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ORIGINAL ARTICLE

Screening for breast cancer–related lymphoedema: self-assessment of symptoms and signs

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Abstract

Introduction In the absence of monitoring programs, those at risk of developing breast cancer–related lymphoedema (BCRL) must detect its development. However, the efficacy of self-assessment for BCRL has not been widely investigated. This study will determine if symptoms and signs of BCRL are associated with lymphoedema detected by bioimpedance spectroscopy (BIS) and whether those with and without BCRL can accurately assess the signs of its presence.

Methods and results Participants with a history of breast cancer ($n = 100$) reported the presence/absence of symptoms associated with upper limb BCRL and underwent assessment for pitting oedema and differences in tissue texture between their arms (pinch). BIS detected BCRL in 48 women. Women were more likely to have BIS-detected BCRL if they reported swelling (odds ratio (OR), 58.8; 95% CI, 4.9 to 709.4; $p = 0.001$) or had inter-limb tissue texture differences in their forearm (OR, 73.5; 95% CI, 7.3 to 736.9; $p = < 0.001$) or upper arm (OR, 23.9; 95% CI, 2.8 to 201.7; $p = 0.003$). Agreement between therapist and self-assessment of signs of BCRL was almost perfect (kappa, 0.819 to 0.940). A combination of self-reported swelling and/or self-assessed forearm tissue texture difference identified all cases of BIS-detected BCRL.

Conclusion Participants accurately identified the presence or absence of physical signs of BCRL in their arm. Perceived swelling and differences in tissue texture in the affected arm were associated with, and sensitive to, BIS-detected BCRL. These findings support the use of self-assessment to determine if BCRL is developing, indicating the need for professional assessment.

Keywords Breast cancer · Lymhedema · Self-assessmnent · Screening · Bioimpedance

Introduction

The development of breast cancer–related lymphoedema (BCRL) is poorly understood [1], and its identification is challenging [2–4]. However, early identification and commencement of treatment may have a significant impact on lymphoedema progression [5, 6], treatment outcomes [7], as well as the overall health, finances and emotional status of those living with the condition [8–12]. Despite the benefits of early intervention, access to specialist lymphoedema services for ongoing BCRL screening and diagnosis is not universal [13]. This has the potential to result in missed detection of developing BCRL.

Risk factors that increase the likelihood of BCRL development have been identified; however, they do not wholly explain who will develop the condition [2, 14–16]. Those women who are at high risk of developing BCRL due to the presence of these risk factors may be referred to BCRL prospective monitoring programs. The introduction of monitoring programs, with intervention commenced when predetermined detection thresholds are reached, has shown reductions in lymphoedema development [6, 17]. However, long-term specialist monitoring of those at risk of BCRL is costly, time consuming or, for some, inaccessible due to travelling distance or lack of trained lymphoedema practitioners. An alternative approach to therapist-driven monitoring is self-assessment by those at risk for BCRL.

Accurate self-assessment of the likely presence of BCRL by those at risk would enable novel pathways for prospective monitoring. Few studies have investigated the feasibility and accuracy of patient self-assessment for the detection of BCRL

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or outlined what self-assessment should include [18, 19]. Therapist-driven monitoring programs for BCRL use a combination of objective measures [6, 20], patient-reported symptoms and physical assessment to monitor changes indicative of developing BCRL [21].The objective measures used for quantifying limb volume during therapist assessments have been studied extensively; however, the relationship between symptoms, physical signs and objective measures is unclear [22–24]. It is likely that self-assessment of BCRL may require a multifaceted approach similar to that used in therapist-driven monitoring. It is unknown, however, if those at risk of BCRL can assess and detect specific signs of the condition in their arm. To enable self-assessment, further research is required to address gaps in knowledge regarding symptoms and physical signs and their relationship to objectively measured BCRL.

