



# Breast region measurements: direct or indirect anthropometry?

*Medidas da região mamária: antropometria direta ou indireta?*

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## ■ ABSTRACT

**Introduction:** Accurate female breast measurements are difficult due to the topography, volume, and projections present there. Therefore, this study aimed to compare breast region measurements obtained by direct (tape measurement) and indirect (computer-based photogrammetry) anthropometry.

**Methods:** This is a transversal study. Forty women were evaluated, aged 18-60 years, body mass index of  $<29.2\text{kg/m}^2$  that had 12 anatomical marks on the breast region and arms. These points' union formed 7 linear segments and 1 angle for each hemibody, and 1 segment common to both hemibodies. The photographs obtained in a standardized way were measured using computer-based photogrammetry with Image Tool™ software. The same segments were also measured by direct anthropometry, using a tape measure. The Shapiro-Wilk test was used to assess whether each variable was normally distributed. The Pearson correlation test was applied to evaluate the correlation between different methods: the direct (tape measurement) and indirect (photogrammetry by Image Tool™) anthropometry. The significance level adopted for statistical tests was 5% ( $p < 0,05$ ). **Results:** Significant differences were found in the comparisons between the tape measurement and computer-based photogrammetry for all segments analyzed ( $p > 0.05$ ). **Conclusion:** There is a correlation between the breast measurements obtained by direct (tape measurement) and indirect (photogrammetry by Image Tool™ software) anthropometry, especially the papilla measures.

**Keywords:** Breast; Anthropometry; Photogrammetry; Mammoplasty; Women; Surgery, Plastic.

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## ■ RESUMO

**Introdução:** As medidas precisas dos seios femininos são difíceis de obter devido à topografia, volume e projeções presentes. Portanto, este estudo teve como objetivo comparar medidas da região mamária obtidas por antropometria direta (fita métrica) e indireta (fotogrametria computadorizada).

**Métodos:** Este é um estudo transversal. Foram avaliadas 40 mulheres, com idades entre 18 e 60 anos, índice de massa corporal  $<29,2 \text{ kg / m}^2$ , que tinham 12 marcas anatômicas na região das mamas e braços. A união desses pontos formou 7 segmentos lineares e 1 ângulo para cada hemicorpo, e 1 segmento comum a ambos os hemicorpos. As fotografias obtidas de forma padronizada foram mensuradas por fotogrametria computadorizada com o software Image Tool<sup>®</sup>. Os mesmos segmentos também foram medidos por antropometria direta, com fita métrica. O teste de Shapiro-Wilk foi usado para avaliar se cada variável tinha uma distribuição normal. O teste de correlação de Pearson foi aplicado para avaliar a correlação entre os diferentes métodos: antropometria direta (medição com fita) e indireta (fotogrametria por Image Tool<sup>®</sup>). O nível de significância adotado para os testes estatísticos foi de 5% ( $p < 0,05$ ). **Resultados:** Diferenças significativas foram encontradas nas comparações entre a fita métrica e a fotogrametria computadorizada para todos os segmentos analisados ( $p > 0,05$ ). **Conclusão:** Existe correlação entre as medidas dos seios da face obtidas pela antropometria direta (medição com fita métrica) e indireta (fotogrametria pelo software Image Tool<sup>®</sup>), principalmente nas medidas da papila.

**Descritores:** Mama; Antropometria; Fotogrametria; Mamoplastia; Mulheres; Cirurgia Plástica

## INTRODUCTION

Accurate measurements of female breasts are challenging due to the topography, volume, and projections present there<sup>1</sup>. Therefore, linear breast reference parameters were created to directly analyze the size, shape and positioning<sup>1-5</sup>.

In clinical practice, breast measurements are done by direct anthropometry, usually using tape measure or compass. However, these measures may be altered due to respiratory oscillations or slight body positioning changes in body positioning<sup>6</sup>. Despite the limitations of direct breast anthropometric measurements, they have been the most widely used method for expressing and comparing mammoplasty results, both in scientific publications and in events (conferences, symposia, forums, etc.).

Given the need for a method that would overcome direct anthropometry limitations, some authors have proposed photogrammetry<sup>7-9</sup>. However, in the literature, the existing studies comparing photogrammetry and direct anthropometry are not specific for the breast region.

