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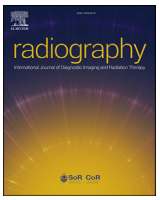

A qualitative study of mammography best practice positioning for female body habitus and breast tissue inclusion in Australia

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ABSTRACT

Introduction: Optimal positioning in mammography is key to maximise the inclusion of breast tissue on the image. This study aimed to explore the top performing Australian radiographers' mammography best positioning techniques for patients with various body habitus and their perspective on optimised breast tissue inclusion.
Methods: Twelve qualified Australian female radiographers with an age range of 20–70 years with equal representation from screening and diagnostic mammography settings were invited through Volpara® Health to participate in an online individual semi structured interview. Audio-recorded data was transcribed and analysed thematically. Key demographics of the participants include age, education, and mammographic experience.
Results: Three key themes emerged for the craniocaudal (CC) view and the mediolateral oblique (MLO) view: good communication, CC detector height and MLO image receptor (IR) angle. Responses to each theme were categorised under six female body habitus for both the CC and MLO views: small, average, large, rib hump, pectus excavatum and pectus carinatum. Effective communication was demonstrated as critical by radiographers during positioning for varied body habitus. A 45° angle was commonly used for an average, small and large body habitus.
Conclusion: Appropriate and customised positioning and effective communication is important during mammography positioning to maximise breast tissue inclusion on the image. Routine CC and MLO positioning techniques cannot be applied for patients with extreme curvature of the thorax or protruding sternum and ribs.
Implications for practice: It is critical for mammography screening programs to include a language interpretation service that targets patients from multiple cultural backgrounds to enhance effective communication during positioning. This study highlights best positioning technique by radiographers that may impact women with extreme thorax curvature or protruding ribs, and subsequent obstruction in optimal positioning.

Introduction

Globally, breast cancer is the second most common cancer and the number one female cancer affecting more than two million women.[1,2] In Australia, breast cancer was diagnosed in 28 % of all female cancers in 2020 with 10,921 new cases identified in women aged 50–74 at a crude rate of 306.7 per 100,000 women.[2] After lung cancer, breast cancer was the second leading cause of death in Australian women in 2022[2,3] with 1404 deaths in women aged 50–74 at a crude rate of 38.4 per 100,000 women.

Mammography is the current global standard imaging modality that detects early breast cancer and other breast symptoms.[4] If not detected early, breast cancer may spread through the lymphatic and or vascular systems and metastasise to other parts of the body

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potentially resulting in death.[4] Mammographic imaging is undertaken in two distinct settings: screening and diagnostic. Screening mammography targets healthy individuals without breast cancer symptoms[5] through systematic population-based screening programs, including BreastScreen Australia (BSA), and is undertaken at regular two-yearly intervals to detect pre-clinical cancers.[6–8] Diagnostic mammography is aimed at individuals with breast symptoms and is undertaken at point in time moments at diagnosis and treatment stages.

The aim of mammography is to include as much of the breast tissue as possible on the image. The success of this is determined using various image evaluation systems (IES). The craniocaudal (CC) projection is one of two routine radiographic views in mammography. When adequately performed, the CC projection clearly visualises the anterior, central, medial, retroareolar and posteromedial portions of the breast.[5,9,10] Although the majority of the breast tissue is exhibited in the CC view, this view does not clearly capture the majority of the lateral breast tissue.[11,12] The mediolateral oblique (MLO) projection is the second routine radiographic view in mammography and when adequately performed,[5,10] nearly all the breast tissue is imaged including the upper outer quadrant of the breast which is the location of the majority (over 75 %) of breast pathology, including breast cancer.[13–16] Additionally, the MLO view uses a variety of image receptor (IR) angle ranging from 30°-70°[5,9-16] to capture breast tissue on the image that may be potentially missed on the CC view which uses one IR angle at 0°.

The thoracic wall (ribs) supports the posterior region of the breast that is positioned vertically from the second to sixth ribs.[12,16,17] The thoracic wall is also adjacent to key anatomical positioning landmarks of the breast including the pectoral muscle and the inframammary angle (IMA). The pectoral muscle lies directly superior to the thorax wall whilst the IMA is found at the inferior region of the breast where the breast tissue connects with the thorax wall.[16,18] Anatomical structures including the thorax size, breast size, shape of the pectoral muscle and the IMA may impact optimal positioning and subsequent image quality. Other key factors that affect mammographic image quality include the expertise of radiographer, patient compliance with respect to communication and instruction, equipment design and variability in female body habitus.[19–23] In terms of radiographers' skills and experiences in positioning techniques, it is important for radiographers to understand the key challenges of positioning and individual variations in the body habitus. Skills include the ability to relax the woman and clear communication to ensure women cooperate and comply during the mammography examination.[5,13,19,23] Furthermore, radiographers should be competent in position techniques, taking the images and in reviewing the quality of the images they produce.[24,25] Importantly, radiographers should be able to manage deficits in image quality when they are identified.[26–29]

Optimal mammography positioning is key to maximise the inclusion of breast tissue on the image. However, optimal positioning can be challenging when an individual's body habitus does not fit the normal screening population. There are subsets within the population that do not fit the considered 'normal' body type. Such individuals include those with very small breasts, large or wide breasts, those with a barrel thorax or kyphosis, those with a rib hump, those with pectus excavatum (PE) (depressed sternum) or pectus carinatum (PC) (prominent protruding sternum/pigeon thorax) (Table 1), frozen shoulder, or recent open-heart surgery.[5,9,30–32] These complexities in human body habitus pose a great challenge in mammography positioning.

This is a component of a larger mixed methods study involving quantitative examination of body habitus implications and validates the findings of a recent study[33] on Australian radiographers' digital era practice in selecting the IR angle for female body habitus for the MLO view of the breast. This study aimed to explore the top performing Australian radiographers' mammography best positioning techniques for patients with various body habitus and their perspective on optimised breast tissue inclusion.

Methods

Study design

A qualitative approach was used to address this study's research objectives. Data collection was undertaken using an online (Zoom) platform to conduct semi structured interviews[34] with qualified radiographers practising mammography in Australia (Table 1). Participants were provided with a participant information statement (PIS) which was sent to them prior to the interview via email. The PIS included several items of information; a formal invitation to participate in the study, the purpose of the study, explanation of any possible risks and benefits for participation in the study, any costs involved, maintaining participants confidentiality, how participants' information would be used and whom to contact if participants have concerns about the conduct of this study. Consent was gained electronically using a secure platform (DocuSign) prior to participation.

