
Mean distance between 2 consecutive centers of pressure, in mm
AP distance between the center of the ellipse area and the geometric barycenter of the body in mm. In the ideal orthostatic balance, the center of the ellipse and the geometric barycenter coincide.

The patients were assessed on the platform in quiet standing through 4 different modalities: close parallel feet-open eyes (PFOE), close parallel feet-closed eyes (PFCE), slightly spread feet-open eyes (SFOE), and slightly spread feet-closed eyes (SFCE). Each assessment lasted 40 seconds preceded by a 5-second waiting time that allowed the patient to become familiar with the position, thus reducing the adaptation artifacts.

Reduction Mammaplasty
All patients underwent a vertical reduction mammaplasty according to a personal technical variation. A standard “C cup” breast mound was reshaped whatever the breast size preoperatively. The average breast tissue removed was 1720 g per patient (minimum 574 g, maximum 3434 g, and median 1632 g).

Statistical Analysis
Quantitative variables regarding the static force platform have been normalized according to the following formula: \(100 \times \frac{(t_2 - t_1)}{t_1}\), where \(t_1\) represents the measurement at time 1 (preoperative time) and \(t_2\) represents the measurement at time 2 (postoperative time). Deviations from the normal distributions of quantitative variables have been tested by the Shapiro test for normality. \(P<0.05\) has been set as the significance threshold for identifying variables that did not follow the normal distribution. As none of the quantitative variables followed the normal distribution, nonparametric tests have been applied. Differences in terms of quantitative variables between 2 subgroups have been evaluated by the Wilcoxon test for paired samples (for comparing distributions at \(t_1\) vs \(t_2\)). Differences in terms of quantitative variables for nonpaired samples have been tested by the Wilcoxon rank-sum test (when comparing quantitative distributions between binary levels) or by the Kruskal-Wallis test (when comparing quantitative distributions between 2 or more levels). Frequency distributions have been tested by the Fisher’s exact test. The binomial test has been used for evaluating whether the proportion of patients improving their health condition was significantly higher than what expected by chance. \(P\) values < 0.05 have been considered statistically significant. All statistical procedures have been performed by the R statistical software (http://www.r-project.org/).

RESULTS

Physiatric Clinical Examination
The results of the physiatric clinical examination are depicted in Table 1. We compared the distribution of binary variables at postoperative time vs preoperative time.

The fraction of patients reporting a reduced lumbar pain score postoperatively rather than preoperatively (thus corresponding to a better condition) is significantly higher than the expected fraction of patients reporting a reduced lumbar pain score by chance (observed fraction = 0.59; expected fraction by chance = 0.33; \(P<0.05\)).

Patients showing an improved spinal extension ROM in \(t_2\) vs \(t_1\) are more likely to reach a corresponding improved spinal flexion ROM (67% vs 10%, \(P<0.05\)).

The other clinical signs and symptoms failed to show any statistically significant improvement.

Roland Morris Disability Questionnaire
The results of the RMDQ are depicted in Figure 3.

The median value of the RMDQ at \(t_2\) is significantly lower than the corresponding value at \(t_1\) \((t_2\): median = 7; interquartile range = 5; \(t_1\): median = 2; interquartile range = 2; \(P<0.01\)).
The results of BBS are depicted in Figure 4. The median values of BBS are summarized in Table 4.

The median value of BBS at \( t_2 \) is significantly higher than the corresponding value at \( t_1 \) (\( t_1 \): median = 48; interquartile range = 14; \( t_2 \): median = 55; interquartile range = 6; \( P < 0.01 \)).

ARGO Static Force Platform

Among the myriad of data resulting from the static force platform, we analyzed 4 parameters as the most reliable for our purposes:

1. The AP distance (in mm) between the center of the ellipse area and the real geometric barycenter of the body, in SFOE and SFCE position.
2. The stay time (in s) in SFCE position.
3. The ellipse area (in mm\(^2\)) in PFOE position.
4. The sway area (in mm\(^2\)/s) in PFOE position.

Results show that the median value of the normalized measurements of AP (\( t_2 \) vs \( t_1 \)) is significantly different from 0 (\( P < 0.05 \)) as the real barycenter tends to reach the ideal one (Fig. 5). In other words, after breast reduction, all of the patients tend to assume a more balanced standing position as they reduce the anterior imbalance of the trunk.

Furthermore, longer stay time and reduction of the ellipse and the sway area are significantly related to RMDQ scores and spinal ROM (Table 5). This suggests that patients who display an increased stay time in the instant centers of pressure and a reduction of the oscillation area show better performance in everyday life tasks and are more likely to improve their spinal ROM too.