The aims of this study, therefore, were to determine:

A. If women with or at risk of BCRL were in agreement with an experienced lymphoedema therapist in the identification of physical signs of lymphoedema in their arm
B. If commonly reported (i) symptoms including perceived swelling, heaviness and tightness and (ii) physical signs of BCRL including differences in inter-limb tissue texture, such as thickness, fullness and firmness as detected by a pinch test, and pitting oedema were associated with bioimpedance spectroscopy (BIS)–detected BCRL
C. The sensitivity and specificity of the BCRL symptoms and signs for BIS-detected BCRL

Materials and methods

Participants

One hundred women aged between 37 and 94 years (61.8 years (mean), 10.6 years (SD)) who had completed treatment for breast cancer that included axillary node removal were recruited from western New South Wales, Australia. Women who were pregnant and had cardiac implants (pacemaker, defibrillator), upper limb metal implants or medical conditions that could impact fluid volumes (e.g. cerebrovascular accident) were excluded from the study. Ethics approval was obtained from the Human Research Ethics Committee of the University of Sydney (Project no: 2016/450). All participants provided written informed consent.

The participants comprised 37 women who had never been diagnosed with BCRL and 63 with a previous clinical diagnosis of BCRL. Of those with a previous diagnosis, 35 women had received treatment for their lymphoedema and 28 women had a recent diagnosis of BCRL but had not started treatment. Following whole arm and segmental BIS measurements of their arms, participants were classified according to BIS detection criteria, irrespective of their clinical diagnosis. Those who met a BIS threshold [25, 26] were classified as *BIS-DETECTED*, and those who did not meet a BIS threshold were classified as *NOT-DETECTED*.

The participants' characteristics are reported in Table 1. There was no difference in age and BMI between the *NOT-DETECTED* and *BIS-DETECTED* groups (Welch's t $P = 0.10$, Mann-Whitney $P = 0.17$). The *NOT-DETECTED* group had significantly lower whole arm BIS ratios than the *BIS-DETECTED* group (Mann-Whitney $P = < 0.001$).

Assessments

All participants attended a single assessment session of approximately 30-min duration in which all measurements were completed. Height, to the nearest 5 mm, and weight, to the nearest 0.1 kg, were measured for calculation of BMI (kg/m^2).

Three participant-reported arm symptoms were assessed: (i) swelling or puffiness, (ii) heaviness and (iii) tightness, which was described as the arm feeling like a blown-up balloon [19]. Using a 10-cm visual analogue scale (VAS), participants marked on it the extent to which they perceived their arm to be swollen, heavy or tight during the past month, with 0 being 'not at all' and 10 being 'extremely' swollen/puffy, heavy or tight. All responses above 5 mm were categorised as the symptom being present. Swelling, heaviness and tightness were chosen as symptoms of interest as they are associated with BCRL [19, 27] and less likely to be directly related to cancer treatment than, for example, numbness, pain or tingling [28].

The presence of pitting oedema in the forearm and changes in tissue texture in the distal upper arm and proximal forearms were assessed by a single experienced lymphoedema therapist. To assess for pitting oedema, the therapist applied thumb pressure [29] to the medial proximal forearms for approximately 30 s. A positive pitting test was a visually evident pit on the affected limb that was different in depth or resolution time from the pitting test completed on the unaffected limb. Where a shallow, rapidly resolving indent was equally evident on both limbs, the pitting test was scored as negative. Differences in tissue texture between the affected and unaffected distal upper arm and proximal forearm were assessed using a pinch test (Fig. 1). Specifically, the tissue superficial to the bones and muscles, i.e. the dermis, sub-dermis and subcutis, was pinched between the thumb and index/middle finger to assess whether the tissue on the affected side felt thicker, fuller, tighter or firmer than that on the unaffected side [30]. The distal upper arm and proximal forearm locations were chosen as they appear to be associated with arm volume change and BCRL [17, 31]. For each of these signs, a positive finding was scored 'yes' whereas if no difference was identified, the finding was reported as 'no'. No grading of the signs was undertaken.