Participant recruitment

Participants were selected from radiographers identified by Volpara® Health Technologies Ltd., a New Zealand corporation[35] with company number 2206998 ("Volpara"), which is the creator and owner of proprietary technology relating to breast cancer detection and diagnosis, and analytics tools for quality assurance, including breast positioning ("TruPGMI"). The top 10 % of radiographers in Australia aged 20—70 years were accessed via the Volpara® Health radiographers data base and invited to participate. Through Volpara®'s monthly recognition program, performance reviews identify top performers using Volpara® data.[36] Radiographers are acknowledged for their top performance in various categories, such as compression, overall quality, positioning, and improvement.[36] Volpara® highlights those radiographers who achieve top 10 % status in these areas via email to encourage a sense of accomplishment and motivates others to strive for excellence.[36] Technically, Volpara® emailed the top 10 % of Australian radiographers to determine their interest in participating in this study. It was then up to the lead researcher to invite the radiographers that showed interest once they were informed of the requirements. The participants were identified as having best practices through automated image quality analysis. To gain perspectives from both screening and diagnostic radiographers, quota sampling was used to ensure the inclusion of 3—6 participants from each setting from the first available participants who responded to the invitation.[37,38] The first available 12 participants that met the inclusion criteria were selected to participate.[38] Qualitative data from this sample of participants enabled the fulfilment of thematic data saturation, a reflection of data redundancy (i.e. when no new themes emerged from original data).[37,39] Prospective participants were notified by email as to whether they were able to participate in the interview. Each participant was given a certificate of appreciation for participating in the interview.

Interview presentation and discussion

Potential participants completed a pre-recruitment eligibility check and signed a consent form prior to participation. The pre-

Table 1
Patient body habitus (thorax) and image quality.

Various body shapes (thorax) and image quality interview presentation topics and key discussion questions.

A. Introduction

a. Welcome the participants to the interview and acknowledge their expertise as the top-performing 10% in positioning techniques.
b. Introduce the research moderator and her role during the interview.
c. Explain the house keeping rules.
d. Provide a short demographic questionnaire to participants to complete on Zoom before commencing the interview and images of body shapes to be discussed.

B. Demographic questions

1. Highest academic qualification attained: *(Please tick one)*
☐ Bachelor of Health Science (Medical Imaging/Diagnostic Radiography)
☐ Diploma of Health Science (Medical Imaging/Diagnostic Radiography)
☐ Associate Diploma of Diagnostic Medical Imaging
☐ Certificate (not including CCPM or CMP)
☐ Other (Australian)……
☐ Other (International)……

2. Do you hold the Certificate of Mammographic Practice (CMP), (formerly known as the Certificate of Clinical Proficiency in Mammography [CCPM])? *(Please tick one)*
☐ Yes
☐ No
☐ I have not heard of this certificate

3. Do you hold the Advanced Breast Imaging Certificate (ABIC)? *(Please tick one)*
☐ Yes
☐ No
☐ I have not heard of this certificate

4. Type of mammography performed: *(Please tick all that apply)*
☐ Diagnostic
☐ Screening

5. In your employment do you solely perform mammography? *(Please tick one)*
☐ Yes
☐ No

6. Please indicate type of employment. *(Please tick one)*
☐ Full time
☐ Part time
☐ Casual

7. How many mammograms do you typically perform each week? *(Please tick one)*
☐ Less than 10
☐ 10 – 20
☐ 20 – 50
☐ 50 – 100
☐ More than 100

8. Years of mammographic experience: *(Please tick one)*
☐ Less than 1 year
☐ 1 - 2 years
☐ 3 - 4 years
☐ 5 - 10 years
☐ More than 10 years
☐ More than 20 years

C. Mammography routine positioning	***Corresponding questions for discussion***
What the two routine mammography positioning is and how it is done. What the key receptor angle selection for the MLO view is.	a. How do you position the routine patient for the CC view? b. What are your best positioning techniques for the routine MLO view? c. How do you decide the receptor angle selection for the MLO view for various thorax presentations? d. What are your best positioning practices to maximise the inclusion of breast tissue for differing thorax presentations? e. If we consider image quality criteria, can you explain how you maximise the: (i) Width of the pectoral muscle; (ii) Length of the pectoralis major muscle; (iii) Length of the posterior nipple line/nipple line (PNL/NL); (iv) Inclusion of the inframammary angle (IMA); (v) Nipple in profile; (vi) Ensure that the anterior margin of the pectoralis major muscle is convex (relaxed) for a routine patient?
D. Definition of various body shapes (thorax) Definition of each of the body shapes (impact on receptor angle selection for the MLO view, impact on image quality)	f. How do you manage positioning for each of the following body shapes (thorax) to maximise image quality? g. How do you change / modify these positioning techniques for each of these various body shapes (thorax) for best practice? h. Do you believe there is a need to include a body habitus criterion in the image evaluation criteria?
D1. Linear body shape (thorax) **Definition: Linear body shape**[15, p. 192] – A body habitus characterized by a long, shallow thorax, a long thoracic cavity, a long, narrow abdominal cavity, and a slender build (*https://medical-dictionary.thefreedictionary.com/hyposthenic*).	***D2. Average body shape (thorax)*** **Definition: Average body shape**[30, p. 183] – Athletic build, normal, similar to large and heavy body but modified by elongation of abdomen and thorax (*http://radtechsociety.blogspot.com/2012/11/body-habitus.html*).
D3. Curvilinear body shape (thorax) **Definition: Curvilinear body shape**[30, p. 7] – Body is large and heavy, bony framework is thick, short and wider thorax, lungs and heart are high, transverse stomach and peripheral colon (*http://radtechsociety.blogspot.com/2012/11/body-habitus.html*).	***D4. Bilateral rib hump body shape*** **Definition: Bilateral rib hump body shape** – Bilateral rib hump deformities prominent at the lower rib arches. Deformities of the chest wall occur because of abnormal development of the skeletal or thoracic cavity[31, p. 268]
D5. Pectus excavatum (depressed sternum, sunken chest) body shape **Definition: Pectus excavatum body shape**[30, p. 130] – A congenital malformation of the chest wall characterized by a funnel-shaped depression with its apex over the lower end of the sternum; it is caused by shortening of the central portion of the diaphragm, which pulls the sternum backward during inhalation, and by the growth of ribs (*https://medical-dictionary.thefreedictionary.com/Pectus+excavatum*).	***D6. Pectus carinatum (pigeon chest, barrel chest) body shape*** **Definition: Pectus carinatum body shape**[30, p. 265] – A malformation of the chest wall in which the sternum is abnormally prominent (*https://medical-dictionary.thefreedictionary.com/Pectus+excavatum).*

