

The Effects of Breast Reduction on Back Pain and Spine Measurements: A Systematic Review

Constantine Papanastasiou,
MD, MSc*†
Jean A. Ouellet, MD, FRCSC†
Lucie Lessard, MD, FRCSC,
FRCSC, FACS*

Background: The aim of this review article was to synthesize the literature on reduction mammoplasty and its effects on the spine. The particular focus was to find these few radiological studies and those investigating changes in spinal angles, posture, center of gravity, and back pain reduction.

Methods: We performed a thorough review of the literature, searching the Medline database for all relevant published data studying reduction mammoplasty and the spine. The search yielded 107 articles of which 11 articles met our specific inclusion criteria. The primary outcome measures of the studies and their respective results were tabulated, contrasted, and compared.

Results: The 11 cohort studies included in this review cover the period from 2005 to 2015 and focus on breast hypertrophy and spine. According to these 11 quantitative studies, breast hypertrophy causes objective, quantitative, measurable disturbances to women living with this condition. Reduction mammoplasty produces an unmistakable improvement in signs, symptoms, and quantifiable measures. Although the majority of included articles in this review described postoperative improvement in spinal angles, there remain discrepancies of results between them.

Conclusions: The studies included in this review did offer a promising glimpse into the complex interaction between breast hypertrophy and the spine. However, future research initiatives can improve upon what these investigators have begun with more refined, objective, radiological evidence. More specifically, we aim to clarify some of the basic hypotheses in our center with the use of EOS. (*Plast Reconstr Surg Glob Open* 2019;7:e2324; doi: 10.1097/GOX.0000000000002324; Published online 12 August 2019.)

Breast hypertrophy is responsible for a broad array of patients' signs and symptoms ranging from mild to debilitating in nature. The most common physical complaints include neck and upper back pain, headache, aching shoulders, painful shoulder grooves, low back pain, intertrigo of the inframammary crease, mastalgia, poor posture, difficulty exercising, and difficulty working a job without absenteeism.¹⁻³ General back pain is known to be the most expensive disease regarding work absenteeism/disability representing up to 1.75% of the

gross national product of some countries and 20.6% of National Health Insurance Survey (NHIS) respondents reporting lower back pain.^{4,5} Breast hypertrophy patients are no exception to these statistics. The mass of hypertrophied breast glands imposes downward traction on the musculofascial sling surrounding the shoulders and neck, namely the trapezius, levator scapula, and rhomboid.^{6,7} There is also increased pressure on the greater occipital nerve, lesser occipital nerve, and dorsal occipital nerves. This was confirmed by Mosser et al.⁸ in a cadaver study of 20 heads from patients with an unknown history of migraine headaches.

The most effective treatment for breast hypertrophy and its accompanying signs and symptoms is bilateral breast reduction surgery: vertical or horizontal techniques. According to satisfaction survey questionnaires and meta-analysis studies, it has been repeatedly proven to be a surgical procedure with a very high patient satisfaction rate.^{9,10} In a study by Brown et al.,¹¹ a satisfaction rate of 89% was demonstrated. It is hypothesized that the center of gravity reverts to its more neutral position

From the *Department of Surgery, Division of Plastic Surgery, McGill University Health Centre (MUHC), Montreal, Quebec, Canada; and †Department of Orthopedic Surgery, Spine Surgery, McGill University Health Centre (MUHC), Montreal, Quebec, Canada.

Received for publication October 29, 2018; accepted March 29, 2019.

Copyright © 2019 The Authors. Published by Wolters Kluwer Health, Inc. on behalf of The American Society of Plastic Surgeons. This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

DOI: 10.1097/GOX.0000000000002324

Disclosure: The authors have no financial interest to declare in relation to the content of this article.

posteroinferiorly. The spine returns to a more neutral curvature, allowing the paraspinal muscles to relax. As such, pain is alleviated.¹² Until relatively recently, the scientific documentation was not totally adequate with the exception of validated satisfaction questionnaires such as the Breast-Q satisfaction outcomes.¹²⁻¹⁵ In addition to the physical disturbances, macromastia has a significant negative impact socially, personally, and as it relates to self-esteem and health-related quality of life of patients.¹⁶

The aim of this review article was to synthesize the literature on reduction mammoplasty and its effects on the spine before and after surgery. The particular focus was to find all radiological studies and those investigating changes in spinal angles, posture, center of gravity, and the relation to pain reduction.