Further Statistically Significant Cross-matched Correlations

We observed significant correlations (\( P < 0.05 \)) between variations of single variables and variations of cervical pain and lumbar pain (\( t_2 \) vs \( t_1 \)). Associations with lumbar pain (Table 6):

1. Lesser lumbar pain conditions in \( t_2 \) vs \( t_1 \) are associated with higher positive variations of BBS at \( t_2 \) vs BBS at \( t_1 \) with respect to those who show no improvement.

Table 1. Scores of Postoperative Physiatric Signs and Symptoms

| Variable                  | Better   | Equal   | Worst  | \( P \)   |
|---------------------------|----------|---------|--------|-----------|
| Cervical pain             | 5 (0.29) | 10 (0.59) | 2 (0.12) | 0.7087    |
| Lumbar pain               | 10 (0.59)| 7 (0.41) | 0 (0)  | 0.0254    |
| Pathological kyphosis     | 0 (0)    | 17 (1)  | 0 (0)  | 1         |
| Pathological lordosis     | 0 (0)    | 17 (1)  | 0 (0)  | 1         |
| ROM flexion               | 6 (0.35) | 11 (0.65) | 0 (0)  | 0.5105    |
| ROM extension             | 5 (0.29) | 12 (0.71) | 0 (0)  | 0.7087    |
| Sensitivity alterations   | 1 (0.06) | 16 (0.94) | 0 (0)  | 0.9989    |

Lumbar pain improvement is the only statistically significant variable.

Fig. 3. Graphic report of the distribution of values obtained with the RMDQ at \( t_1 \) vs \( t_2 \). At \( t_2 \), the values are gathered in the area corresponding to the lesser perceived disability. The scarlet spots in the graphic are the median values. The single high isolated red spot at \( t_2 \) is the only case that referred a worse postoperative outcome.

Table 2. Results of the Most Selected Items in the RMDQ Questionnaire

| Most Frequently Selected Items                                  | Preoperative Time (%) | Postoperative Time (%) |
|----------------------------------------------------------------|-----------------------|------------------------|
| I climb the stairs slower than usual because of my back         | 83                    | 33                     |
| I frequently change my posture to bring comfort to my back      | 75                    | 40                     |
| I walk slower than usual because of my back                     | 75                    | 40                     |
| Because of my back I have to hang on to something to get up     | 67                    | 17                     |
| from my armchair                                                |                       |                        |
| I have difficulty in wearing my socks (even stocking) because   | 67                    | 17                     |
| of my back pain                                                 |                       |                        |
| Because of my back I do not bend nor kneel                      | 50                    | 17                     |
2. Similarly, lesser lumbar pain conditions in \( t_2 \) vs \( t_1 \) are associated with higher variations of AP distance of the real barycenter from the center of the ellipse in the SFCE position. And so, the patients who tend to reduce the anterior displacement of the barycenter are more likely to reduce the lumbar pain as well.

Associations with cervical pain (Table 7):
Patients who displayed a higher improvement in cervical pain at \( t_2 \) vs \( t_1 \) were those in whom lesser amounts of breast tissue were removed.

We also observed significant correlations between variations in the amount of removed breast tissue and BBS (\( t_2 \) vs \( t_1 \)) (Table 8). This shows that those who have had a higher amount of breast tissue removed are more likely to show greater and positive variations of BBS.

We also observed significant correlations between variations of single variables and RMDQ (\( t_2 \) vs \( t_1 \)) (Table 9).

**DISCUSSION**
Breast hypertrophy causes a myriad of symptoms, the most common being pain, psychosocial discomfort, and skin lesions.

The increased weight of the breasts causes several spinal postural alterations, such as dorsal kyphosis and anterior shoulder dislodgement, that may eventually lead to morphological stable alterations in the growing individual or degenerative changes in the adult. Anterior shoulder dislodgement and dorsal kyphosis may also be exacerbated by the psychological attitude to disguise the large volume of the breasts. Dorsal kyphosis is somewhat compensated by an increase of the lumbar lordosis which in turn leads to a prominent abdomen.27,28 Such a complex postural alteration tends to directly involve the cervi-

---

**Table 3. Median Values of the RMDQ**

| Variable | \( t_1 \) | \( t_2 \) | \( P \) |
|----------|---------|---------|-------|
| RMDQ    | 7 (5)   | 2 (2)   | 0.002 |

\( t_1 \), median and interquartile range at \( t_1 \); \( t_2 \), median and interquartile range at \( t_2 \).

---

**Table 4. Median Values of the BBS**

| Variable | \( t_1 \) | \( t_2 \) | \( P \) |
|----------|---------|---------|-------|
| BBS      | 48 (14) | 55 (6)  | <0.01 |

\( t_1 \), median and interquartile range at \( t_1 \); \( t_2 \), median and interquartile range at \( t_2 \).

---

Fig. 4. Graphic report of the distribution of values obtained with the BBS at \( t_1 \) vs \( t_2 \). At \( t_2 \), the values are gathered in the area corresponding to better balance ability. The scarlet spots in the graphic are the median values.