Any other comments?
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……
……
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Abbreviation: CMP, Certificate of Mammographic Practice; CCPM, Certificate of Clinical Proficiency in Mammography; ABIC, Advanced Breast Imaging Certificate; CC, Craniocaudal; MLO, Mediolateral oblique; PNL, Posterior nipple line; NL, Nipple line; IMA, Inframammary angle.

recruitment eligibility check that the potential participants completed consisted of demographic questions on age, highest level of academic qualification related to radiography, whether radiographers held the current certificate of clinical proficiency in mammography, types of mammography performed, employment status and whether they solely perform mammography, and the number of years of mammographic experience that radiographers had. Potential participants had to complete answering all the questions to meet the eligibility check. Participants who met the eligibility check and had provided written consent were contacted by the research team. A Zoom link was emailed by the research team to the eligible participants at a time identified as suitable for both parties. Eligible participants completed the demographic questions and the consent form prior to the interview (Table 1) to save time, assist in participant preparation on the research topic and ensure a focused discussion with the radiographers could occur.[37] The interview took approximately 60 min of the participants' time and was conducted in September 2023.

The first author conducted the interviews which were recorded using both the Zoom audio recording software and a digital recorder. Consent for use of both recording devices was gained verbally at the beginning of the interview from all participants. Each interview session comprised: introduction and consent, demographic questionnaire, a review of key female body habitus, and a detailed presentation using PowerPoint to facilitate discussion (Table 1). The participants did not receive the PowerPoint presentation prior to the interview. To ensure consistency and rigor during each interview, the researcher undertook time keeping, note takings, question moderation for clarification and understanding, and responded to technical and other participant queries.[37] The researcher conducting the interviews has previous experience in conducting qualitative interviews and focus groups.[40] The PowerPoint presentation was reviewed prior to use in this study by two experienced radiographers who specialised in mammography. Throughout each interview, the participants were encouraged to seek clarification on any concepts, terminologies or cultural misunderstandings that were discussed.

Data collection and analysis

Semi structured, open-ended questions were used to explore the phenomenon. Two recording devices were used in each of the interviews, and responses were transcribed verbatim and analysed to identify recurring themes and data patterns using Braun and Clarke's thematic analyses method.[39] To ensure accuracy and rigor, extraction of key themes was conducted independently and collaboratively by the first two authors. The data was managed using two tables that ensured generated themes were captured for the six female body habitus for the CC views (Table 3), and the six female body habitus for the MLO views (Table 4). The six female body habitus comprised small, average, large, rib hump, pectus excavatum (PE) and pectus carinatum (PC). The analysis initially took an inductive approach to ensure that the findings were grounded in participant responses and the data was analysed at semantic level.[37] The first two authors identified positive and negative responses that either supported or negated the key themes using constant comparison within and across transcripts.[37] Final coding was performed by both authors, with the first author coding all of the data and the second author double-coding half.[37] Conflicts were resolved by consensus.

Results

Twelve Australian female radiographers with an age range of 20–70 years from screening and diagnostic mammographic setting participated in an online (Zoom) individual semi structured interview (Table 2). The most common age range of radiographers was between 40 and 49 (n = 4, 33.33 %) and 20–29 (n = 3, 25 %). An equal number of radiographers held (n = 5, 41.67 %) and did not hold (n = 5, 41.67 %) the certificate of mammographic practice and two (16.67 %) have not heard of this certificate. Over half (n = 7, 58.33 %) of the radiographers performed both diagnostic and screening mammography. Table 2 presents the demographic and clinical characteristics of the 12 radiographers.

A brief questionnaire was administered at the start of the interview, which comprised of eight key questions labelled “a-h” (Table 1). The data is presented in Table 1 with the exception of questions “e” and “h” on image quality criteria which was not analysed for this study. The definition of each body habitus was placed next to the corresponding image. The remaining free-text questions “a-d” and “f-g” were included in the thematic analysis and responses informed the key themes identified for the CC view and MLO view. The final coding was then examined to identify two quotes that support and two quotes that negate the key themes. Participant quotations have been selected and presented in Table 3 (CC view) and Table 4 (MLO view) to illustrate both common and diverse responses.

Radiographers' perception on good communication and body habitus

Views on average, large and rib hump body habitus in CC position

In the CC position (Table 3), radiographers communicated minimum instruction to patients with a small, PE and PC body habitus. Radiographers' views on average, large and rib hump body habitus when positioning using the CC view are presented in Table 5a.

Views on small, average, large, rib hump, PE and PC body habitus in MLO position

In the MLO position (Table 4), radiographers had mixed responses on communication with varied body habitus. Radiographers' views on small, average, large, rib hump, PE and PC body habitus when positioning using the CC view are presented in Table 5b.

Radiographers' perception on CC detector height, MLO IR angle and body habitus

Views on small, PC, rib hump, average and PE body habitus, and CC detector height

In the CC position (Table 3), radiographers highlighted the specific techniques of selecting the correct detector height for varied body habitus. Radiographers' views on small, PC, rib hump, average and PE body habitus when positioning using the CC view are presented in Table 5c.

Views on small, average, large, rib hump, PE and PC body habitus, and MLO IR angle

In the MLO position (Table 4), radiographers demonstrated key IR angle selection for varied body habitus. Radiographers' views on small, average, large, rib hump, PE and PC body habitus when positioning using the MLO view are presented in Table 5d.

Discussion

Radiographers in this study demonstrated that good communication is key to gaining trust and maintaining rapport with the patient during mammography positioning. To ensure good and complete images are captured, continuous communication is

Table 2
Demographic and clinical characteristics of expert Australian radiographers performing mammography examinations.