Table 1 Participant characteristics by diagnostic group

	NOT-DETECTED (n = 52)	BIS-DETECTED (n = 48)	P value
Age (years)^	60.1 (10.0)	63.7 (11.1)	0.10
BMI (Kg/m^2)^	29.3 (9.0)	30.4 (8.5)	0.23
Arm dominance (right:left) (n)	42:10	45:3	
Dom:non-dom affected (n)	21:31	25:23	
Whole arm BIS ratio*	1.001 (0.964 to1.034)	1.171 (1.098 to 1.292)	< 0.001
Time since BC surgery (days)*	1041 (402.3 to 2248)	928.0 (331.3 to 4004)	0.68
Previous clinical diagnosis of BCRL, n (%)	15 (29%)	48 (100%)	
Previous BCRL treatment, n (%)	12 (23%)	23 (48%)	
Recent clinical BCRL diagnosis+, n (%)	3 (6%)	25 (52%)	

^ Mean (SD)

*Median (inter quartile range)

+ Recent clinical BCRL diagnosis with participant assessed prior to commencement of treatment

BMI, body mass index; *Dom:non-dom*, dominant limb affected:non-dominant limb affected; *BIS*, bioimpedance spectroscopy; *BC*, breast cancer; *BCRL*, breast cancer–related lymphoedema

The participant, blinded to the therapist's rating, conducted their own assessment of the presence of the physical signs of BCRL. For the pitting oedema test, following application of pressure by the therapist, the participant was asked if they could see a difference between the two locations where pressure had been applied on the forearms. For the pinch test, the participant completed their own pinch of their proximal forearms and distal upper arms bilaterally to assess difference between the tissues. If the participant indicated that there was a difference, they were asked to indicate which side felt thicker, fuller, tighter or firmer.

The presence of objectively measured BCRL in the upper limb was determined by BIS, using previously reported thresholds for the whole arm [25] and four segments within the arm [26]. BIS is a sensitive measure for monitoring and detection of BCRL [6, 25, 32]. Whole arm measurements and segmental BIS assessments were completed using an SFB7 impedance spectrometer (Impedimed Ltd., Brisbane) employing previously described protocols [26, 33]. In brief, sites for electrode placement were marked with an indelible pen and cleaned with an alcohol wipe. The measurement electrodes were placed at the metacarpal phalangeal (MCP) joint of the third digit, mid-wrist (dorsum) in line with the ulnar styloid and on the dorsum of the arm at 10, 20, 30 and 40 cm proximal from the ulnar styloid process. The current drive electrodes were placed at the base of the third toe on the right foot, over the third MCP (for whole arm BIS) and the base of the nail bed of the third fingers (for hand and segmental measurements) [26]. The measurement electrodes for the whole arm measures were positioned based on the principles of equipotential [34]. Calibration of the SFB7 was assessed daily using the test cell supplied by the manufacturer. BIS files were analysed using the Bioimp software (v 5.2.4.0).

BIS ratios were calculated by dividing the resistance of the unaffected limb/segment by the affected limb/segment ($R_{0unaffected}/R_{0affected}$). These ratios were compared with previously reported thresholds [25, 26]. Participants were classified as having lymphoedema if their inter-limb BIS ratio exceeded at least one of these previously reported thresholds based on normative population: exceeding ≥ 3SD above the mean for the whole arm [25], exceeding 2SD above the mean for the dominant arm and for segmental measurements, one arm segment exceeding ≥ 3SD above the mean or ≥ 2 arm segments exceeding ≥ 2SD above the mean [26].