The spine attempts to stay in balance using the least amount of energy possible and preferably in a neutral position. The excessive weight of hypertrophic breasts acts as a lever to disrupt stabilizing forces of the neck and back. The center of gravity of the body is altered moving superiorly and anteriorly during daily activities. This results in an altered curvature of the spine resulting in increased lumbar lordosis (LL), thoracic kyphosis (TK), and cervical lordosis (CL) (J. Ouellet, Personal Communication, 2018).¹² There is an ensuing compensatory contraction of the paraspinal muscles. This constant muscle contraction can cause significant and persistent pain requiring chronic pain control medication around the clock in many patients just to get through the day.

METHODS

Inclusion criteria were English and French language publications, human subjects, bilateral reduction mammoplasty, extractable outcomes, and full-text availability. Our aim was to find the studies in the literature studying the effects of breast hypertrophy on the spine. PubMed was used to search all relevant published data studying reduction mammoplasty and the spine from the Medline database of the US National Library of Medicine. The searches were conducted in July 2017. Using PubMed, the search strategy combined combinations of keywords “breast reduction,” “reduction mammoplasty,” “spine,” “spinal,” “vertebral,” “posture,” “back,” and “skeletal.” The resultant articles were assessed, and their references were inspected for further articles pertinent to this review. The search yielded a total of 107 citations. Ninety-seven of the articles did not match our inclusion criteria because they did not combine analyses of both breast and spine interaction. One article found in the references of an included paper was subsequently added as it met our inclusion criteria. The remaining 11 articles met our inclusion criteria and were suitable for analysis (See Fig. 1). The selected studies were graded using the University of Oxford Center for Evidence Based Medicine Levels of Evidence (See Fig. 2). The data from the selected articles are presented in Table 1. The primary outcome measures of the articles and their respective results are displayed. Initially, a meta-analysis of the studies was contemplated. However, this was deemed unfeasible as the outcome measures and methodology differed too drastically even between those few studies, suggesting the need to study this subject in better depth.

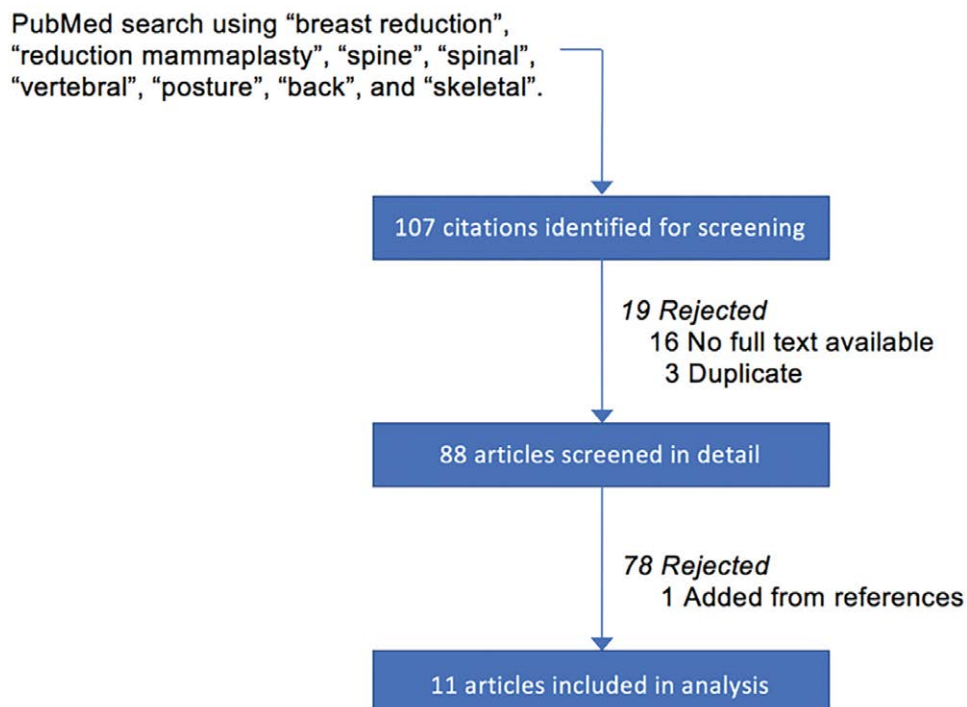


Fig. 1. Article selection flow chart.

