

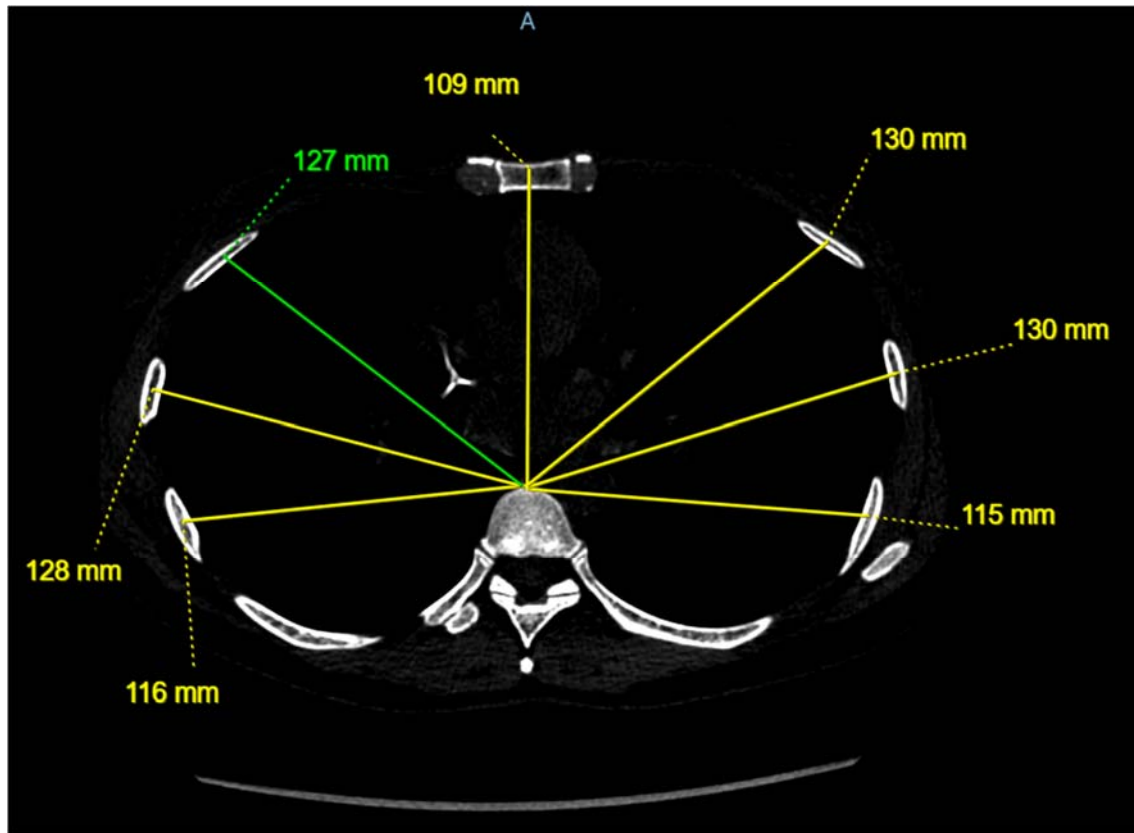
## Appendix A

**Table 1: Measurement of an average (normal), small (leaner) and large (curvilinear) female anterior thoracic (rib cage) sizes**