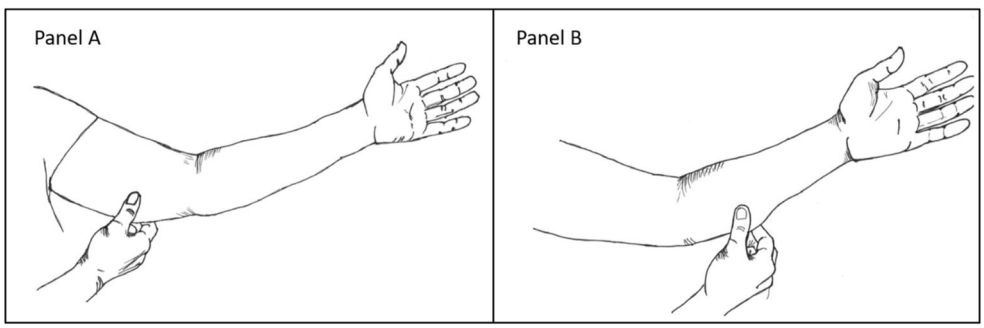

Fig. 1 Position and technique for pinch assessment of distal upper arm (**a**) and forearm (**b**)

Statistical analysis

Participant characteristics, absolute impedance and BIS ratio data were checked for normality using the Shapiro-Wilk test. Differences between the two groups were assessed using Mann-Whitney test or Welch's *t* test.

Cohen's kappa coefficient was used to determine the extent of agreement between the participant and experienced lymphoedema therapist in the detection of physical signs of BCRL. A Kappa coefficient greater than 0.8 is considered clinically acceptable or, as reported by Viera and Garrett [35], 'almost perfect'.

Chi-squared analysis was used to determine whether participant-reported symptoms and therapist-detected physical signs of BCRL were individually associated with BIS-detected BCRL lymphoedema. Odds ratios were calculated to demonstrate the strength of associations between each explanatory variable and BIS-detected BCRL. All explanatory variables associated with BIS-detected BCRL at $p < 0.25$ [36] were entered into logistic regression to determine the independent relationships between participant-reported symptoms and therapist-detected physical signs of BCRL and BIS-detected BCRL. Variables not meeting the level of significance were progressively removed prior to reanalysis until only significant variables remained.

Sensitivity and specificity of each explanatory variable for BIS-detected BCRL was determined. To determine the utility of using two significant explanatory variables as a screening test, one symptom and one physical sign were used to calculate the sensitivity and specificity of using the two tests together, irrespective of order, with a positive result on either test being sufficient to prompt further diagnostic procedures.

Therapist-detected data were used to determine the associations between BIS-detected BCRL and physical signs to ensure accuracy of detection of the signs. Both therapist and participant-detected data were used in analysis of sensitivity and specificity of the physical signs; however, only participant-detected data was used to determine sensitivity and specificity of the screening test to determine accuracy of self-assessment.

Data were analysed using Prism 7 for Windows (version 7.01) and MedCalc (version 18.2.1). The level of significance was set at 0.05.

Results

Agreement between participant and therapist in the detection of physical signs of BCRL

Inter-rater agreement between the therapist and the participant for the detection of physical signs of BCRL was *'almost perfect'* [35] for all physical assessments: pitting oedema (kappa, 0.94 (95% CI, 0.87 to 1.00)), pinch test in the forearm (kappa, 0.94 (95% CI, 0.87 to 1.00)) and upper arm (kappa 0.82 (95% CI, 0.71 to 0.93)).

Participant-reported symptoms and therapist-detected physical signs

Participant-reported symptoms and therapist-detected physical signs of BCRL were present in both the *BIS-DETECTED* and *NOT-DETECTED* groups (Table 2). For example, 96% of women in the *BIS-DETECTED* group and 33% of women in the *NOT-DETECTED* group perceived their arm as being swollen. There were, however, significantly more women in the *BIS -DETECTED* group than in the *NOT-DETECTED* group who reported symptoms and had physical signs indicative of BCRL (Mann-Whitney $P < 0.01$ for each variable).