Level	Description
1A	Systematic review of randomized control trials with homogeneity
1B	Individual RCT
1C	All or none (e.g. all had a particular outcome prior to an intervention and now no such outcomes occur)
2A	Systematic review of cohort studies with homogeneity
2B	Individual cohort study
2C	Ecological studies and "outcomes" research
3A	Systematic review of case-control studies with homogeneity
3B	Individual case-control study
4	Case series or poor quality cohort and case-control studies
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research, or "first principles"

RCT = randomized controlled trial.

Fig. 2. University of Oxford Center for Evidence Based Medicine Levels of Evidence.

RESULTS

The articles included in this in-depth review cover the period from 2005 to 2015 and focus on breast hypertrophy, back pain, and spine. The 11 cohort studies included in this review had sample sizes ranging from $n = 10$ to $n = 50$. Table 1 summarizes the data with regards to type of study, cohort size, outcome measures, and results.

Reviewed Studies Characteristics

A total of 11 studies were included in this review from 2005 to present. The 2 studies by Benditte-Klepetko et al.²⁶ and Krapohl¹ examined women with breast hypertrophy in the nonsurgical setting. Nine studies evaluated a cohort of breast hypertrophy patients both preoperatively and postoperatively.^{17–25} The studies by Sahin et al.,¹⁹ Lapid et al.,²⁰ Barbosa et al.,²³ Tenna et al.,²⁴ Foreman et al.,²⁵ and Krapohl¹ were nonradiological and more external measurement

based. These 6 studies used 3D gait analysis, back inclination angle, center-of-pressure displacement, center-of-gravity oscillations, lower back compressive force, and functional spine score, respectively.^{1,19,20,23–25} Five of the studies were radiological in nature.^{17,18,21,22,26} The studies by Berberoglu et al.,¹⁷ Karabekmez et al.,¹⁸ Karaaslan et al.,²¹ and Findikcioglu et al.²² used regular x-rays to compare preoperative and postoperative spinal parameters while Benditte-Klepetko et al.²⁶ used magnetic resonance imaging (MRI). Some of the outcome measures of these radiological studies included CL angle, TK angle, LL angle, lumbosacral inclination, and sagittal balance disturbance.^{17,18,21,22} In addition to MRI, Benditte-Klepetko et al.²⁶ made use of the Visual Analog Scale (VAS) pain score and the Beck Depression Inventory.

Spinal Angles: Cervical, Thoracic, and Lumbar

Only 5 previous studies compared reduction mammoplasty patients' preoperative and postoperative spinal angles.^{17,18,20–22} Three studies found positive improvement. Berberoglu et al.¹⁷ found a statistically significant decrease in CL (9.9 ± 0.9 , $P < 0.001$) and TK (17.0 ± 6.1 , $P < 0.001$). Karabekmez et al.¹⁸ also demonstrated significantly improved CL (8.7 ± 3.7 , $P < 0.001$), TK (13.9 ± 4.3 , $P < 0.001$), and improved sagittal balance ($P = 0.008$). Improvement in TK (-2.7 , $P < 0.001$), LL (-3.2 , $P < 0.001$), and sacral inclination angle (-0.9 , $P = 0.005$) was found by Findikcioglu et al.²²

Two studies were not statistically significant. Those 2 studies are the following: Lapid et al.²⁰ with no statistically significant improvement in back inclination angle (0.89 ± 3.48 , $t = 0.104$) and Karaaslan et al.²¹ with no statistically significant improvement in TK and LL.