Fig. 5. Graphic report of the distribution of normalized values of AP distance from the ideal barycenter at \( t_1 \) vs \( t_2 \). The values show a slight general improvement of this parameter.
The combined increased lumbar lordosis and dorsal kyphosis complex is demonstrated to reduce the overall ability to keep a stable balance and to perform dynamic tasks requiring a stable balance. Such a clinical picture is actually better defined as a marked discomfort rather than a proper disability. Also in our sample the actual disability from breast hypertrophy was modest and was consistently displayed by the preoperative median scores of the physiatric clinical examination, the BBS, and the RMDQ. Such a light status of disability included altered balance control, reduced performance in everyday life tasks, lumbar pain, cervical pain, reduced flexion, and extension ROM in the spine.

In our experience, all of the tests consistently demonstrated across the whole sample range a
significant improvement in the functional status following a reduction mammaplasty.

The physiatric clinical examination, the BBS, the RMDQ, and the static force platform balance assessment demonstrated multiple statistically significant associated outcomes.

The RMDQ showed a remarkable functional recovery with reduction to almost zero the residual levels of disability at the postoperative time.

Older patients and those with a higher body mass index, although affected by a higher degree of disability before surgery, postoperatively achieved the same performance status as the younger ones and those with a lesser body mass index, thus displaying a higher delta between the pre- and postoperative time. Such a result might be explained by supposing that as age and being overweight are impairing conditions in everyday life activities, breast hypertrophy might be even more disabling for those patients. Vice versa, in the younger and normal-weight patients, the potential impairment in everyday life tasks from a breast hypertrophy is more compensated by some sort of higher functional reserve. The higher delta in the postoperative recovery in the overweight patients might be related to the increased quantity of breast tissue removed.

The BBS demonstrated a body balance improvement, consistent with data from static force stabilometry. Indeed, the static force platform demonstrated a statistically significant reduction of the AP distance between the center of the ellipse area and the geometric barycenter of the body in all of the patients after breast reduction. Such an outcome demonstrates recovery of a more favorable postural pattern with reduction of the anterior imbalance. Therefore, postoperatively, all of our patients narrowed the gap between the actual body barycenter and the ideal one.

The physiatric clinical examination demonstrated a dramatic decrease of lumbar pain in 10 out of 17 patients. Such an outcome is related to the antigravity muscle action sparing that follows a breast reduction.

Pain reduction in turn reduces the antalgic stiffness and improves the spinal ROM. In our sample, the improvement of the spinal ROM in flexion matched a similar improvement in extension.

The low back pain relief matched an improved balance status as proved by the statistically significant association of the physiatric clinical examinations with both the BBS and the static force platform. Such an improvement in the balance status concerned both the ability in everyday life tasks and a marked reduction of the anterior imbalance of the body. In the latter postoperative outcome, the actual barycenter approached the ideal one.

The pain reduction and the performance improvement in everyday life tasks demonstrated by the RMDQ matched the increased balance in terms of increased stay time in the instant centers of pressure and overall reduction of the oscillation area.

An apparently paradoxical outcome was observed in our sample where the larger the removed breast volume the lesser the cervical pain relief. Such a figure might be explained with the irreversible consolidation of the chronic cervical pain in the largest and long-standing breast hypertrophies. Furthermore, surgical correction of breast hypertrophy could not correct any anatomically stabilized spinal deformity.

On the contrary, the greater the volume of breast removed, the better the performance of everyday life tasks as demonstrated by the BBS.

The statistically significant associations of the outcomes from the traditional tests with those from the static force platform mutually cross-validates all of the assessment methods. The static force platform assessment might therefore help the clinician to support the diagnosis of functional impairment from a breast hypertrophy with objectively based data.

Considering breast reduction alternatively as a functional or a cosmetic operation has long been debated in the literature, and still it is an open issue for insurance companies and National Health Systems.

In a former publication, we proposed an objective anthropometric discriminating criterion to differentiate a functional from a cosmetic breast reduction. The association of an anthropometric criterion with an objective static force platform assessment might be a further proposal to definitively justify the functional indication for breast reduction.

**CONCLUSIONS**

Surgical correction of breast hypertrophy can achieve both spinal pain relief and recovery of performance status in everyday life tasks, owing to a functional rearrangement of postural muscles with a consistent work sparing of antigravity muscles. Breast hypertrophy should be surgically corrected in the earlier stages to maximize such a spinal pain relief. Nevertheless, reduction mammaplasty is not likely to reverse any chronically stabilized spinal deformities and to get maximum benefit a physiotherapy protocol should follow surgery.
The static force platform assessment consistently confirmed the effectiveness of an accurate clinical examination of functional impairment from breast hypertrophy.