Characteristic	Respondents: (n = 12; %)
A. Range of age category in years:	***(n = 12):***
20–29	3 (25.00 %)
30–39	2 (16.67 %)
40–49	4 (33.33 %)
50–59	1 (8.33 %)
60–70	2 (16.67 %)
B. Highest academic qualification:	***(n = 12):***
Doctor of Philosophy (PhD) (Medical Imaging/Diagnostic Radiography)	0 (0.00 %)
Master of Health Science (Medical Imaging/Diagnostic Radiography)	1 (8.33 %)
Bachelor of Health Science (Medical Imaging/Diagnostic Radiography)	5 (41.67 %)
Diploma of Health Science (Medical Imaging/Diagnostic Radiography)	2 (16.67 %)
Associate Diploma of Diagnostic Medical Imaging	1 (8.33 %)
Certificate (not including CCPM or CMP)	0 (0.00 %)
Other (International)	1 (8.33 %)
Other Australian qualification (please specify):	2 (16.67 %)
C. Certificate of Mammographic Practice (CMP):	***(n = 12):***
Yes	5 (41.67 %)
No	5 (41.76 %)
I have not heard of this certificate	2 (16.67 %)
D. Type(s) of mammography performed:	***(n = 12):***
Diagnostic	2 (16.67.%)
Screening	3 (25.00 %)
Both diagnostic and screening	7 (58.33 %)
E. Employment status:	***(n = 12):***
Full time	6 (50.00 %)
Part time	5 (41.67 %)
Casual	1 (8.33 %)
F. Solely perform mammography:	***(n = 12):***
Yes	2 (16.67 %)
No	10 (83.33 %)
G. Years of mammographic experience:	***(n = 12):***
Less than 1 year	2 (16.67 %)
1–2 years	3 (25.00 %)
3–4 years	1 (8.33 %)
5–10 years	1 (8.33 %)
11–20 years	2 (16.67 %)
More than 20 years	3 (25.00 %)

Abbreviation: n, total number; %, percentage; PhD, Doctor of Philosophy; CCPM, Certificate of Clinical Proficiency in Mammography; CMP, Certificate of Mammographic Practice.

required throughout the examination. Good communication is a two way process and can be influenced by the radiographers' level of education and clinical experience, the patients levels of anxiety, education, ability to understand the instructions being conveyed, and their ability to comply with the positioning requirements/instructions.[5,20] These findings align with the current mammography literature on the importance of effective communication between radiographers and the patient.[9,10,19] This is reinforced by Pollard et al.[41] who reported that effective communication between a radiographer and patient enables the patient to feel confident, comfortable and at ease and is key to maximising patient compliance and inclusion of breast tissue on the mammographic image.[5,9,42]

In the CC view, most of the radiographers reported that they communicated positively during positioning of women with an average, large and rib hump body habitus. Interestingly, there were no responses elicited on good communication for women with a linear and PC body habitus. This could be due to the fact that the vast majority of women undergoing mammography procedures fall into what is considered to be the average or 'normal' body habitus. As such communicating with this group comes naturally and with minimal effort. Women outside this range of body habitus require more complex positioning and as such additional instruction and more communication. Findings in the current study on the importance of communication with women exhibiting larger body habitus aligns with studies done elsewhere.[43,44] These same studies revealed that women with larger body shapes are challenging to position in mammography[43] and degrade image quality[44]; therefore, more emphasis is given on instructions during positioning to produce a good quality image. Women with a linear body shape seem to comply easily during positioning due to their slim posture; therefore, radiographers did not emphasise the need to communicate effectively. Another reason could be that women with linear body shapes tend to fit easily onto the machine during positioning. The PE body habitus did not require any additional communication/instructions compared to other body habitus and less communication in women with PC. Although minor instructions may be given to women with PC during mammography positioning, a possible explanation could be that these group of women with protruding and depressing sternum body shapes[30,32] may not be commonly presented for mammography examinations compared to the general screening population.

In the MLO view, most radiographers reported that they communicated effectively with women with an average, large, rib hump, PE and PC body habitus. Again, no responses were elicited for communication with women with a linear body habitus. This is probably due to the fact that MLO views require the selection of various IR angles[5,9,43] and as such constant communication is necessary to maximise patient compliance and ensuring high quality images. Regardless of body habitus, the communication required to complete these MLO images is higher than that required

Table 3
Generated themes for various body habitus: CC view.