Gait, Center of Gravity, and Sagittal Balance

Karabekmez et al.¹⁸ demonstrated a postoperative return to normal sagittal balance in all 7 patients with disturbed sagittal balance preoperatively. Sahin et al.¹⁹ used 3D gait analysis on 10 patients to demonstrate a statistically significant improvement in maximum anterior pelvic tilt (41% reduction), average maximum spine anterior flexion (30% improvement), and an improved body posture when walking after breast reduction surgery. In the study by Barbosa et

Table 1. Cohort Studies: Cohort, Outcome Measures, and Results

Study	Cohort	Outcome Measures	Results
Berberoglu et al. ¹⁷	40	CL, TK, LL, LSI (Lumbosacral Inclination), and back pain alleviation	Improvement in all spinal angles, decreased back pain
Karabekmez et al. ¹⁸	22	CL, TK, LL, and SBD	Improvement in all spinal angles, SBD corrected
Sahin et al. ¹⁹	10	3D gait analysis (APT and SAF angles)	Improvement in APT, SAF, and in body posture when walking
Lapid et al. ²⁰	42	Back inclination angle	No statistically significant improvement in back inclination angle
Karaaslan et al. ²¹	34	TK and LL	No statistically significant improvement in TK or LL
Findikcioglu et al. ²²	30	TK, LL, and LSI	Improvement in all spinal angles
Barbosa et al. ²³	14	Center-of-pressure displacement	Significant improvement in postural control
Tenna et al. ²⁴	30	Center-of-gravity oscillations	Improvement in posture
Foreman et al. ²⁵	11	Lower back compressive force	35% reduction in lower back compressive force
Benditte-Klepetko et al. ²⁶	50	MRI, spine score, VAS pain score, and BDI	Increasing breast weight correlated with degenerative spine disorders and depressive symptoms
Krapohl ¹	50	Functional spine score	Spinal function significantly impaired with increasing breast weight

APT, anterior pelvic tilt; BDI, Beck Depression Inventory; LSI, lumbosacral inclination; SAF, spine anterior flexion; SBD, sagittal balance disturbance.

al.,²³ it was demonstrated that postoperative patients had a smaller center-of-displacement area and improved postural control. Tenna et al.²⁴ demonstrated, by means of static stabilometry, that postoperative reduction mammoplasty patients have objectively improved posture at the 6-month postoperative mark ($P = 0.032$).

Spine MRI, Spine Score, Functional Spine Score, and Lower Back Compressive Force

Benditte-Klepetchko et al.²⁶ utilized MRI to investigate 50 breast hypertrophy patients for degenerative changes in the thoracic and cervical spine more specifically. The investigators evaluated “loss of signal characteristics, posterior and anterior disc protrusion, narrowing of the disc space, and foraminal stenosis” and deviations in the frontal and sagittal plane.²⁶ Their results demonstrated that breast weight had a statistically significant positive effect ($P = 0.02$) on pathological findings such as spine score (0.71, $P < 0.0001$), pain (0.69, $P < 0.0001$), Beck Depression Inventory (0.58, $P < 0.0001$), and body mass index (BMI) (0.57, $P < 0.0001$). Age also had a statistically significant positive improvement correlation with pathological findings ($P = 0.03$).²⁶ These articles confirm that breast hypertrophy overloads the spine leading to advanced degenerative disease. In another prospective study but with a small cohort of patients, Foreman et al.²⁵ found that, postoperatively, their 11 reduction mammoplasty patients had a 35% decrease in low-back compressive forces. Such findings of change in center of gravity post breast reduction is in keeping with the off-loading of the musculature.

Pain and Relief

Lapid et al.²⁰ reported that, preoperatively, 71.4% of their subjects had a higher VAS pain score. This statistic improved postoperatively with 19.0% patients reporting a higher VAS pain score. Barbosa et al.²³ revealed an improvement in shoulder and neck pain, headache, hand numbness, and upper/lower back pain. The investigators attributed this symptom relief to an improvement in postural control.²³ Participants in the study by Foreman et al.²⁵ demonstrated a 76% postoperative reduction in self-reported disability, with the greatest improvements in the categories for frequency of pain and discomfort with travel. Benditte-Klepetchko et al.²⁶ found a significant correlation r between pain and breast weight (0.69, $P < 0.0001$), MRI score (0.46, $P = 0.0012$), spine score (0.75), Beck Depression Inventory (0.61, $P < 0.0001$), and BMI (0.58, $P < 0.001$).