## OBJECTIVE

This study compares breast region measurements obtained by direct (tape measurement) and indirect (computer-based photogrammetry, Image Tool<sup>™</sup> software) anthropometry.

## METHODS

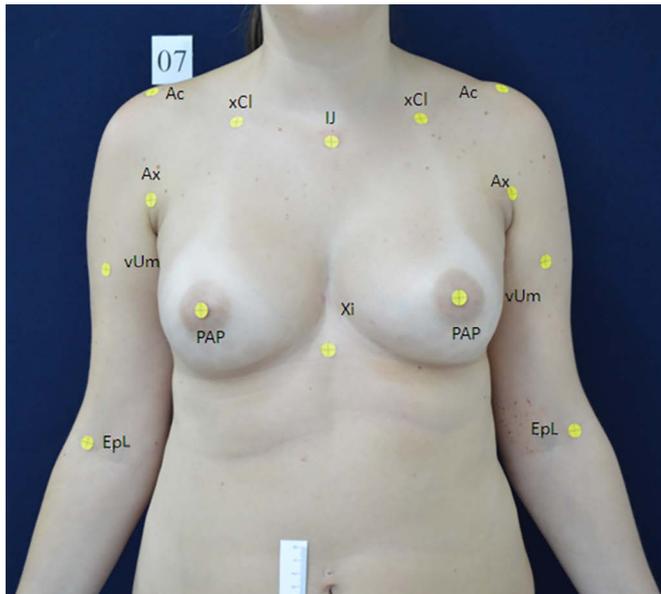
The study was approved and conducted by the Research Ethics Committee of the Universidade Federal de São Paulo (UNIFESP) (1054/10). Written informed consent was obtained from all volunteers before their inclusion in the study.

Forty female volunteers, aged 18 to 60, body mass index (BMI) of  $<29.9 \text{ kg/m}^2$ , were included in the study, between June and December 2018. They were recruited from the Plastic Surgery Division Outpatient Service at UNIFESP. Each side of the thorax was separately analyzed, with a total of 80 hemibodies. Women who underwent a mastectomy, with a history of any type of conservative breast surgery, congenital or acquired chest deformities and severe breast ptosis in which

the nipples cross a transverse line at the limit of the umbilicus were not included in the study.

Each volunteer was instructed to place their feet on predetermined marks on the floor with a 3 cm distance between their medial margins and remain in anatomical position, with the head in the Frankfurt position during measurements. The distance between the most posterior point of the volunteer's feet and the photography background was 70cm.

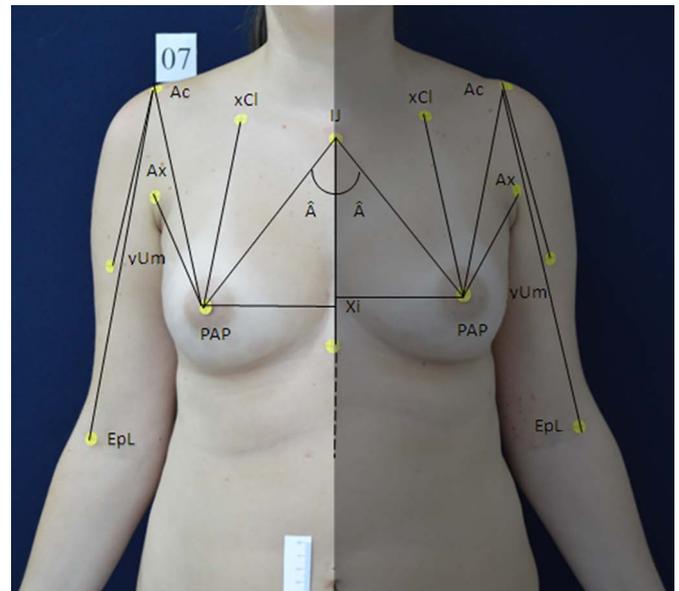
Self-adhesive labels with 0.6 cm diameter were used to mark the anatomical landmarks used in each hemibody. These landmarks in counterclockwise were: the center of the mammary papilla (PAP), the midpoint of the base of the xiphoid process (Xi), jugular notch center (IJ), half the distance between the jugular notch center and the acromion (xCl), lateral border of the acromion (Ac), the most cranial point of the fold in the anterior axillary line (Ax) and the anterior projection of the lateral epicondyle (EpL) (Figure 1).



