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Original article

Three-dimensional scapular kinematics, shoulder outcome measures and quality of life following treatment for breast cancer – A case control study

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ABSTRACT

Background: There are no conclusive results concerning changes in scapular kinematics associated with upper limb dysfunctions after breast cancer surgery.
Objective: To compare the three-dimensional (3-D) scapular kinematics during elevation of the arm between women after breast cancer surgery and controls. Shoulder range of motion (ROM), muscle strength, pain intensity, upper limb function, and quality of life were also assessed.
Methods: Forty-two women were assigned to two groups (surgery group, n = 21; control group, n = 21). 3-D scapular kinematics was collected during elevation of the arm in the scapular plane. ROM was assessed using a digital inclinometer, muscle strength using a manual dynamometer, pain with the Visual Analogue Scale (VAS), upper limb function with the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and quality of life with the 36-item Short-Form Health Survey (SF36).
Results: The surgery group presented decreased scapular upward rotation at 120° of arm elevation in the scapular plane ($p < .05$; $d = -0.88$), decreased shoulder external rotation ROM and strength of shoulder abduction and external rotation when the affected side was compared to the non-affected side and control group. Moreover, the surgery group also reported higher pain, increased upper limb disability and poorer quality of life compared with healthy controls.
Conclusion: Scapular upward rotation seems to be decreased at 120° of arm elevation in women following breast cancer surgery. In addition, shoulder external rotation ROM, abduction strength, external rotation strength, function, and quality of life are also impaired in these women. They also experienced pain during the studied movements.

1. Introduction

Breast cancer is the second most commonly diagnosed neoplasm in women (Ferlay et al., 2015) and accounts for about 25% of all cancers (Ferlay et al., 2015; Ghoncheh et al., 2015). Surgical treatment is important and brings benefits to these women. However, postoperative complications can occur in the short term such as dehiscence along the suture, seroma formation, hematoma, necrosis, persistent pain (Harris et al., 2012), and scapula alata (Testa et al., 2014; Adriaenssens et al., 2012). In the late postoperative period, morbidities related to decreased quality of life (Borstad and Szucs, 2012), lymphedema (Rietman et al., 2006; Sagen et al., 2014), functional limitation of the upper limbs (Collins, 2008; Harrington et al., 2014; Harris et al., 2012; Shamley et al., 2012), and shoulder muscle weakness (Harrington et al., 2014; Harris et al., 2012) may be observed. However, the lack of details regarding types of surgical procedures used in previous studies (Harrington et al., 2014; Harris et al., 2012) limits the interpretation of their results.

The residual effects of surgery may affect shoulder motion. Previous research has focused on altered scapular movements in breast cancer surgery recipients in the affected limb from two months to six years post-surgery (Borstad and Szucs, 2012; Shamley et al., 2009; Crosbie et al., 2010). It is important to notice that there are several methodological differences among these studies such as the lack of an

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asymptomatic control group without shoulder disorders (Borstad and Szucs, 2012; Shamley et al., 2009), and the inclusion of elderly adults (Crosbie et al., 2010) which may influence interpretation of the results since aging was already demonstrated to be related to alterations in scapular orientation (Endo et al., 2004). Thus, there is still a lack of information about the possible changes in scapular kinematics of women after surgical treatment for breast cancer. Moreover, exploring shoulder outcomes related to range of motion and muscle strength are also important to understand upper limb function and quality of life following the surgery.

The primary aim of the present study was to compare the 3-D scapular kinematics during elevation of the arm between women after breast cancer surgery and controls. The secondary aims were to compare shoulder range of motion (ROM), muscle strength, upper limb function, and quality of life between the groups and to identify the intensity of pain in the affected arm in women who underwent surgical treatment. Our hypothesis was that women who underwent surgical treatment for breast cancer would have bilateral kinematics alterations compared to the control group, bilateral restriction in range of motion, and decreased muscle strength. In addition, after the surgery, these women should present upper limb disabilities and lower quality of life compared to the control group and will report high perceived pain in the affected limb.

2. Methods

A case control study was used in accordance with the STROBE checklist (von Elm et al., 2008).