BMI and Posture

In the study by Berberoglu et al.,¹⁷ there was no significant correlation found between postoperative vertebral angle and patient BMI. However, Karabekmez et al.¹⁸ established significant correlations between BMI and total excised breast tissue volume ($P = 0.0001$) and Δ CL angle postoperatively ($P = 0.03$). Lapid et al.²⁰ found that back inclination was dependent on the BMI of the patient (-0.274 , $P = 0.001$). In the study by Findikcioglu et al.,²² it was determined that BMI had a significant correlation with preoperative TK ($r = 0.700$, $P < 0.001$), LL

($r = 0.740$, $P < 0.001$), and sacral inclination angle ($r = -0.005$, $P = 0.977$). The study conducted by Benditte-Klepetchko et al.²⁶ demonstrated that BMI could prompt the development of spine disorders, postural anomalies, and depressive symptoms. In addition, they found a statistically significant correlation r between BMI and breast weight (0.57, $P < 0.0001$), spine score (0.51, $P = 0.0001$), and pain (0.37, $P < 0.0001$).²⁶ In a study of $n = 346$ patients by Colman et al.,²⁷ it was also demonstrated that BMI had a significant main effect on breast volume. In fact, the median breast volume of obese subjects was nearly triple that of their counterparts with normal BMI.

DISCUSSION

We are presently studying back pain in breast hypertrophy patients with EOS at our University center, and this is why we have embarked on this in-depth scientific review of this topic.²⁸ Even presently in 2018, quantitative tests to evaluate patients' back pain before and after surgery are still less than optimal.^{29,30}

On this topic in the literature, 107 scientific articles were found, but only 11 were valuable scientific articles with quantitative measures. Breast hypertrophy causes objective, quantitative, measurable disturbances in women living with this condition.²⁹ It results in pain and fatigue that can negatively affect these women severely in their day-to-day life at home and especially at work. This makes their work productivity levels difficult to maintain. In a study by Cabral et al.,³¹ it was scientifically demonstrated that breast reduction results in a significant decrease in working hours lost, impairment at work, overall productivity loss, and daily activity impairment outside of work. Validated questionnaires were used to report those symptoms in a quantitative fashion. In general, back pain is on the rise as a major health burden especially with increasing rates of morbid obesity and rising BMI.³² In a study conducted in the Netherlands, the cost of back pain was found to be substantial enough to represent 1.7% of the country's gross national product and the most expensive disease regarding work absenteeism and disability.⁵

The well-validated Breast-Q study standard questionnaire for evidence-based breast surgery revealed that over 95% of patients were pleased post breast reduction and 96% of those would “do it again.”³³

On the other hand, pure quantitative self-esteem assessment was reported using the Multidimensional Body Self-Relations Questionnaire (MBSRQ) and clearly demonstrated breast hypertrophy's negative effects on self-esteem.³⁰

Another valuable quantitative tool is the classic VAS. Breast hypertrophy patients did score highly, with 10 being the worst pain on this scale. One study demonstrated a VAS score reduction from 69.5 preop to 13.3 postop.¹⁷ Breast hypertrophy causes immense pain for patients as mentioned above on the VAS scale. In all studies that applied a component of pain evaluation, a significant improvement in pain postoperatively was demonstrated.^{17,20,23,25,26}

The mechanism by which this pain reduction is achieved is still not fully understood. It is likely a multifac-

Table 2. Highlighted Spinal Angle Findings

Study	Cohort	Δ CL	Δ TK	Δ LL	Δ Back Inclination Angle	Sagittal Balance
Berberoglu et al. ¹⁷	40	-9.9±0.9; <i>P</i> <0.001	-17.0±6.1; <i>P</i> <0.001			
Karabekmez et al. ¹⁸	22	-8.7±3.7; <i>P</i> <0.001	-13.9±4.3; <i>P</i> <0.001			Improvement, <i>P</i> =0.008
Lapid et al. ²⁰	42				No significant improvement	
Karaaslan et al. ²¹	34		No significant improvement	No significant improvement		
Findikcioglu et al. ²²	30		-2.7; <i>P</i> <0.001	-3.2; <i>P</i> <0.001		

tor sequence of transformations in the spine, its ligamentous attachments, and possibly tension in the paraspinal musculature as well. In addition, this pain-alleviating mechanism in itself deserves further study.²⁸