**Figure 1.** Demarcation of the anatomical landmarks and anthropometric points. Ac: Lateral border of the acromion; xCl: Half the distance between the jugular notch center and the acromion; IJ: Jugular notch center; Ax: The most cranial point of the fold in the anterior axillary; vUm: Halfway point between the acromial end and the projection of the lateral epicondyle; PAP: Center of the mammary papilla; Xi: Midpoint of the base of the xiphoid process; EpL: Line and the anterior projection of the lateral epicondyle.

From these points, 8 line segments and 1 angle per hemibody were formed. Only the segment passing through the anterior median line, from the center of the jugular notch to the base of the xiphoid process (segment IJ-Xi), was common to both hemibodies. The other 7 segments were formed bilaterally: center of the mammary papilla to the anterior median line, passing through the base of the xiphoid process (segment PAP-Xi), center of the mammary papilla to jugular notch center (segment IJ-PAP), the center of the mammary

papilla to half the distance between the jugular notch center and the acromion (segment xCl-PAP), the center of the mammary papilla to the lateral border of the acromion (segment Ac-PAP), the center of the mammary papilla to most cranial point of the fold in the anterior axillary line (segment Ax-PAP), lateral border of the acromion to the anterior projection of the lateral epicondyle (segment Ac-EpL), half the distance between the acromion and the lateral epicondyle to the lateral epicondyle (Ac-yUm). The confluence of the segments (IJ-Xi) and (IJ-PAP) formed the  $\hat{A}$  angle (Figure 2).



**Figure 2.** Distance of the anatomical landmarks and anthropometric points. Ac: Lateral border of the acromion; xCl: Half the distance between the jugular notch center and the acromion; IJ: Jugular notch center; Ax: The most cranial point of the fold in the anterior axillary;  $\hat{A}$ : Angle; yUm: Halfway point between the acromial end and the projection of the lateral epicondyle; PAP: Center of the mammary papilla; Xi: Midpoint of the base of the xiphoid process; EpL: Line and the anterior projection of the lateral epicondyle.

We used a Sony™ DSC-W120 digital camera, with the distance from the lens to the voluntary determined by the framework, without zooming, on a tripod with bubble level. All photographs were standardized with 7.0 megapixels and JPEG format. Two spotlights were positioned at the height of 1.50m from the floor and at a distance of 1.60m from the photography background, convergently directed, each one angled at 45° to the blue photography background (Figure 3).

The breast region's photographic framing was delimited superiorly by a transverse line at the gnathion (Gn) and inferiorly by a transverse line at the bottom of the navel. A ruler with a millimeter scale 0-10cm long was attached to the volunteer's right mesogastric region to proceed to the Image Tool™ 3.0 software calibration. A centimeter-scale was chosen for digital photogrammetry.

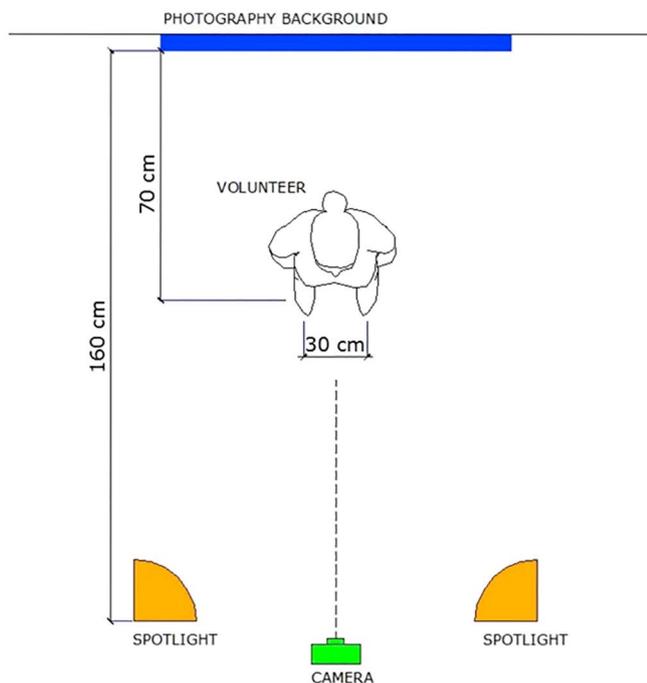


Figure 3. Photographic standardization and systematization.