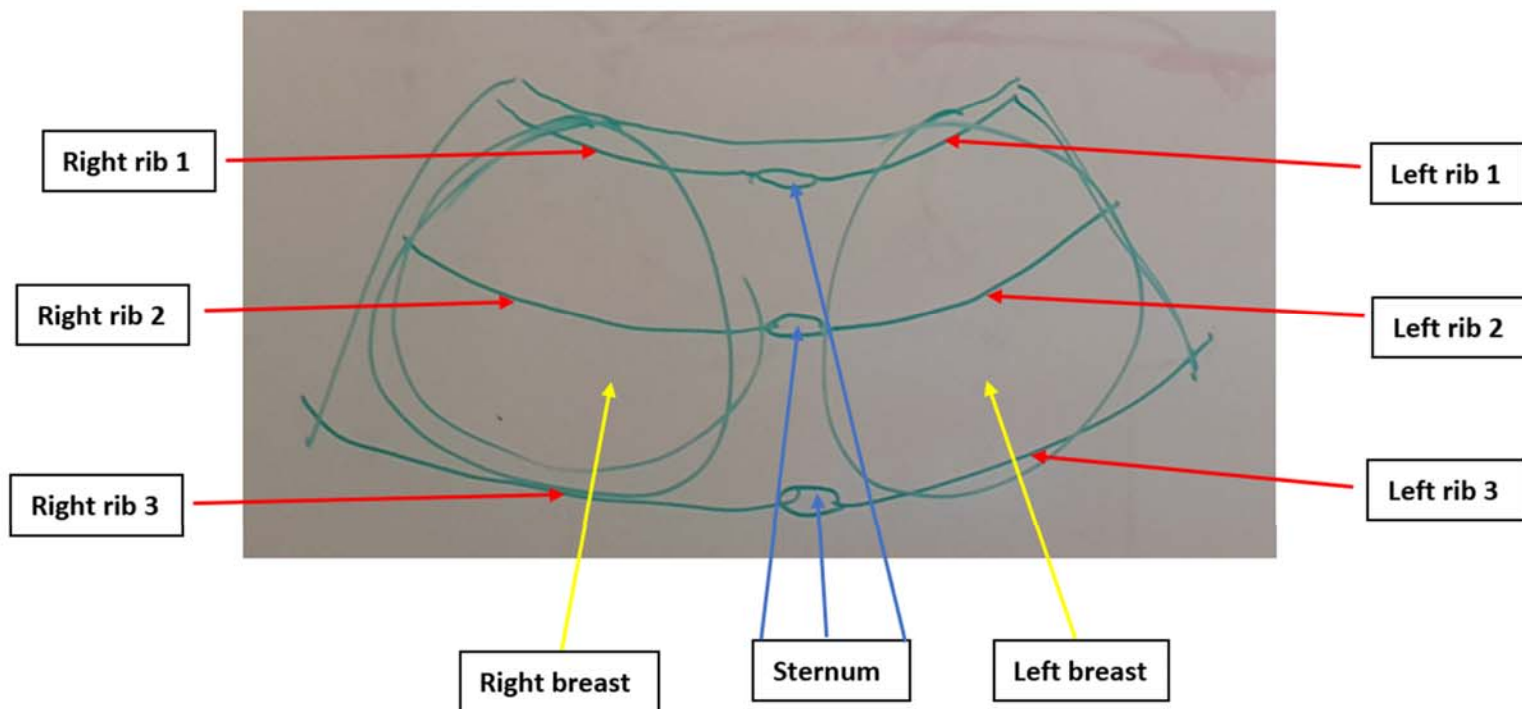
<b>Measurement of an average (normal) female anterior thoracic (rib cage) size</b>							
<b>Cross sections (mm)</b>	<b>Right rib1</b>	<b>Right rib2</b>	<b>Right rib3</b>	<b>Sternum</b>	<b>Left rib1</b>	<b>Left rib2</b>	<b>Left rib3</b>
1	87.1	74.3	65.4	64.4	85.1	72.5	64.9
2	109.1	115.3	111.1	107.6	110.1	115.4	111.7
3	120.1	131.3	135.4	131.2	123.6	134.1	137.6
4	129.6	139.8	141.3	134.1	130.7	141.2	142.5
5	136.5	142.9	141.8	135	135.4	143	143.2
6	137	139.3	134.2	127.9	136.5	141.6	137.2
<b>Measurement of a small (leaner) female anterior thoracic (rib cage) size (-2SD)</b>							
<b>Cross sections (mm)</b>	<b>Right rib1</b>	<b>Right rib2</b>	<b>Right rib3</b>	<b>Sternum</b>	<b>Left rib1</b>	<b>Left rib2</b>	<b>Left rib3</b>
1	63	44.4	42.2	36.8	61.3	42.7	39.9
2	87.4	88.7	75.2	71.1	87.1	86	75.8
3	98	104.6	100.1	92.8	101.6	108.2	103
4	103.5	110	106.8	93.1	106.7	112.8	107.8
5	109.2	111	102.2	89.7	110.4	112.3	102.1
6	106.8	100.8	90.8	80.3	107.1	104.1	94.6
<b>Measurement of a large (curvilinear) female anterior thoracic (rib cage) size (+2SD)</b>							
<b>Cross sections (mm)</b>	<b>Right rib1</b>	<b>Right rib2</b>	<b>Right rib3</b>	<b>Sternum</b>	<b>Left rib1</b>	<b>Left rib2</b>	<b>Left rib3</b>
1	111.3	104.2	88.5	92	108.9	102.4	89.8
2	130.8	142	147.1	144.2	133.2	144.9	147.7
3	142.1	158	170.7	169.6	145.5	160	172.3
4	155.7	169.7	175.9	175.2	154.7	169.5	177.2
5	163.8	174.9	181.3	180.3	160.5	173.8	184.2
6	167.3	177.8	177.6	175.6	165.9	179	179.8

**Note:** A total of 347 female thoracic (rib cages) were measured using computed tomography (CT) axial scans across six cross sections with three anterior rib landmark points on the left side of the sternum and three anterior rib landmark points on the right side of the sternum (breastbone). \* All measurements are recorded in millimetres (mm) and rounded to the nearest one decimal place.