Body habitus	Theme	
	Good communication	Detector height/air gap (distance)
Small (linear) +	**"…** *and I just say, can you do a little breath in and breathe all the way out and hold, and then I'll bring down the compression plate really close to the sternum and then I'll let them breathe again". [P2]*	*"I don't modify a lot for the CC's because as long as I'm getting that height correct when I'm doing that positioning at the start, I find that I don't have any trouble getting all of that breast tissue in the image, anyway, doing my standard technique". [P3]*
		"*So, you need to make sure that the bucky height is correct for the CC's. So, that you don't miss any tissue as well". [P8]*
–		*"The top of their pecs can't fit in if receptor so straight, this steep as possible to 50 N and so, they can stand on their feet. They are comfortable to lean in same technique for the IMA. But yes, stretching slender bodies ever, that is possible. And I don't lean it as much as an average person, because, if very thin and most of what we can feel at the top of the breast. It's the pec muscle". [P7]*
Average (typical) +	*"Usually, obviously, I've introduced myself and so they're aware of what I'm about to do. Because it's quite a personal thing to kind of direct them to the machine. I'll have my right hand on their shoulders, so that's I kind of lift the breast and then put them forth. At which case I'll say that everything's okay, and then I'll slowly move my hand away whilst keeping them forwards. Because a lot of people are very apprehensive about getting too close". [P5]*	**"…** *I bring her a bit closer to the machine, her rib cage might be sort of*5 cm *back away. There's a bit of a gap. Then I'll make sure that she's standing in a position where, when I lift the breast, it ends up on the center of the detector plate". [P2]*
	"For an average type, I asked my patient to completely relax first before guiding them towards the mammography unit. So, they should be totally relaxed. Their shoulders … they would usually stand, and I would support their breasts of interest through to the mammography unit and raise the mammography unit to the inframammary". [P7]	*"I first lift the inferior mobile margin to its limit, and I have the client just slightly away from the front detector edge and I have them lean forward onto the detector plate. And so, if that leaning action brings the superior tissue in even with the inferior margin …" [P4]*
–	**"***For the average body, I generally sort of keep everything fairly normal". [P10]*	**"***Sometimes I'll adjust the angle slightly, just a couple of degrees, just so I can bring that tissue through and get it imaged clearly, so that when that compression comes down it doesn't just push it off the detector again". [P3]*
	"*And then I will bring down the compression pedal at a slow rate, and I usually tell the people that as we all know, this is an uncomfortable position for examination, and they must let me know if it's painful in any way, and then I can change whatever". [P12]*	**"…** *because we used to lift breast up so, that the information is demonstrated at the bottom. So, once we lift the breast up and we can see how much of a big space we have at the bottom and that big space, we don't need it. But at the top it's very important to get the pec muscle and the axillary …" [P7]*
Large (curvilinear) +	**"***And I'm very aware of IMA. That skin under there can be quite rough and fragile. So, I do warn them that when we're doing this, that they must lift their own breasts off rather than that it can stick, and I want them to be very careful with their breast and same sort of thing. I use a lot of words to get them to do the work rather than me pushing them, or I lean on them to try to get them gently each time I finish the picture. Lift your breast off the detector, because you may stick, and we don't want to tear any of that fragile skin". [P6]*	**"***I think with this one it's really important to make sure that you are feeling for any tissue that can be caught behind the detector because that can actually catch the skin and prevent people from getting more breast on the detector as well as sometimes you can get breast tissue caught behind there. So, I would really be making sure, and I would feel around the back as I'm pulling the breast forward to make sure there's nothing wedged behind the board …" [P5]*
	"… I'm always conscious of that, too. I always take a check there and make sure that if I can see or feel any irritation or ask about how that skin is under there, is it okay? Because that needs to be taken into account to if I like, you wouldn't want us to do any tearing or do any damage to that skin, because that's going to impact how they are for the rest of the imaging, too." [P10]	**"…** *for the CC's moved the lady away from the machine a little bit and lean forward rather than being right up against the bucky. And that will give you a little bit more room". [P8]*
–		**"***One other thing I do, that changes a little bit is I make sure that I bring that other breast onto the detector at the start to get that medial curve on of the breast that I'm imaging. And then once I start to bring that compression down. Then I'll move that breast off the detector and that just helps to keep that medial border on the detector without it being moved away by the other breast". [P3]*
		"… will definitely need to bend the elbow when you're positioning for the CC's, and maybe even raise it a little bit. So, that you remove the creases from the lateral side of the breast on the medial CC. Make sure that the angle is correct, and that there are no folds. So, always move the fold out on that CC medially, and ensure that adequate compression". [P8]
Rib hump +	*"I feel for where the ribs are sitting as well, and if I feel there's a rib sort of a little bit lower, I'll let them know that I'm going to lift the board up a bit higher and just sort of roll past that rib so that they know". [P3]*	**"…** *make sure that the bucky is at the correct height. That's so important, because you don't want them leaning down. Leaning forward because you'll lose the inferior part of the breast which is so important. So, we'd have the bucky and the lady upright. I wouldn't have them leaning too much, maybe just slightly forward for the CC's". [P8]*
	"*It can be a difficult one to. And I'm in this category. So, I'm always very much explain it to people in sense, and I don't know whether it's appropriate. But I say, oh, you've got a chest like mine. We have to do this with the CC. I find that it can just be harder because it's pushing into their ribs. They tend to pull back a bit further and the faster to sort of get themselves more comfortable. So, I need them in a relatively uncomfortable position for these. So, I explained that I'm going to move*	**"***So again, often I'll have to bring the height up, but just almost step the lady back away from the machine slightly and then get her to really lean forward". [P11]*

Table 3 (*continued*)

Body habitus	Theme	
	Good communication	Detector height/air gap (distance)
	as quickly as I can. But you know this is going to be fairly uncomfortable to dig into your ribs here". [P10]	
–	*"In a CC, one of my techniques is to get them. If, say, I'm doing the right CC, I'll get their opposite hand, their left hand to reach in front, and there's that pocket, that handle that I often get them to hold onto, which just sort of locks them into that sort of straight on position, find that they'll often turn in the CC. You'll find a bit more of a comfortable position, but I really want that straight on top down. CC, so, yeah, I think that's probably something that I'd routinely do in those situations as I get them to with their opposite hand, reach across and take hold of that handle to hold them in position. That kind of keeps them firmly in there. Yeah, it's probably one thing that I change again". [P10]*	*"I'd often put the paddle on which one has the hole in it, so I can hold the breast out from the body a bit easier than the normal 1824 paddle again". [P9]*
Pectus excavatum (PE) +		*"Sometimes I will step them away from the machine a little bit more, so I get more of a lean happening. Just to help to try to bring that breast tissue away from the chest wall slightly, as I compress. If it's quite severe, sometimes I will put a little bit of an angle on the machine as well to try to get sort of up in between those breasts, so that I can get a bit more of that medial breast tissue on the images". [P3]*
		"I will just angle them slightly to get that medial tissue on a bit more. And then once I've kind of angled them slightly, try and pull that medial tissue on, I still then just scoop around and try and pull as much lateral tissue on as I can". [P11]
–		*"… for the CC, that's probably the hardest to try and get the breast on. I would try and bring their head around from the face shield if they were flexible enough to bring their breast on the plate a little bit more". [P9]*
		"I don't routinely do it in CC, I would normally just try and achieve a CC as standard with no angle". [P10]
Pectus carinatum (PC) +	*"I would ask the lady to lean forward so not be right up to the bucky again. Maybe, step back a little tiny bit, lean forward". [P8]*	*"Only for the CC, when someone has breast like this, the receptor height might be just a teeny bit higher. So, after I've lifted the breast, get them to tip in and place the breast on the detector from there I might just slightly raise the detector height, because that's like bringing a compression plate up from underneath.*
		And then it will help get more superior breast tissue as I bring the paddle down, because it's not going to scrape as long down along the chest wall and exclude tissue". [P2]
		"It would be important to get the height of the breast right. So, you're not missing any breast". [P9]
–		*"But most of the time, if you can angle the body appropriately, then you can get adequate tissue through on there still". [P3]*
		"I wouldn't check, I don't change the angle". [P12]

Abbreviation: + support; - negate; P, Participant; PE, Pectus excavatum; PC, Pectus carinatum; CC, Craniocaudal; IR, Image receptor; IMA, Inframammary angle.

when capturing CC images. Women with a linear body habitus may be easy to position onto the machine thereby requiring minimal instructions. Women that have undergone mammography examinations in the past often have higher a greater understanding of the instructions communicated to them by the radiographer which again maximises compliance and breast tissue inclusion. However, the same communication instructions may not be clearly understood by a woman that attend mammography screening for the first time or where English is not their first or primary language.