Association of symptoms and physical signs with BIS-detected BCRL

Chi-square analysis indicated that all participant-reported symptoms and therapist-detected physical signs of BCRL were individually associated with BIS-detected BCRL, with odds ratios ranging between 5.0 and 47.4 (Table 2). All variables were therefore retained for further analysis using logistic regression. Step-wise analysis revealed a lack of independence among the variables. The final logistic regression model comprised three independent variables that were each significantly associated with BIS-detected BCRL: (i) participant-reported swelling, (ii) therapist-completed forearm pinch test and (iii) and therapist-completed upper arm pinch tests. Participants who perceived their upper limb to be swollen were 59 times more likely to have BCRL detected by BIS (95% CI, 4.88 to 709.43; $P = 0.001$) than those who did not perceive their limb to be swollen. Participants with a positive pinch test in the forearm were 74 times (95% CI, 7.32 to 736.91; $P = <0.001$) more likely to have BCRL detected by BIS than those who did not have a positive test, and those with a positive pinch test in the upper arm were 24 times (95% CI, 2.84 to 201.69; $P = 0.003$) more likely to have BCRL detected by BIS compared with those without the physical sign.

Sensitivity and specificity of symptoms, physical signs and BIS-detected BCRL

For each symptom and physical sign, the sensitivity and specificity were determined. The majority of the symptoms and physical signs had greater sensitivity than specificity for BIS-detected BCRL (Table 3). For example, the presence of perceived swelling correctly classified 96% of those with BIS-detected BCRL, whereas an absence of this sensation

Table 2 Unadjusted odds ratios of symptoms and physical signs of BCRL in women who have undergone breast cancer surgery with node removal

	Symptom or sign Present	BIS-DETECTED BCRL group (%)	NOT-DETECTED BIS group (%)	Chi-square	Odds ratio (95% CI)	*P* value
Participant-reported symptoms						
Perceived swelling	Yes	95.8	32.7	40.0	47.4 (10.3 to 218.7)	< 0.01
	No	4.2	67.3			
Perceived tightness	Yes	60.4	21.2	14.4	5.7 (2.4 to 13.7)	< 0.01
	No	39.6	78.8			
Perceived heaviness	Yes	77.1	40.4	12.3	5.0 (2.1 to 11.9)	< 0.01
	No	22.9	59.6			
Therapist-detected physical signs						
Pinch test positive (forearm)	Yes	93.8	25.0	45.7	45.0 (11.9 to 169.6)	< 0.01
	No	6.3	75.0			
Pitting	Yes	91.7	23.1	44.9	36.7 (10.9 to 123.0)	< 0.01
	No	8.3	76.9			
Pinch test positive (upper arm)	Yes	72.9	23.1	22.9	9.0 (3.6 to 22.2)	< 0.01
	No	27.1	76.9			

correctly classified only 67% of women who did not have BIS-detected BCRL.

To investigate the utility of using symptoms and participant-detected physical signs as a screen for the presence of BIS-detected BCRL, two independent explanatory variables were used together to determine their combined sensitivity and specificity for BIS-detected BCRL. The variables chosen were (i) perceived arm swelling, which was the only symptom that was independently associated with BIS-detected lymphoedema and (ii) the forearm pinch test, which had the higher association with BCRL of the two independent physical signs (Table 2). These two variables when used together improved sensitivity for BIS-detected BCRL. One hundred percent of women who had BIS-detected BCRL perceived their arm to be swollen and/or had a positive forearm pinch test ((sensitivity, 1.00; 95% CI, 92.6 to 100%), (specificity, 0.62; 95% CI, 0.47 to 0.75)). There were no false negatives identified with this screening approach, i.e. no women with BIS-detected BCRL were identified as being disease-free by the screen. The false positive rate was 20%, i.e. only 20% of women who perceived their arm to be swollen and/or had a positive forearm pinch test did not have BCRL detected by BIS thresholds.