Direct anthropometry was performed with a tape measure with a scale in millimeters. The tape measure was placed in the label's center and directed to the label's center on the opposite side of the selected segment. For measuring the  $\alpha$  angle, a dotted line was drawn using a dermatographic pen and a metallic ruler, crossing over the segment IJ-Xi and another one over the segment IJ-Pa. Then, a 180° clear plastic protractor was placed in the center of the label of the jugular notch (IJ), and the measure corresponding to the angle was obtained. The same evaluator collected all indirect (photography and software) and direct anthropometry data.

### Statistical analysis

Data will be analyzed using GraphPad Prism 6.0 for Windows. Variables were tested for normal distribution by the Shapiro-Wilk test. Data are presented as mean and SD. The Pearson correlation test was applied to evaluate the correlation between the direct (tape measurement) and indirect (photogrammetry by Image Tool™ software) anthropometry, considering weak correlation (0.20 to 0.39), moderate correlation (0.40 to 0.69), a strong correlation (0.70 to 0.89) and very strong correlation (0.9 to 1). A significance level of 5% ( $p < 0.05$ ) was adopted to interpret the data.

## RESULTS

The study included 80 breasts of 40 female volunteers with a mean age of 29.1 ( $\pm 10.3$ ) years old,

weight of 63.4 ( $\pm 5.4$ ), height of 1.57 ( $\pm 0.1$ ) and BMI of 25.7 ( $\pm 2.2$ ). The prevalence of white race was 65%, black 2.5%, and others 32.5%. Table 1 shows the clinical characteristics of all volunteers.

Table 1. Clinical characteristics for all volunteers.

Mean $\pm$ SD	
Age (years)	29.1 $\pm$ 10.3
Weight (kg)	63.4 $\pm$ 5.4
Height (m)	1.57 $\pm$ 0.1
BMI (kg/m <sup>2</sup> )	25.7 $\pm$ 2.2
<b>Race (%)</b>	
White	65%
Black	2.5%
Others	32.5%

SD: standard deviation; BMI: Body mass index.

The means of segments obtained using the tape measure (direct anthropometry measurements) and photogrammetry by Image Tool™ software (indirect anthropometric measurements) were 16.35 ( $\pm 1.14$ ) and 12.90 ( $\pm 1.69$ ) of IJ-Xi, 11.16 ( $\pm 1.07$ ) and 10.98 ( $\pm 1.30$ ) of PAP-Xi, 22.08 ( $\pm 3.08$ ) and 18.24 ( $\pm 2.65$ ) of IJ-PAP, 21.46 ( $\pm 3.54$ ) and 15.66 ( $\pm 2.82$ ) of xCl-PAP, 22.00 ( $\pm 3.45$ ) and 14.29 ( $\pm 2.82$ ) of Ac-PAP, 14.44 ( $\pm 3.28$ ) and 8.57 ( $\pm 2.52$ ) of Ax-PAP, 29.12 ( $\pm 1.58$ ) and 24.53 ( $\pm 1.91$ ) of Ac-EpL, 14.49 ( $\pm 0.95$ ) and 12.30 ( $\pm 1.00$ ) of Ac-yUm, and 29.90 ( $\pm 2.91$ ) and 37.82 ( $\pm 4.60$ ) of  $\hat{A}$  angle. The measurements of all segments obtained using the tape measure (direct anthropometry measurements) showed significant differences when compared with photogrammetry by Image Tool™ software (indirect anthropometric measurements) (Table 2).

There was a moderate positive and statistically significant correlation between the measures:  $\hat{A}$  angle ( $r = 0.46$ ;  $p < 0.0001$ ), Ac-yUm ( $r = 0.64$ ;  $p < 0.0001$ ), IJ-Xi ( $r = 0.64$ ;  $p < 0.0001$ ) and Ac-EpL ( $r = 0.66$ ;  $p < 0.0001$ ) (Table 2 and Figure 4); strong positive and statistically significant correlation between the measures: Ac-PAP ( $r = 0.79$ ;  $p < 0.0001$ ), Ax-PAP ( $r = 0.79$ ;  $p < 0.0001$ ), xCl-PAP ( $r = 0.83$ ;  $p < 0.0001$ ) and IJ-PAP ( $r = 0.86$ ;  $p < 0.0001$ ) (Table 2 and Figure 5); and very strong positive and statistically significant correlation between the measure: PAP-Xi ( $r = 0.91$ ;  $p < 0.0001$ ) (Table 2 and Figure 6).