It has been presumed that a change in spinal angles may occur postoperatively after reduction mammoplasty, but only few studies have explored this clinical question. Five studies in this review compared preoperative and postoperative spinal angles. Statistically significant improvement was demonstrated in 3 of the 5 studies.^{17,18,22} On the other hand, the 2 other studies did not demonstrate any significant angle correction.^{20,21} Even in the few studies looking at the spinal angles in a quantitative manner, there is contradiction. In those 5 studies, CL and TK angles seem to correct to a higher and more consistent degree than does LL angle. Although the majority of included articles in this review described postoperative improvement in spinal angles, there remain discrepancies of results between them.

In addition, the radiological studies did reveal their respective weaknesses. The study by Berberoglu et al.¹⁷ used reference values for incline angles from the general population. It would have been more interesting to find these values for their study population and the variation between age and sex groups.¹⁷ Findikcioglu et al.²² stated their greatest limitation to be the fact that vertebral angles vary widely in the population and as such the reference range is equally wide. Finally, the study by Benditte-Klepetko et al.²⁶ excluded obese women and women over 40 years of age. This may have caused their cohort to be unrepresentative of the typical population seeking breast reduction as they have a high BMI and they are over 40 years of age in most cases.

In summary, the 11 studies extracted and available in the literature fitting all the inclusion criteria from 107 studies are the only ones that have made attempts at quantifying back pain in breast hypertrophy. We have reviewed these articles to evaluate the different technologies (PT, x-ray, and MRI) presently available to quantify pain and discomfort of breast hypertrophy. The results are summarized and presented in Tables 1 and 2.

Despite their limitations, the 11 articles selected for this study provide an initial contribution. With this thorough review, the 5 best imaging-based scientific articles revealed conflicting results such as positive improvement versus no improvement for the same breast pathology. The literature is contradictory at best for a surgery with a

95% Breast-Q postoperative satisfaction and 96% of those patients who would “do it again” given the option.³³

In conclusion, this systematic review confirms that there is room for further future studies with better quantitative tools and methodology.

Lucie Lessard, MD, FRCSC, FRCSC, FACS

Chief, Division of Plastic Surgery
McGill University Health Centre (MUHC)
1650 Cedar Ave., Montreal, QC, Canada H3G1A4
Room D6-269
E-mail: lucie.lessard@mcgill.ca

REFERENCES

- Krapohl BD. Functional evaluation of the spine in patients with breast hypertrophy. *Plast Surg Nurs*. 2005;25:187–189.
- Collins ED, Kerrigan CL, Kim M, et al. The effectiveness of surgical and nonsurgical interventions in relieving the symptoms of macromastia. *Plast Reconstr Surg*. 2002;109:1556–1566.
- Chiu TW, Stone C. *Stone's Plastic Surgery Facts and Figures*. 3rd ed. Cambridge: Cambridge University Press; 2011.
- Deyo RA, Mirza SK, Martin BI. Back pain prevalence and visit rates: estimates from U.S. National Surveys, 2002. *Spine (Phila Pa 1976)*. 2006;31:2724–2727.
- van Tulder MW, Koes BW, Bouter LM. A cost-of-illness study of back pain in The Netherlands. *Pain*. 1995;62:233–240.
- Ducic I, Iorio ML, Al-Attar A. Chronic headaches/migraines: extending indications for breast reduction. *Plast Reconstr Surg*. 2010;125:44–49.
- Freire M, Neto MS, Garcia EB, et al. Functional capacity and postural pain outcomes after reduction mammoplasty. *Plast Reconstr Surg*. 2007;119:1149–1156; discussion 1157.
- Mosser SW, Guyuron B, Janis JE, et al. The anatomy of the greater occipital nerve: implications for the etiology of migraine headaches. *Plast Reconstr Surg*. 2004;113:693–697; discussion 698.
- Brown AP, Hill C, Khan K. Outcome of reduction mammoplasty—a patients' perspective. *Br J Plast Surg*. 2000;53:584–587.
- 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.
- Redaelli A, Berjano P, Aebi M. Focal disorders of the spine with compensatory deformities: how to define them. *Eur Spine J*. 2018;27(suppl 1):59–69.
- Cano SJ, Klassen AF, Scott AM, et al. The BREAST-Q: further validation in independent clinical samples. *Plast Reconstr Surg*. 2012;129:293–302.
- Pusic AL, Klassen A, Cano SJ, et al. Validation of the breast evaluation questionnaire. *Plast Reconstr Surg*. 2007;120:352–353.
- Pusic AL, McCarthy C, Cano SJ, et al. Clinical research in breast surgery: reduction and postmastectomy reconstruction. *Clin Plast Surg*. 2008;35:215–226.