Giovanni Nicoletti, MD, FEBoPRAS
Plastic, Reconstructive and Aesthetic Surgery
Department of Clinical Surgical, Diagnostic and Paediatric Sciences
University of Pavia
Pavia, Italy
E-mail: giovanni.nicoletti@unipv.it

ACKNOWLEDGMENTS
We thank Alan Serge McGhee, MSc, Glasgow City Council Education Department, for his contribution to the submission of this dissertation. We also thank Flaviana Cazzola and Gian Mario Pelizzoli for their much appreciated technical support.

REFERENCES
1. Ducic I, Iorio ML, Al-Attar A. Chronic headaches/migraines: extending indications for breast reduction. Plast Reconstr Surg. 2010;125:44–49.
2. Guerra AS, Correia CM, Videira e Castro JM, et al. Macromastia: a risk factor for carpal tunnel syndrome? Hand Surg. 2011;16:283–287.
3. Kerrigan CL, Collins ED, Striplin D, et al. The health burden of breast hypertrophy. Plast Reconstr Surg. 2001;108:1591–1599.
4. Sigurdson L, Mykhalskovskiy E, Kirkland SA, et al. Symptoms and related severity experienced by women with breast hypertrophy. Plast Reconstr Surg. 2007;119:481–486.
5. Chadbourne EB, Zhang S, Gordon MJ, et al. Clinical outcomes in reduction mammoplasty: a systematic review and meta-analysis of published studies. Mayo Clin Proc. 2001;76:503–510.
6. Jones SA, Bain JR. Review of data describing outcomes that are used to assess changes in quality of life after reduction mammoplasty. Plast Reconstr Surg. 2001;108:62–67.
7. Rankin M, Borah GL, Perry AW, et al. Quality-of-life outcomes after cosmetic surgery. Plast Reconstr Surg. 1998;102:2139–2145; discussion 2146.
8. Lettermann G, Schurter M. The effects of mammary hypertrophy on the skeletal system. Ann Plast Surg. 1980;5:425–431.
9. Chao JD, Memmel HC, Redding JF, et al. Reduction mammoplasty is a functional operation, improving quality of life in symptomatic women: a prospective, single-center breast reduction outcome study. Plast Reconstr Surg. 2002;110:1644–1652; discussion 1653.
10. Brühlmann Y, Tschopp H. Breast reduction improves symptoms of macromastia and has a long-lasting effect. Ann Plast Surg. 1998;41:240–245.
11. Lettermann G, Schurter M. The effects of mammary hypertrophy on the skeletal system. Ann Plast Surg. 1980;5:425–431.
12. Spector JA, Karp NS. Reduction mammoplasty: a significant improvement at any size. Plast Reconstr Surg. 2007;120:845–850.
13. Sood R, Mount DL, Coleman JJ III, et al. Effects of reduction mammoplasty on pulmonary function and symptoms of macromastia. Plast Reconstr Surg. 2003;111:688–694.
14. Tenna S, Brunetti B, Trivelli M, et al. Postural variations after breast reduction: introduction of a new technique to achieve an objective analysis. Ann Plast Surg. 2012;68:261–264.
15. Padua R, Padua L, Ceccarelli E, et al. Italian version of the Roland Disability Questionnaire, specific for low back pain: cross-cultural adaptation and validation. Eur Spine J. 2002;11:126–129.
16. Stevenson TJ. Detecting change in patients with stroke using the Berg Balance Scale. Aust J Physiother. 2001;47:29–38.
17. Baratto L, Jacono M, Morasso P, et al. Acquisition time in surgical, diagnostic and pediatrie sciences. Surgical, Diagnostic and Paediatric Sciences 2003;111:688–694.
34. Kerrigan CL, Collins ED, Striplin D, et al. The health burden of breast hypertrophy. *Plast Reconstr Surg.* 2001;108:1591–1599.
35. Kerrigan CL, Collins ED, Kim HM, et al. Reduction mammaplasty: defining medical necessity. *Med Decis Making* 2002;22:208–217.
36. Schnur PL, Hoehn JG, Ilstrup DM, et al. Reduction mammaplasty: cosmetic or reconstructive procedure? *Ann Plast Surg.* 1991;27:232–237.
37. Strömbeck JO, Malm M. Priority grouping in a waiting list of patients for reduction mammaplasty. *Ann Plast Surg.* 1986;17:498–502.
38. Nicoletti G, Scevola S, Faga A. Is breast reduction a functional or a cosmetic operation? Proposal of an objective discriminating criterion. *J Plast Reconstr Aesthet Surg* 2009;62:1644–1646.
39. Freire M, Neto MS, García EB, et al. Functional capacity and postural pain outcomes after reduction mammaplasty. *Plast Reconstr Surg.* 2007;119:1149–1156; discussion 1157–1158.