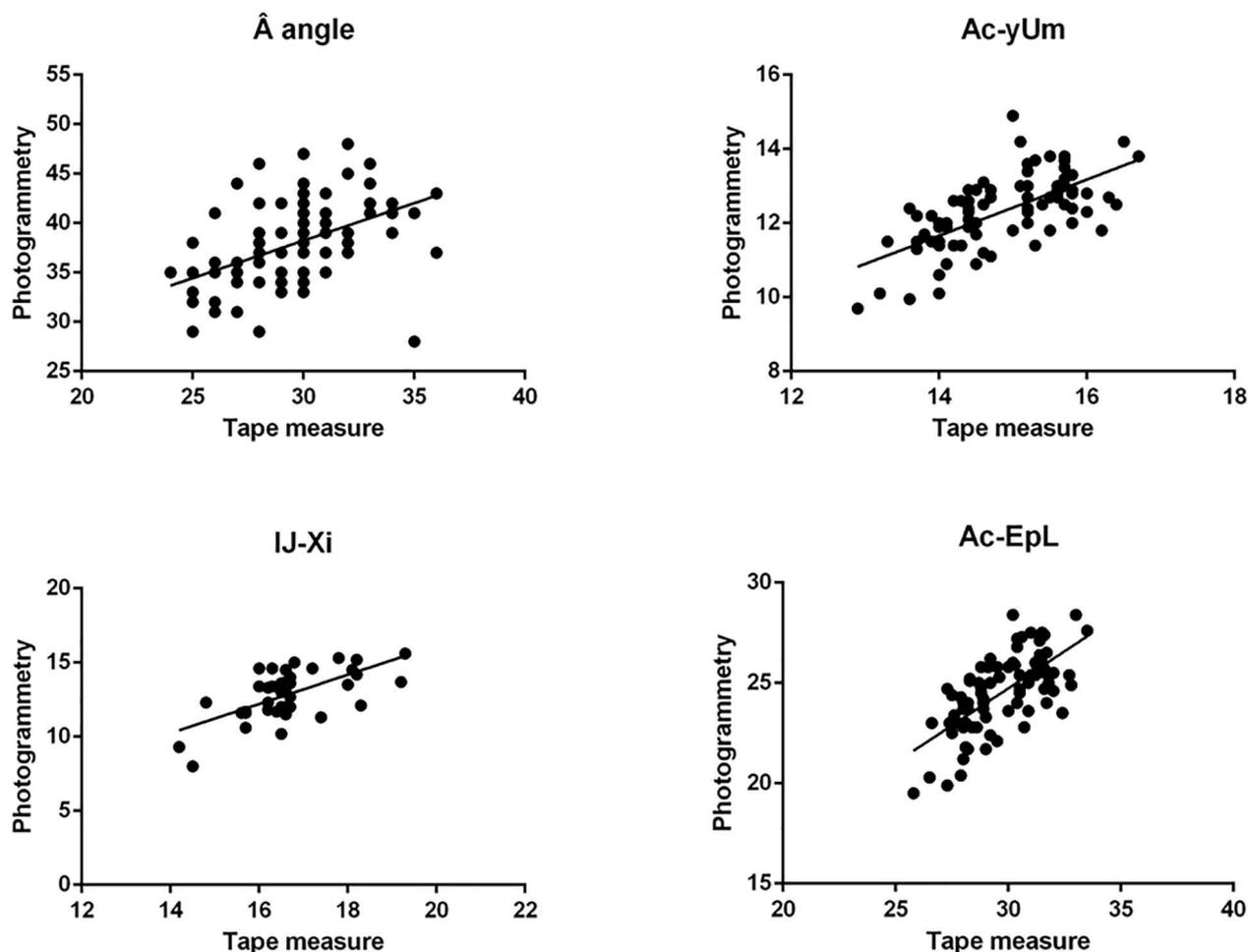
## DISCUSSION

Breasts are considered a symbol of femininity, sensuality, and motherhood; therefore, they play a fundamental role in women's physical and mental health<sup>10</sup>. In 1955, Penn<sup>2</sup> collected measurements from 150 women; only 20 considered having symmetrical

**Table 2.** Mean, Standard deviation (SD), Pearson correlation (r), Confidence interval (CI) and p value of measurements obtained with tape measure and photogrammetry by Image Tool™.