15. Mundy LR, Homa K, Klassen AF, et al. Understanding the health burden of macromastia: normative data for the BREAST-Q Reduction Module. *Plast Reconstr Surg*. 2017;139:846e–853e.
16. Cerrato F, Webb ML, Rosen H, et al. The impact of macromastia on adolescents: a cross-sectional study. *Pediatrics*. 2012;130:e339–e346.
17. Berberoğlu Ö, Temel M, Türkmen A. Effects of reduction mammaplasty operations on the spinal column: clinical and radiological response. *Aesthetic Plast Surg*. 2015;39:514–522.
18. Karabekmez FE, Gokkaya A, Isik C, et al. Does reduction mammaplasty revert skeletal disturbances in the vertebral column of patients with macromastia? A preliminary study. *Aesthetic Plast Surg*. 2014;38:104–112.
19. Sahin I, Iskender S, Ozturk S, et al. Evaluation of breast reduction surgery effect on body posture and gait pattern using three-dimensional gait analysis. *Aesthetic Plast Surg*. 2013;37:549–553.
20. Lapid O, de Groof EJ, Corion LU, et al. The effect of breast hypertrophy on patient posture. *Arch Plast Surg*. 2013;40:559–563.
21. Karaaslan O, Demirkiran HG, Silistreli O, et al. The effect of reduction mammaplasty on the vertebral column: a radiologic study. *Sci World J*. 2013;2013:701391.
22. Findikcioglu K, Findikcioglu F, Bulam H, et al. The impact of breast reduction surgery on the vertebral column. *Ann Plast Surg*. 2013;70:639–642.
23. Barbosa AF, Lavoura PH, Boffino CC, et al. The impact of surgical breast reduction on the postural control of women with breast hypertrophy. *Aesthetic Plast Surg*. 2013;37:321–326.
24. 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.
25. Foreman KB, Dibble LE, Droge J, et al. The impact of breast reduction surgery on low-back compressive forces and function in individuals with macromastia. *Plast Reconstr Surg*. 2009;124:1393–1399.
26. Benditte-Klepetko H, Leisser V, Paternostro-Sluga T, et al. Hypertrophy of the breast: a problem of beauty or health? *J Womens Health (Larchmt)*. 2007;16:1062–1069.
27. Coltman CE, Steele JR, McGhee DE. Breast volume is affected by body mass index but not age. *Ergonomics*. 2017;60:1576–1585.
28. Papanastasiou C, Fortin M, Ouellet J, et al. PSRC podium presentation & abstract QS 36: quantitative orthopaedic spine benefits post breast reduction - preliminary results. *Plast Reconstr Surg*. 2018;6(4S):138.
29. Kerrigan CL, Collins ED, Kim HM, et al. Reduction mammaplasty: defining medical necessity. *Med Decis Making*. 2002;22:208–217.
30. Kerrigan CL, Collins ED, Striplin D, et al. The health burden of breast hypertrophy. *Plast Reconstr Surg*. 2001;108:1591–1599.
31. Cabral IV, Garcia ED, Sobrinho RN, et al. Increased capacity for work and productivity after breast reduction. *Aesthet Surg J*. 2017;37:57–62.
32. Statcan. Statistics Canada - overweight and obese adults (self-reported). 2014.
33. Gonzalez MA, Glickman LT, Aladegbami B, et al. Quality of life after breast reduction surgery: a 10-year retrospective analysis using the breast Q questionnaire: does breast size matter? *Ann Plast Surg*. 2012;69:361–363.