Radiographers in this study highlighted the importance of maintaining the correct detector (IR) height for patients with a small, PC and rib hump body habitus. It was also revealed that adjusting the correct detector height of mammography unit depends on the height of the patient and the distance between the IR and breast. These findings confirm that in the CC view, the IR should be positioned about 1–2 cm above the level of the IMA at 90° to achieve maximum contact area and optimum compression force balance.[10,45] Although patients with a PE, rib hump and PC body habitus may be difficult to capture the IMA due to the inward curvature of the rib toward the sternum (PE), protruding ribs (rib hump) and the protruding sternum (PC), additional CC and MLO views are required to capture the breast tissue.[5] Particularly, in the CC view, there is evidence that a large distance between the IR and the breast acts as an air gap to reduce the amount of scattered radiation reaching the IR.[9] To improve resolution and sharpness of the breast images resulting in high image quality,[9] the air gap between the chest wall and the detector should be minimised. For radiographers a conscious effort to identify body habitus, adjust detector height, and identify the appropriate air gap between chest wall and the IR should be taken into consideration as this will help to maximise breast tissue inclusion.[5,46–48]

In this study, radiographers revealed that their decision to select the preferred IR angle for various body habitus depends on the patient presentation and alignment of the pectoral muscle. This finding confirms the evidence that in the MLO view, the mammography IR angle is usually rotated between various angles ranging 30°-70° to suit the individual body habitus and to reflect the orientation of the pectoral muscle to maximise breast tissue inclusion.[5,9,46–48] There may be implications to using different angles on the possibility to compare the new images with previous images. Radiographers are trained to "standardise" their positioning techniques so that the new images could reflect an accurate breast tissue representation of previous images. However, given the impact of the varied human body habitus on the resultant image

Table 4
Generated themes for various body habitus: MLO view.

Body Habitus	Theme	
	Good communication	Image receptor (IR) angle of MLO view
Small (linear) +	*"From usually sort of explaining, can I get you to drop off your shoulder rather than going, letting them go and going around the other side". [P10]*	*"… I think that they'll be fine with just the sort of average 45°. I don't go above 50° for that angulation. I sort of go just a couple of degrees like 48 is probably the sweets what I find for most of these, just to get that angle a bit higher up to sort of suit that pec muscle a bit better. But I found going over 50 is almost a bit too much for most patients". [P3]* *"… in the MLO, I will often increase my angle from 45 to 50. I don't like to go much past 50, but 50–55 at most. But yeah, so I'll sort of I can increase my angle on my MLO, just to get it sort of in line with where the sternum is". [P10]*
–	*"… just making sure the patient feels comfortable too often they apologize for being small chested and all. You don't have much to work with them. Sorry, I always sort of play that down, and no, that's silly like I'm in the same boat. You're in good hands here, we will absolutely get … We'll get a mammogram. It's fine. So, make sure they're comfortable". [P10]*	*"… the first thing I will do is adjust the angle of my machine. So, I'll often increase that angle slightly, so it's a bit steeper to try to match their pec muscle". [P3]* *"I suppose the angle yeah, in line with the ribs. And maybe the next person might not be using the same angle. But yeah, I tend to go with whatever I would normally use and then, you know, I can change it. So, it's a little bit more comfortable to bring them closer". [P5]*
Average (typical) +	*"… I talk a lot, and I think that would be my own unique tip is I think if you're telling somebody to do something sometimes it's great to tell them. Why? Because then they actually understand the importance of doing it. And I have a lot of patients said to me, oh, wow! That was the best mammogram I've ever done, or they say to me, I really like how you talk to me the whole way through it, because it kind of distracted me, and also it just like lulled me into doing it. And so that is kind of why I keep doing it". [P2]* *"I noticed people get quite sensitive if it's feeling like it's pulling here because there's that Chinese burn kind of sensation that they can get. So, I warn them. And I say, you know, just bear with me. Sometimes you can get a bit of pulling. It might be a bit uncomfortable, but I can. I usually get in there and release the skin that's caught and get them remind them to relax their shoulder back, so I can continue to compress without them interfering with how much breast tissue I've got on, because if they pull away you have to start again, and we all know that you want to be as efficient as you can". [P5]*	*"… our machine is set up with 45°, …and I just go to that. And it tends to work. And even I don't really change it very much. … it's based on decades of mammographers knowing that that angle worked. So, I just roll with it". [P2]* *"So, for an average type of patient, I have the machine at 45°". [P3]* *"… I turn the detector, explain that patient is, step aside, adjust the detector to 45-degree angle. That we are saying an average size patient, so that 45-degree angle, I would say, sort of is usually pretty correct for most patients … but for the most part 45° I get them to turn so that they're facing sort of with their right, say I'm going to stay on the right-hand side". [P10]*
–		*"So, I usually start by turning the machine to the correct angle for the patient. From memory, I use about 55° or 50°, sorry. Sometimes I bring that a bit further over, depending on the patient's presentation". [P5]* *"I like 47°. So, the breast is supported by that angle. So, it's not as straight as 50° where the breast goes down with gravity. So, it's a bit supported, but it's not too angled at 45°". [P7]*
Large (curvilinear) +	*"And for the MLO, you would have once positioned definitely need to ask the patient. They can push their bottom out just so there's less sort of tummy coming in under the breast. And that can cause artifacts on the picture. So, by pushing that a little bit more out of the way, it will get a better picture". [P9]* *"And at that point, this is where it's really important, where I explain that this is fairly firm uplift out. I'm going to hold to a position. And then I'm going to run my finger underneath. I'll need to make sure that I don't have any folds in the picture, so I'm going to get you to push the bottom out". [P10]*	*"Again, one way or the other and oftentimes I find that I go to 55, rather than 45. This 45 tends to then just put more detector in the way of the tummy that's already there. So sometimes it's going to steeper angle helps to and be able to avoid a bit of that tummy". [P4]* *"… I would decrease the angle just to make it easier to bring the tummy out of the way. But usually, I just go with the 45, and if I'm struggling, then I would alter the angle and make it a bit steeper, so maybe to 40". [P9]*
–		*"… I flatten the angle for these ones a bit. I also bring them a little bit further away from the machine and focus a bit more on poking their bottom out and tipping them away from me so towards their back leg and then into the machine as well. Tipping them away a little bit more, I find helps because you have a bit more room to manoeuvre the IMA, and to make sure that you have enough space to lift that breast tissue up high enough without sort of the abdomen getting in the way". [P3]* *"… sometimes with this one it can help just having just a slightly shallower angle. Sometimes that just lets the client lay back a little bit more. That can just kind of help get the breast away from, if I do have a little bit of a bigger tummy or whatever. So yeah, you can sometimes just reduce the angle a little bit will help for that". [P11]*
Rib hump +	*"These patients often present with bony clavicles as well. So, I'll be mindful to let them know. You know, sometimes, when I'm compressing cause, a lot of women are really worried about the compression being the main, you know. Oh, you're squishing my boob so as I'm compressing, I'll say, oh, as I'm compressing,*	*"… I would start with 50 and say if there's full contact along the length of the lateral breast margin". [P4]* *"I have to sort of take a bit of a sidestep and have a look at their sternum angle. I find that generally this is still about 45, with those ribs. You still have a significant angle. I never go sort of*