Segments	Tape measure	Photogrammetry	r	CI	p value
	Mean $\pm$ SD	Mean $\pm$ SD			
IJ-Xi	16.35 $\pm$ 1.14	12.90 $\pm$ 1.69	0.64	0.50 to 0.76	< 0.0001
PAP-Xi	11.16 $\pm$ 1.07	10.98 $\pm$ 1.30	0.91	0.86 to 0.94	< 0.0001
IJ-PAP	22.08 $\pm$ 3.08	18.24 $\pm$ 2.65	0.86	0.78 to 0.90	< 0.0001
xCl-PAP	21.46 $\pm$ 3.54	15.66 $\pm$ 2.82	0.83	0.75 to 0.88	< 0.0001
Ac-PAP	22.00 $\pm$ 3.45	14.29 $\pm$ 2.82	0.79	0.69 to 0.86	< 0.0001
Ax-PAP	14.44 $\pm$ 3.28	8.57 $\pm$ 2.52	0.79	0.70 to 0.86	< 0.0001
Ac-EpL	29.12 $\pm$ 1.58	24.53 $\pm$ 1.91	0.66	0.52 to 0.77	< 0.0001
Ac-yUm	14.49 $\pm$ 0.95	12.30 $\pm$ 1.00	0.64	0.49 to 0.75	< 0.0001
Â angle	29.90 $\pm$ 2.91	37.82 $\pm$ 4.60	0.46	0.27 to 0.62	< 0.0001

SD: Standard deviation; r: Pearson correlation; CI: Confidence interval; IJ-Xi: Segment from the jugular notch center to the base of the xiphoid process; PAP-Xi: Center of the mammary papilla to anterior median line, passing through the base of the xiphoid process; IJ-PAP: Center of the mammary papilla to jugular notch center; xCl-PAP: Center of the mammary papilla to half the distance between the jugular notch center and the acromion; Ac-PAP: Center of the mammary papilla to lateral border of the acromion; Ax-PAP: Center of the mammary papilla to most cranial point of the fold in the anterior axillary line; Ac-EpL: Lateral border of the acromion to anterior projection of the lateral epicondyle; Ac-yUm: Half the distance between the acromion and the lateral epicondyle to the lateral epicondyle; Â angle: Confluence of the segments (IJ-Xi) and (IJ-PAP).