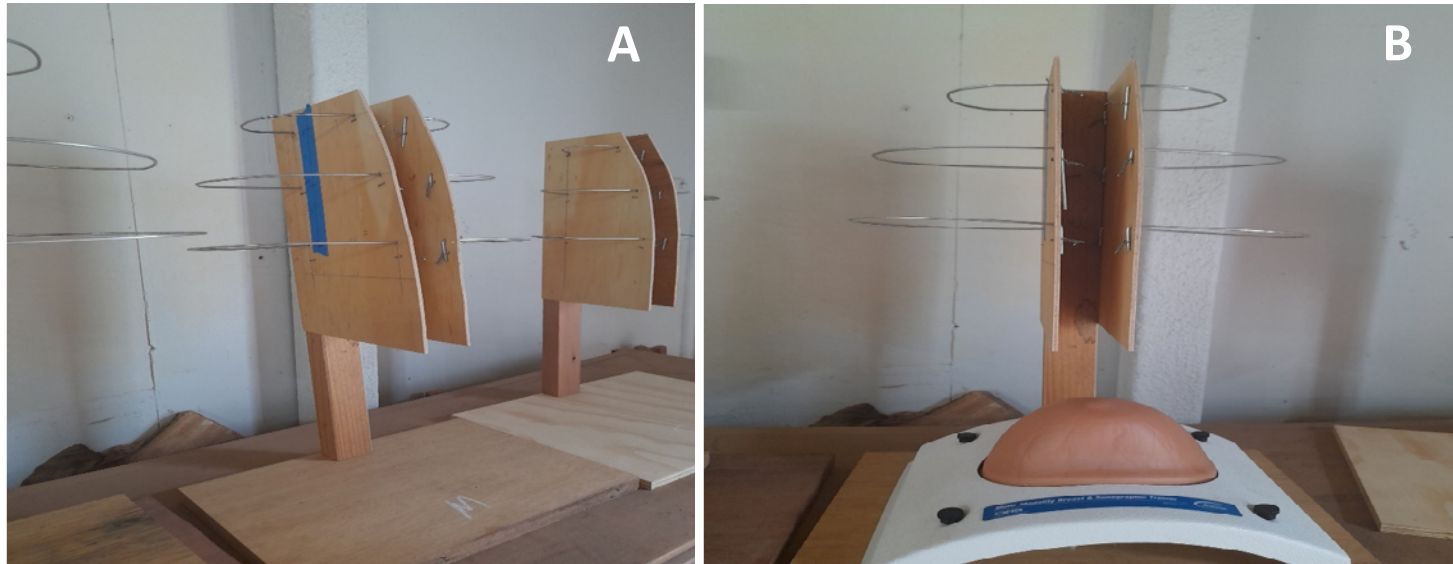
A retrospective analysis of 347 de-identified female patient's computed tomography (CT) non-contrast chest axial scans were retrieved from the Medical Imaging and Data Resource Center (MIDRC) open access database<sup>28</sup> to calculate the dimensions of three female thoracic (rib cage) sizes (small, medium and large). The measurements started from the anterior thoracic spine of the CT axial scan and ended at the centre or tip of each of the three rib landmark points on the left and right side of the sternum. The measurement of the sternum started from the anterior thoracic spine and ended at the centre or tip of the sternum (Appendix B, Fig. 1). Images excluded from this study included patients' that have undergone radiotherapy, male breasts, patients with chest pathologies, extreme rib curvatures or gross chest wall deformity<sup>29</sup>. The mean values reflected an average (normal) female thoracic (rib cage) size, the minus two standard deviation (-2SD) values reflected the small (leaner) female anterior thoracic size and the plus (+) 2SD values reflected a large (curvilinear) female anterior thoracic size (Appendix A, Table 1). All measurements are recorded in millimetres (mm) and rounded to the nearest one decimal place. The three sizes of measurements (average, small, large) (Appendix A, Table 1) including a visual schematic drawing of the female thorax (Appendix B, Fig. 2) were used to construct three thoracic size models using wood (Appendix B, Figs. 3A and 3B), thin meshed wires (Appendix B, Figs. 4A and 4B), glued with papier Mache (Appendix B, Figs. 5A and 5B), painted with white paint (Appendix B, Figs. 6A and 6B) and painted with orange rubber latex (Appendix B, Figs. 7A and 7B). The construction process of the three thoracic size models will be described in detail in the first author's Doctor of Philosophy (PhD) thesis. In this mammography experimental study, mammographic exposures using one CC view and six MLO views were repeated for each breast-thorax size combination (Appendix B, Figs. 8A and 8B), capturing images for the three sizes of breast phantoms (small, average and large) attached to three sizes of female thorax models (small, average and large) individually at angles of 0°, 30°, 40°, 45°, 50°, 55° and 60°.