Discussion

Self-assessment of the likely presence of BCRL by those at risk would allow for novel pathways for prospective monitoring. The use of a symptom and physical sign associated with BCRL provided a screening approach that indicated both the need and lack of need for clinical follow-up of women at risk of BCRL. The primary benefit of self-assessment screening is the capacity to determine those who are likely to be disease-free. The high sensitivity of being negative for both perceived arm swelling and tissue changes in the forearm (pinch test) should provide reassurance to patients and therapists that the patient most likely does not have BCRL at the time of self-assessment. A negative screening result, however, does not completely rule out the possibility of subclinical BCRL or

Table 3 Sensitivity and specificity of symptoms and physical signs of BCRL in women who have undergone breast cancer surgery with node removal and have BIS-detected BCRL

Variable	Sensitivity (95% CI)	Specificity (95% CI)
Reported swelling	*0.96* (*0.86* to *1.00*)	*0.67* (*0.53* to *0.80*)
Reported heaviness	0.77 (0.63 to 0.88)	0.60 (0.45 to 0.73)
Reported tightness	0.60 (0.45 to 0.74)	0.79 (0.65 to 0.89)
Participant pitting oedema test	0.90 (0.77 to 0.97)	0.81 (0.68 to.90)
Therapist pitting oedema test	0.92 (0.80 to 0.98)	0.77 (0.63 to 0.88)
Participant positive forearm pinch-test	*0.94* (*0.83* to *0.99*)	*0.77* (*0.63* to *0.88*)
Therapist positive forearm pinch-test	*0.94* (*0.83* to *0.99*)	*0.75* (*0.61* to *0.86*)
Participant positive upper arm pinch-test	*0.73* (*0.58* to *0.85*)	*0.79* (*0.65* to *0.89*)
Therapist positive upper arm pinch-test	*0.73* (*0.58* to *0.85*)	*0.77* (*0.63* to *0.88*)

Italicised figures are those that were retained as independent factors when examined for multicollinearity

indicate that BCRL will not develop in the future. Regular self-assessment, therefore, should be encouraged during the first few years after surgery when BCRL is most likely to develop [14, 15].

The presence of the perceived arm swelling and/or a positive forearm pinch test, in contrast, does not constitute a diagnosis of BCRL but rather indicates that a patient should seek diagnostic assessment by a lymphoedema therapist. This research found that implementing the self-screen as a prerequisite to therapist assessment in the current study population would ensure that 80% of the women assessed in the clinic did in fact have BIS detectable BCRL, without risk of not assessing true cases. Twenty percent of the women with a positive self-screen did not have BIS-detected BCRL at the time of assessment. This percentage is most likely due to reported swelling in the *NOT-DETECTED* group; however, ongoing monitoring of these women may reveal changes indicating the development of BCRL that could not be detected by the single assessment. In addition to the obvious benefits for women who do not have access to BCRL monitoring programs, the low false positive rate of the self-screening process may have implications for prospective monitoring programs. Further research employing pre-surgery baseline measurements is required to determine if the perceived swelling/pinch test screening process could reduce utilisation of prospective monitoring services by women who do not have BCRL (i.e. those with a negative self-screen).

This is the first study to determine that specific physical signs of BCRL are associated with measurable BCRL. The relationship between lymphoedema stages, which consider multiple physical signs and reversibility of oedema, is only moderately correlated with limb volume [37], whereas the presence of pitting oedema and differences in inter-limb tissue texture were found to be strongly associated with BIS-detected BCRL. The strong association between specific signs and BIS-detected BCLR is unsurprising as lymphatic failure may lead to a progressive accumulation of extracellular fluid, keratinocytes, fibroblasts, histocytes, adipose and collagen in the affected tissues which leads to changes in tissue texture [38, 39]. We also found multicollinearity between pitting oedema and the other physical variables. The presence of oedema in the tissues would, by necessity, change the volume and texture of the tissue making it feel thicker, fuller, tighter or firmer in comparison with normal tissue and thus provide a positive pinch-test.