**Figure 4.** Moderate correlation between photogrammetry and tape measure.

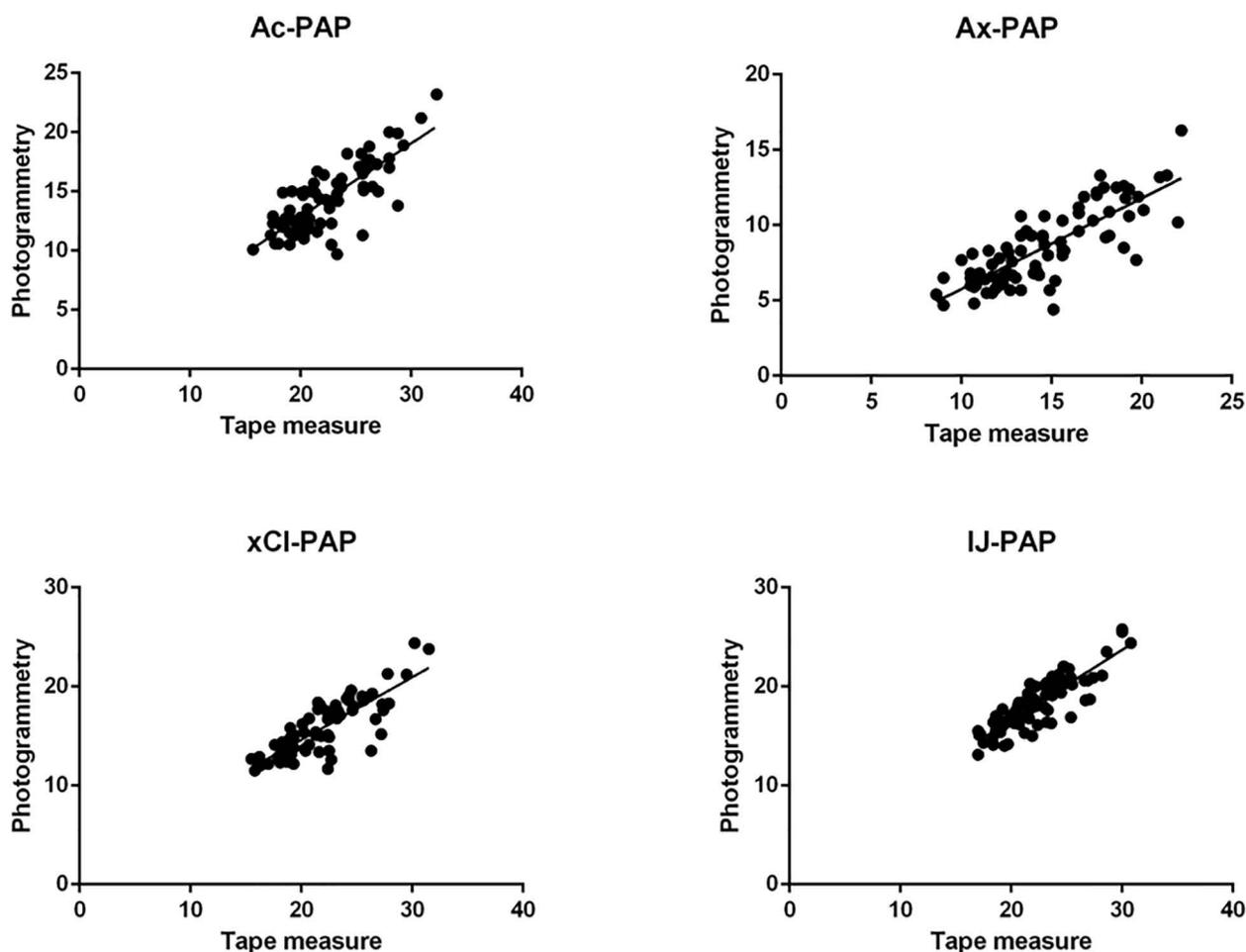


Figure 5. Strong correlation between photogrammetry and tape measure.

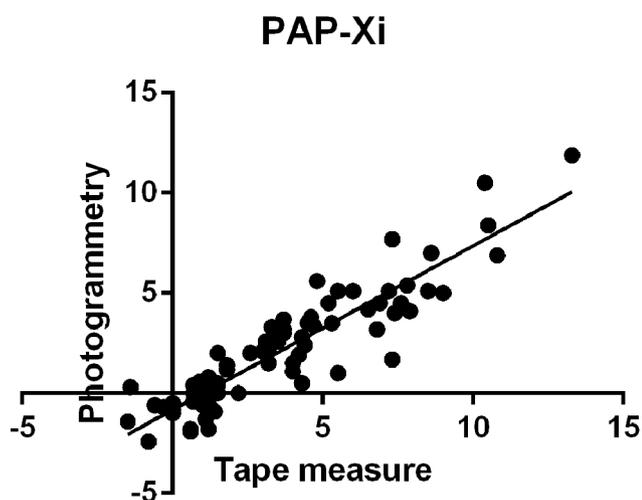


Figure 6. Very strong correlation between photogrammetry and tape measure.

and aesthetically perfect breasts. This way, an attempt was made to set a normal standard for breast measures. Since then, several authors have developed protocols for direct breast anthropometric measurements<sup>1-5</sup>. When used the same anthropometric points for direct measurement of the breast region, using different measuring instruments (compass and metric tape), there may be differences in the measures found<sup>6</sup>. Nechala et al., in 1999<sup>8</sup>, have compared direct anthropometry with photogrammetry for face measurements and concluded that there was no consensus on determining the best measurement method.

Given the lack of consensus of photogrammetry in different body areas, this study aimed to investigate the differences between measurements obtained by direct (tape measurement) and indirect (digital photogrammetry) anthropometry of the breast region, a subject of significant importance in plastic surgery. The standardization of positions, relative measurements, and photographic angles and markers on the anthropometric points and/or anatomical landmarks

bring reliability and reproducibility to a scientific study<sup>11-15</sup>. The systematization and standardization of photographic framing, distance, and height of the camera and reflectors so as patient positioning are needed procedures for sequenced evaluations, for example, for pre- and postoperative comparisons, thereby allowing validating the comparison of techniques and results, preserving the scientific rigor<sup>13</sup>.