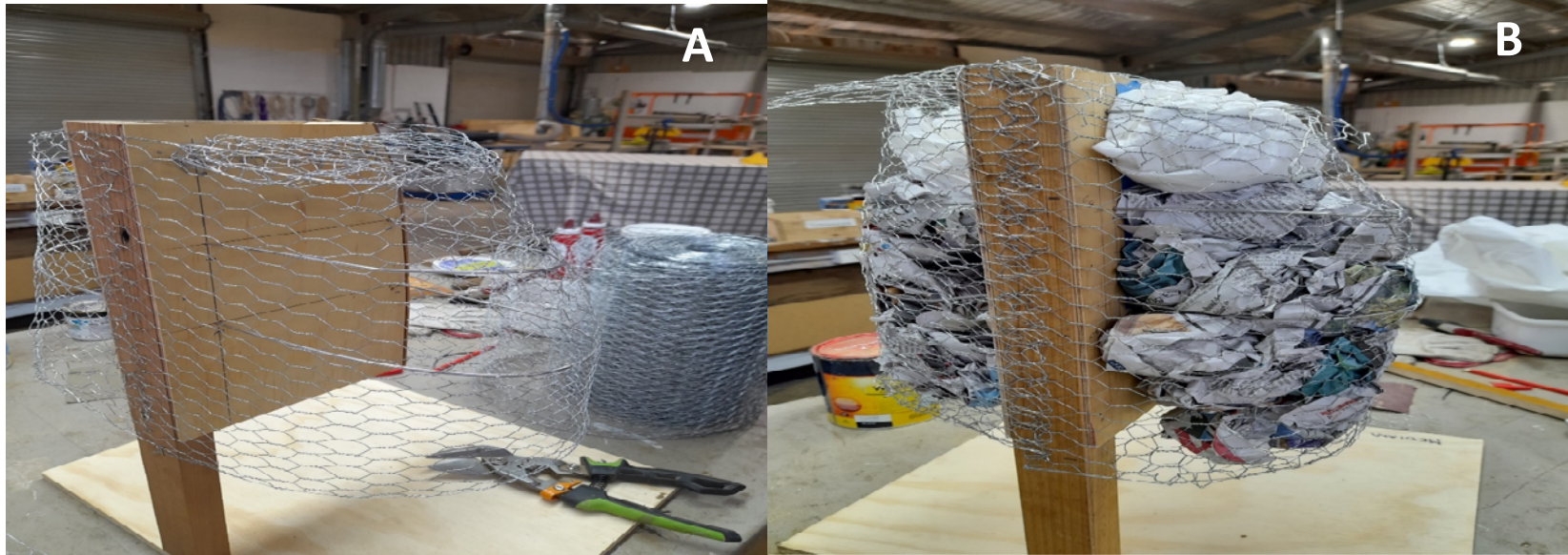
**Appendix B (Fig. 1):** The measurements started from the anterior thoracic spine of the female CT axial scan and ended at the centre or tip of each of the three rib landmark points on the left and right side of the sternum. The measurement of the sternum started from the anterior thoracic spine and ended at the centre or tip of the sternum. Source: CT chest data used in preparation of this article was obtained from the Medical Imaging and Data Resource Center (MIDRC) open access database<sup>28</sup>.



**Appendix B (Fig. 2):** Schematic drawing and labelling was used to visualise a female rib cage shape with a cross section of three anterior ribs as seen from the outside.



**Appendix B (Figs. 3A and 3B):** Three thin long wires based on measurements from table 1 were used to construct the three female rib cage sizes (average, small and large). Figure 3A shows wooden female rib cage models of average and small size. Figure 3B shows wooden female rib cage model of large size.