Whilst a number of studies have addressed self-report of swelling and self-report of lymphoedema status [27, 40], none has determined whether women can accurately detect specific physical signs of BCRL in their arm. The high inter-rater agreement in the detection of specific physical signs in this study contrasts with the lack of accuracy in self-assessment of lymphoedema stage that involved self-assessment of multiple physical signs within overlapping categories [41]. The high agreement in this study may be due to the use of simple instructions such as 'When you pinch your skin in this area (indicating the tissues of the proximal forearm and distal upper arm) does it feel the like the same spot on the other side? Or does one side feel thicker, fuller, tighter or firmer?' and the simple yes/no categorical interpretation of results.

Self-reported swelling, heaviness and tightness are symptoms commonly associated with BCRL [19, 27, 42]. In contrast to other studies, this study found that only the perception of arm swelling was associated with BCRL. This finding may result from two related elements of the current study that differ from previous research. Firstly, the use of both segmental and multiple whole arm BIS thresholds enabled correct identification of the women with mild and localised BCRL [31] who otherwise would have been classed as BCRL free as they did not meet the higher 3SD whole arm thresholds. Secondly, this study had similar proportions of women with treated BCRL and women who had recently been diagnosed but had not started treatment in the *BIS-DETECTED* group. Early BCRL is characterised by soft pitting oedema [43]. The increased extracellular fluid that comprises this oedema may impact mechanoreceptors in the tissues and cause sensations of swelling [44], whereas other sensations such as heaviness and tightness may not be experienced until increases in limb volume occur as the lymphoedema progresses.

There were some limitations to this study. One of the biggest challenges in lymphoedema research is correctly classifying women as to the presence or absence of BCRL. Precedence in this study was given to BIS classification of lymphoedema rather than to clinical diagnosis to provide confidence in the accuracy of results [3]. Whilst we are confident that women were correctly identified as having lymphoedema through the application of multiple whole arm and segmental BIS thresholds, without a comparison pre-surgery baseline we cannot be entirely confident that all women who did not meet these thresholds were correctly classified as BCRL free. Secondly, the specificity of the pinch tests may have been negatively impacted by prior treatment. Twelve (23%) women in the *NOT-DETECTED* group had undergone treatment for clinically diagnosed BCRL. Successful treatment of their BCRL resulted in these women being allocated to the *NOT-DETECTED* group as they no longer met BIS thresholds. However, ten (83%) of these women still presented with either a positive forearm or upper arm pinch test, possibly due to pathological tissue changes, for example, preferential adiposity of their affected arm, that are not impacted by conservative treatment programs [45]. Finally, further prospective research is required to confirm the utility of the swelling/pinch test criteria as a BCRL screening process and the best procedure for education and implementation of self-assessment screening.

Conclusion

Women at risk of BCRL are able to undertake their own screening to determine their likelihood of lymphoedema development. The screening process is based on the presence of perceived swelling in the at-risk arm and assessment of inter-limb tissue texture differences between the forearms. This combination of perceived symptoms and physical signs of BCRL accurately identifies women without BCRL as well as women who require further investigation. Self-screening by women at risk of BCRL provides an alternative screening approach to one that is therapist driven. In addition to providing reassurance regarding BCRL-free status or signalling need for further clinical assessment, self-assessment may have other positive self-efficacy and self-care agency benefits for breast cancer survivors.

Author contributions BJ Svensson contributed to the study conception and design, data collection, analysis and interpretation of data and manuscript preparation; ES Dylke, LC Ward and SL Kilbreath contributed to the study conception and design, analysis and interpretation of data and manuscript preparation. DA Black contributed to the analysis and data interpretations.

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Conflict of interest Dr. Svensson reports grants from the Health Education Training Institute during the conduct of the study. Author Ward provides consultancy services to Impedimed Ltd., a manufacturer of impedance devices. Drs. Dylke, Black and Kilbreath have nothing to disclose.

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