An alternative method is an indirect anthropometry using computer-based photogrammetry, which performs the measurement of photographs with graphic software aid and does not require the patient's physical presence for data collection<sup>8,9</sup>. This method allows centesimal precision, reducing errors, besides enabling measurements over time. Thus, it is possible to compare pre- and postoperative differences quantitatively.

The average time spent with data collection for each volunteer, from the beginning to the end of the measurement interview was 34 minutes, 10 minutes spent only for measurements with a tape measure. Four volunteers reported discomfort while performing the measurements. This event did not allow a tacit recommendation of scientific rigor concerning the need of 2 intra-evaluator measurements to verify the accuracy or the degree of reproducibility of the method used.

The determining factor for the use of the labels was the fact that they minimize discomfort and pain as felt when marking with pen the center of the mammary papilla. Christie et al., in 2005<sup>16</sup>, used this same tactic, reporting that the use of self-adhesive labels at the time of the photography sessions lessened the discomfort of demarcating anthropometric points besides reducing the chances of errors.

According to Westreich, in 1997<sup>1</sup>, the most challenging measurements were the segment from the axilla to the center of the mammary papilla, and the segment of the mammary fold's lateral point since markings made on soft tissue are too much variable to be included in studies of breast measurements. These markings can vary from woman to woman and change even with the patient's slight movements, and may, therefore, be inaccurate, which was also highlighted in the study by Smith et al. (1986)<sup>4</sup>.

Until now, the breasts are measured by digital photography. However, the studies are not clear, and standardization should be made for the breast measurement. The literature used direct anthropometry<sup>1,4,6,7</sup> or the studies evaluated mastectomy and voluminous breast<sup>17,18</sup>. The Pearson correlation test demonstrated that measures that are directly related to the breast presented a strong or very strong correlation. However, measurements related to the arm and chest showed a moderate correlation. Therefore, for measurements related to the breast, especially the

papilla, the use of tape measure and digital photography performed by Image Tool™ could be an option in the evaluation of breasts in women. Thus, the discomfort reported by volunteers could be minimized because digital photography is faster than a tape measure.

Although clinical photographs have been taken in 5 different positions - anteroposterior (AP), right and left profiles and right and left oblique, according to literature guidelines<sup>1,14,15</sup> - in this study, given the fact that all points determined for evaluation could also be evaluated in frontal position, only the AP position was standardized. How was demonstrated by Quieregatto et al., in 2015<sup>19</sup>, our results demonstrate that the association between direct and indirect anthropometry could not be indiscriminately used. The present study demonstrates two forms to evaluate the healthy breast. We are looking for the best way to suggest breast evaluation. Other studies are necessary to compare different breast measurement software.

## CONCLUSION

There was a correlation between direct (tape measurement) and indirect (photogrammetry by Image Tool™ software) anthropometry in the segments that directly involve the breast, especially the papilla. c

## COLLABORATIONS

- PRQES** Analysis and/or data interpretation, Conception and design study, Conceptualization, Data Curation, Final manuscript approval, Formal Analysis, Investigation, Methodology, Project Administration, Realization of operations and/or trials, Resources, Software, Validation, Visualization, Writing - Original Draft Preparation, Writing - Review & Editing
- AFPM** Analysis and/or data interpretation, Conception and design study, Data Curation, Investigation, Methodology, Software, Writing - Review & Editing
- SF** Analysis and/or data interpretation, Conception and design study, Conceptualization, Data Curation, Formal Analysis, Methodology, Project Administration, Realization of operations and/or trials, Supervision, Writing - Original Draft Preparation, Writing - Review & Editing
- AAQES** Data Curation, Formal Analysis, Investigation, Software, Visualization

- FF** Analysis and/or data interpretation, Conception and design study, Conceptualization, Formal Analysis, Project Administration, Resources, Software, Supervision, Writing - Review & Editing
- REL** Analysis and/or data interpretation, Conceptualization, Data Curation, Final manuscript approval, Formal Analysis, Methodology, Supervision, Validation, Writing - Review & Editing
- MSN** Analysis and/or data interpretation, Conceptualization, Final manuscript approval, Investigation, Methodology, Supervision, Visualization, Writing - Original Draft Preparation
- LMF** Analysis and/or data interpretation, Conceptualization, Final manuscript approval, Investigation, Supervision, Writing - Review & Editing

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