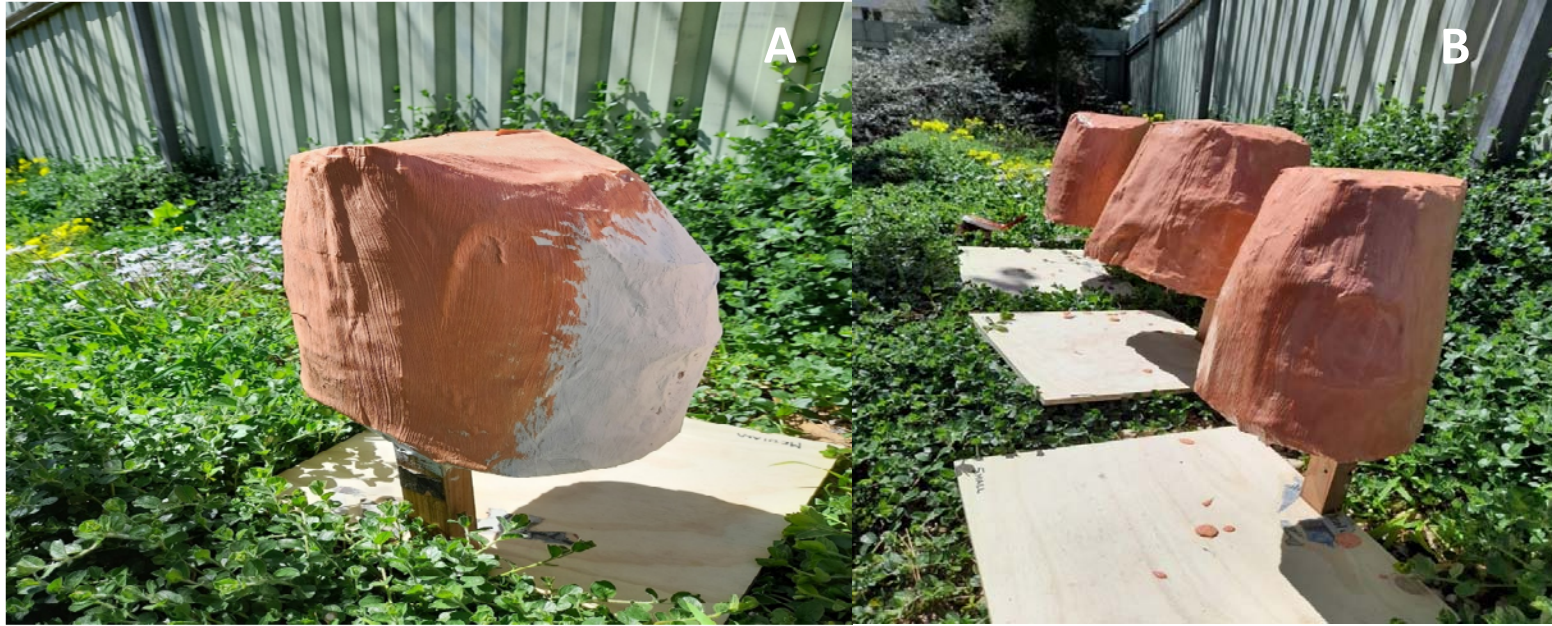
**Appendix B (Figs. 4A and 4B):** Meshed wire was attached around the three wooden female rib cage models to reflect real rib cages. Figure 4A shows meshed wire attached around the large wooden female rib cage model. Figure 4B shows used newspapers and old plastics that were placed inside the empty gap/space created by the meshed wires to reflect internal soft tissue organs such as stomach, heart, lungs, etc and to provide stability to the three rib cage models.



**Appendix B (Figs. 5A and 5B):** Papier Mache was glued around the three wooden female rib cage models to provide stability and left to dry for three days.



**Appendix B (Figs. 6A and 6B):** The three rib cage models with dried papier Mache were painted white to provide stability and left to dry in the sun for three days.



**Appendix B (Figs. 7A and 7B):** Rubber latex was painted on all three rib cage models to provide more stability and left to dry in the sun for three days.



**Appendix B (Figs. 8A and 8B):** Figure 8A shows positioning for CC view of average sized breast phantom attached to average sized thoracic model. Figure 8B shows MLO positioning of average sized breast phantom with attachment to average sized thoracic model at 45-degree angle. Image courtesy of Mammography department in Heidelberg Repatriation Hospital and Austin Health in Melbourne, Australia (28<sup>th</sup> October 2024).