Table 4 (*continued*)

Body Habitus	Theme	
	Good communication	Image receptor (IR) angle of MLO view
	I might be, you know, knocking your collar bone a little bit, and so that helps them often". [P5] *"… just my personal positioning tip is just clear communication. Just explaining this isn't going to be very comfortable. This is going to dig into your ribs here. But let me just get it. Listen to position just communicating with this is what I'm trying to achieve. Once I've got them in position, I don't sort of let go and reposition the rest of the body. I tend to have hold that there, and they make my adjustments while holding the breast. But yeah, no, I would just say. Yeah, yeah, I can see that we're going to catch all ribs. So, I need you to get to push your bottom out like, I just sort of yeah, clear communication, I think, is the only thing I can think of". [P10]*	*lower. So, I'm always sort of 45 or steeper, but I tend to not make it steeper for the for the MLO". [P10]*
–	*"I always tell ladies that good posture has no place in this mammogram room". [P6]*	*"… I do rarely adjust the angulation of the machine. … it's hard to sort of visualize, because everyone's so different" [P1].* *"It's more the MLO and I probably would be doing the held-out breath, because then the ribs gonna be sunken in as much as it can go before, I can press the breast. When I'm about to compress, I would ask you to take a little breath in, breathe all the way out and hold. And that's gonna really take that rib out of the way". [P2]*
Pectus excavatum (PE) +	*"I'm just gonna say, sometimes I would say to her, hey, do you mind if I just bring in a colleague who's more experienced? That's another thing I might do as well". [P2]* *"Just make sure that the other shoulder is dipped down a little bit or back a little bit, but all movement will be very, very small. There's no major changes, and it just needs to be really good communication because otherwise you have to start again". [P8]*	*"I tend to stick to 50, but if they're particularly tall and slender, I would increase it to 55 for the MLO". [P6]* *"I would start with an MLO angle of 50, because that gives you that more up. It just enables you to lean across, lean them across a little bit further". [P8]*
–		*"I think that patient there is quite average to slim, so she's probably just gonna be the standard angle. Or maybe I would increase the angle a tiny bit. But I don't think angle is gonna be the problem here". [P2]* *"I would keep it standard to what the machines". [P5]*
Pectus carinatum (PC) +	*"Just clear communication. Making sure that their muscles are as soft as we can make them. Making sure that in that MLO, that their shoulders are nice and soft and relax, and that they're not holding on to tight. Because I think that particularly in smaller busted women, I constantly talk touch … while I talk about them. I can't help. But I do them, too. I'm always talking about making sure that. Yeah, that if they if they tense up in their muscles the type and it's going to make it even harder. So, trying to keep them nice and relaxed and keep a really calm communication happening with them and make sure they've the shoulder soft. The hand is soft … and we can usually achieve something". [P10]* *"So, as I'm bringing them in for the MLO, I really tell them just to slump and almost cave their chest in, and that lets that chest sink in so that you can pull their breast tissue away. Better so sometimes I'll get them to use a breathing technique like I'll say, just take a breath in, and then I'll say, as you breathe out, just really cave your chest in and let your chest really relax and sink in and that will just kind of let that sternum, just compress in a bit more than normal, so that you can then pull that tissue forward". [P11]*	*"And the receptor angle, either 50 or 45 for the end alone. Yeah, just kind of get into the slouchy as possible". [P6]* *"For the MLO, I think quite a shallow angle would be better as well. So, I will probably try for maybe a 35- or 40-degree angle. The patient might not really be facing the machine; you might be at a bit of an angle of 45. So, the nipple space looks front facing on the image". [P9]*
–		*"I would just start with the average one that the machine has, and then if I'm positioning her and I'm finding it's not working like I might be about to compress and bring down the paddle, and I can see that the paddle angle is just not along the sternum at all. I might be saying. Actually, I need to change and alter my angle". [P2]* *"I think I would use the same position. I just learned ageing. Yes, and the first positioning we mentioned today. Yes, I used to stay in particular technique. Same angle. It's a straight angle and everything as far as a slim body". [P7]*

Abbreviation: + support; - negate; P, Participant; PE, Pectus excavatum; PC, Pectus carinatum; MLO, Mediolateral oblique; IR, Image receptor; IMA, Inframammary angle.

quality, there is the possibility of missing breast tissue in some patients even though radiographers may use the same or different angles. Radiographers in this study use 45° as the default base angle for various body habitus and decreased or increased the angle slightly depending on the patient presentation. Radiographers demonstrated that 45° is the preferred angle for patients with average, linear and large body habitus. These findings contradict recent findings by Pape[33] indicating that most radiographers (59.1 %) identified using a 45° angle for all body habitus except linear. For the linear body habitus there seemed to be a common

Table 5
Radiographers' views and key themes on various body habitus in the CC and MLO position.