## Appendix C:

**Table 2: Breast image measurement showing the average, standard deviation, minimum and maximum values of female breast sizes and breast volume.**

Measurement (mm/ml)	CC PNL (Height)	CC Diameter	CC Radius	CC (R <sup>2</sup> )	CC Volume (mm <sup>3</sup> )	CC Volume (ml)	MLO PNL (Height)	MLO Diameter	MLO Radius	MLO (R <sup>2</sup> )	MLO Volume (mm <sup>3</sup> )	MLO Volume (ml)
Average (mean)	62.87	163.78	81.89	6791.40	480171.98	480	73.27	194.66	97.33	9518.02	781312.30	781
Standard Deviation (SD)	16.29	19.87	9.94	1656.29	258743.26	258.74	16.69	13.42	6.72	1289.95	402248.70	402.25
Small (-1SD)	46.58	143.91	71.95	5135.11	221428.72	221.43	56.58	181.23	90.61	8228.08	379063.60	379.06
Large (+1SD)	79.16	183.66	91.83	8447.70	738915.24	738.92	89.96	208.08	104.05	10807.97	1183561.00	1183.56
Small (-2SD)	30.29	124.04	62.02	3478.82	-37314.54	-37.31	39.89	167.81	83.89	6938.13	-23185.09	-23.19
Large (+2SD)	95.45	203.53	101.76	10103.99	997658.51	997.66	106.66	221.51	110.77	12097.92	1585809.70	1585.81

**Note:** A total of 360 female mammograms were assessed and measured for PNL and volume using digital mammography. \* All measurements are recorded in mm. Except the conversion to volume of water for the CC and MLO views are recorded in ml. All measurements are rounded to the nearest two decimal places.

**Abbreviation:** PNL, Posterior nipple line; mm, millimetre; ml, millilitre; R<sup>2</sup>, Radius squared; mm<sup>3</sup>; cubic millimetre; CC, Craniocaudal; MLO, Mediolateral oblique.

The three female breast sizes were calculated using mean values reflecting average size standard deviation (SD), minus 1 standard deviations (-1SD) values reflecting small breast size and +1SD values reflecting large breast size from a total of 360 mammograms of a Chinese female screening population downloaded from The Chinese Mammography Database (CMMD)<sup>30</sup>. Considering the breast shape as being oval, volume for the CC view was based on the algebraic formula of a circular base using the Katariya et al.<sup>34</sup> method: Volume = Pi (3.14) x (radius CC)<sup>2</sup> x height (posterior nipple line [PNL] CC)/3. The volume included on the CC view was calculated using the PNL (also known as the breast height), the breast width (BW) (the distance from the most lateral point of breast tissue to the most medial point of breast tissue) and the radius (recorded as half the BW)<sup>32-34</sup>. The calculation of breast volume on the MLO view replicated the CC view calculations except BW was defined as the distance from the most inferior extent of breast tissue to the junction between the most superior extent of breast tissue and the posterior edge of the image. Since the MLO view captures significantly more breast tissue than the CC view<sup>7-10</sup>, the volume of the three breast sizes were calculated in cubic millimetre (mm<sup>3</sup>) using the MLO measurements (Appendix C, Table 2). These measurements were then converted to millilitre (ml) using the standard formula: 1 mm<sup>3</sup>

= 0.001 ml or the volume values in mm<sup>3</sup> were divided by 1000. After conversion, the final volume of the three breast sizes include: a) small = 379.06 ml; b) medium = 781 ml; and c) large = 1183.56 ml ([Appendix C, Table 2](#)).

Three large high-quality party balloons filled with water equivalent to the volume in ml of each breast size (small = 379.06 ml; medium = 781 ml; large = 1183.56 ml) were weighed in grams (g) using a mini kitchen digital weighing scale<sup>37</sup>. The weight of each water balloon reflected the three breast sizes and weighed: a) small = 449 g; b) medium = 875 g; and c) large = 1.063 kilogram (kg). Three pairs of breast phantom sizes with weight almost similar to the weight of the water balloons were bought online at Amazon Australia<sup>38</sup> to reflect real female breasts. The breast phantoms were made from 100% non-allergic full medical silicone. The weight of each pair of breast phantoms according to the three sizes include: a) small = 504 g; b) medium = 804 g; and c) large = 998 g. The weight of one breast phantom for each size include: a) small = 252 g; b) medium = 402 g; and c) large = 499 g.