Sub-heading and body habitus						
	a. Radiographers' views on average, large, and rib hump body habitus in CC position.					
	Average	Large and rib hump				
	Radiographers seem to communicate clear instructions at the beginning before the positioning process such as '*… I've introduced myself and so they're aware of what I'm about to do' [P5]* and during the act of positioning to allow them (patients) to relax with instructions such as '*… they should be totally relaxed … '* [P7] and others felt communication as a two way process such as '*… I usually tell the people … this is an uncomfortable position … and they must let me know*' [P12].	Radiographers use multiple instructions to encourage patients to assist them (radiographers) position some parts of their (patients) breast such as *'I use a lot of words to get them to do the work (positioning) rather than me pushing them … '* [P6].				
	b. Radiographers' views on small, average, large, rib hump, PE and PC body habitus in MLO position.					
	Small	**Average**	**Large**	**Rib hump**	**PE and PC**	
	Radiographers encouraged patients with a small body habitus not to feel uncomfortable regarding their tiny body shape but to comply with the positioning.	Radiographers received positive comments from patients with average body habitus such as '*… I really liked how you talk to me the whole way through it … '* [P2] when clear instructions are given at the beginning of the positioning process with the reasons for the positioning technique explained.	Patients with a large body habitus are often instructed to *'push their bottom out'* [P9] due to their large abdomen which might obscure a proper positioning.	Radiographers feel the need to provide clear communication to patients with rib hump since they *'often present with bony clavicles'* [P5] and protruding ribs that may inhibit breast tissue inclusion.	Patients with PE and PC are challenging to position due to their depressing or protruding sternum, respectively and radiographers are encouraged to provide *'good and clear communication'* [P8, P10] and try to *'keep their shoulders soft and relaxed'* [P10].	
	c. Radiographers' views on small, PC, rib hump, average and PE body habitus in CC position.					
	Small, PC and rib hump	**Average**	**PE**			
	Radiographers stressed the importance to getting the *'correct detector height'* [P3, P2, P8] for a patient with a small, PC and rib hump body habitus to minimise the potential of missing breast tissue.	Patients were informed to move their rib cage *'a bit closer to the (mammogram) machine'* with a gap of about 5 cm [P2] whilst other patients were instructed to stand *'slightly away from the front detector edge then lean forward onto the detector plate'* [P3, P4, P11] to maximise breast tissue inclusion.	Some radiographers '*adjust the IR angle slightly within few degrees'* [P3, P11], especially, for PE patients whilst other radiographers *'lift the breast up'* to reduce the gap between the breast and the detector place [P7] to maximise tissue inclusion.			
	d. Radiographers' views on small, average, large, rib hump, PE and PC body habitus in MLO position.					
	Small	**Average**	**Large**	**Rib hump**	**PE**	**PC**
	The common IR angle for a small body habitus is 45° [P3] but some radiographers may slightly increase the angle to 50° to align with the patient's pectoral muscle [P3], ribs [P5] and sternum [P10].	Most machine is pre-set to 45° angle and radiographers tend to use this angle (45°) instinctively [P2, P3] whilst some radiographers use 50° or 55° [P5] by *'turning the machine to adjust with the patient's presentation'* [P5].	Some radiographers use 55° to *'avoid the tummy'* [P4] from obscuring the breast image whilst other radiographers use the common angle of 45° but may slightly angle to 40° [P9] depending on patient presentation.	Few radiographers *'would start with 50° angle to maintain contact with the length of the lateral breast margin'* [P4] whilst other radiographers assess the patients' sternum angle and ribs before using the 45° [P10].	Some radiographers *'tend to stick to 50°'* angle [P6, P8].	Other radiographers tend to use 45–50° angle [P6] and 35–40° for the PC body habitus to align with the anterior region of the nipple *'facing on the image'* [P9].

Abbreviation: P, Participant; CC, Craniocaudal; MLO, Mediolateral oblique; PE, Pectus excavatum; PC, Pectus carinatum.

default (44.9 % of radiographers) to apply a 50° angle.[33] Both studies confirmed that the 45° angle is historically set and is the automated set angle on most manufacturer's equipment allowing radiographers to use this angle for efficiency and consistency.[33] To note, in this study, a small number of radiographers (n = 2) routinely used a 50° angle for a small, rib hump and PE body habitus in order to align with the patient's pectoral muscle, ribs and sternum. For the PC body habitus, radiographers in this study preferred to use a range of 45-50° angle and 35-40° angle to align with the anterior region of the nipple. These findings could possibly explain the use of 45° and 35° as the default base angles which could then be slightly increased depending on the patient's height and thorax size. Although consideration of the height of the patient and thorax size as contributing factors when determining the choice of angle for the CC and MLO imaging was not a focus of this study, it is clear that both potentially influence patient position and therefore impact tissue inclusion and image quality and warrants further investigation.

Strengths and limitations

A major strength of this study is that it is the first study exploring the top performing Australian radiographers' perceptions on best positioning techniques in mammography for various body habitus. This study documents the importance of effective communication and selection of the correct detector height for the CC view and the preferred IR angle for the MLO view to maximise breast tissue inclusion. Importantly, this study documents for the first-time radiographers' perceptions of selecting the preferred IR angle for patients with a rib hump, PE and PC body habitus.

The limitations in the study acknowledge that variability and potential bias cannot be measured or controlled which can limit the accuracy and generalisability of the findings. This was mitigated through rigorous study design, participant selection, data collection and data analysis process. The online mode of the study using Zoom and the interview presentation were developed based on a previous evidenced-based study[37] and was both informally and formally pilot tested.[37] The lead researcher did not have any personal or professional associations with the participants during the selection process to minimise any potential for bias. To ensure accuracy and rigor, data extraction and analysis was conducted independently and collaboratively by the two first authors. Since participant selection was based on who responded first with a small sample size, the results may be limited depending on the participant's years of mammographic experience. While a homogenous sample was used, sample size may influence generalisability beyond the sample.[38,49] Finally, while demographics were not the focus of this study representation of results is limited to Australian radiographers.

Implications for practice

Policy makers and practitioners in mammography screening programs need to consider additional language translation services and/or recruit skilled language interpreters within breast imaging facilities to enhance effective communication and clarify patients' understanding of positioning instructions. Although some mammography screening facilities may offer this service, it is critical that it includes language interpretation that targets patients from multiple cultural backgrounds where English is not the first or primary language. To enhance best positioning practice, it is suggested that further study includes interviewing the expert mammographers showing the results before and after the modifications to minimise the potential for missing breast tissue. While radiographers in this study conveyed best positioning techniques for patients with varied body habitus, further quantitative research is in process to determine the impact of the thorax size, breast size and IR angle selection and how this impacts breast tissue inclusion during CC and MLO positioning.

Conclusion

This qualitative study explored the perceptions of the top performing Australian radiographers in mammography and their best positioning techniques for varied body habitus. The study demonstrated that effective communication between a radiographer and patients with varied body habitus is critical during mammography positioning to maximise breast tissue inclusion on the image. Although radiographers may easily adapt their positioning techniques to align with the average or 'normal' body habitus instinctively, the same techniques cannot be applied for patients with challenging body habitus such as extreme curvature of the thorax or protruding sternum and ribs. Importantly, this study enables understanding on how varied body habitus impacts the amount of breast tissue imaged during mammography and how radiographers can best manage this in their practice.

Participant consent

All participants gave written consent prior to participation.

Ethics statement

This study was approved by the Charles Sturt University Human Research Ethics Committee on the 03/08/23; approval number H23623.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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