2.1. Participants

Participants (n = 118) that were not receiving cancer treatment were recruited by phone from an outpatient breast cancer surgery database from the Oncology Institute that is part of the local hospital, through local media, and through personal contacts of the investigators. To be included in the surgery group, the participants had to have: a single episode of breast conserving surgery or mastectomy, associated with axillary lymphadenectomy and sentinel lymph node biopsy up to six years previously (Singh et al., 2013); the capacity for voluntary arm elevation in the scapular plane greater than 90° as evaluated with a digital inclinometer. The exclusion criteria were: relapse of breast cancer; surgical treatment for bilateral breast cancer; presence of lymphedema, measured by differences of limb circumference between sides greater than 1.5 cm (Harris et al., 2001; Cinar et al., 2008); diagnosis of metastasis; shoulder pain compatible with shoulder impingement symptoms as determined by a positive Hawkins-Kennedy test (Hawkins and Kennedy, 1980), since inclusion of such participants would make it difficult to distinguish between changes in the studied movements that were due to shoulder impingement syndrome as opposed to the surgical treatment itself; previous history of surgery or fractures in the upper limbs; allergy to double-sided tape; body mass index (BMI) greater than 28 kg/m^2 because higher BMI's may increase error through skin motion artifacts during kinematics recording (Gupta et al., 2013).

The control group was matched to the surgery group with respect to age, weight, and height. All participants were women, without no reported shoulder pain, no history of cancer or upper limb dysfunction, based on self-report and active-motion exam by a physical therapist, including no known past medical history or history of shoulder problems (Teece et al., 2008). The exclusion criteria of the control group were the same as those identified in the surgery group except for those criteria concerning the breast cancer condition. Thus, a total of 42 participants completed the study (Fig. 1). All participants gave their written informed consent to participate in this study, which was approved by the Human Research Ethics Committee at the University (number 895.356) and conducted according to Resolution 466/12 of the National Health Council (NHC).

2.2. Procedures

Scapular kinematics, ROM, and muscle strength were evaluated in both sides of the surgery group and one side of the matched control group where the evaluated side in the control group was matched to the dominant or non-dominant side in the surgery group. For the surgery group, the order of the side that would be assessed first was randomized using a computer program (www.randomization.com). Since the control group was women without shoulder pain, pain intensity at rest and during arm movement was only evaluated in the surgery group. Upper limb function and quality of life were evaluated in both groups.

2.3. 3-D scapular kinematics

3-D scapular kinematics was collected using the Flock of Birds® (Ascension Technology, Burlington, VT, USA) electromagnetic tracking system integrated with the MotionMonitor ™ software (Innovative Sports Training, Chicago, IL) using a sampling frequency of 100 Hz. The tracking methodology used for 3-D kinematics is described in detail in other studies (Camargo et al., 2015; Haik et al., 2014) according to the recommendations of the International Society of Biomechanics (Wu et al., 2005). Three surface sensors were attached. Two were attached with double-sided adhesive tape to the sternum and acromion and the third was attached to the humerus using a cuff secured with Velcro to the distal humerus. Kinematics motion analysis involved selecting scapular data at 30°, 60°, 90°, and 120° of humerothoracic elevation. Participants remained standing and performed three consecutive arm elevation repetitions in the scapular plane and the average between them was used in the analysis. This procedure is a reliable method (intraclass correlation coefficient, ICC, for within-day assessment: 0.92-0.99) to evaluate the scapular movement in participants with and without symptoms of shoulder impingement (Haik et al., 2014).

2.4. Range of motion (ROM)

Active range of motion was assessed for shoulder abduction, flexion, and internal and external rotation using a digital inclinometer (Acumar™, Lafayette Instrument Company, Lafayette, IN) that measures angles from a horizontal or vertical reference within 1° of accuracy, as reported by the manufacturer. Participants were seated in a standardized chair with lumbar support but no arms to measure shoulder abduction and flexion (Kolber and Hanney, 2012) and were instructed to lift their thumbs up toward the ceiling as high as they could without any external force by the evaluator. The inclinometer was positioned in the proximal region of the elbow, distal to the glenohumeral joint. Abduction and flexion were performed in the coronal and sagittal planes, respectively.

Participants were supine to measure shoulder internal and external rotation (Thomas et al., 2011; Awan et al., 2002). The shoulder to be evaluated was positioned at 90° of abduction. For internal rotation ROM, the evaluator provided scapulothoracic stabilization by grasping the coracoid process and scapula spine to avoid compensatory motion of the shoulder (Kamonseki et al., 2017). The inclinometer was positioned in the middle third of the posterior or anterior region of the forearm to measure internal and external rotation, respectively. Two consecutive repetitions were performed for each motion. The mean of the two repetitions was considered for analysis.

2.5. Muscle strength

Strength, measured with a maximal isometric test of the shoulder abductors and external rotators, was assessed with a manual dynamometer (Lafayette Instrument Company, Lafayette, IN, USA). Participants were seated in a standardized chair with lumbar support but no arms during all measurements and were instructed to perform movements against the dynamometer. The dynamometer was fixed by

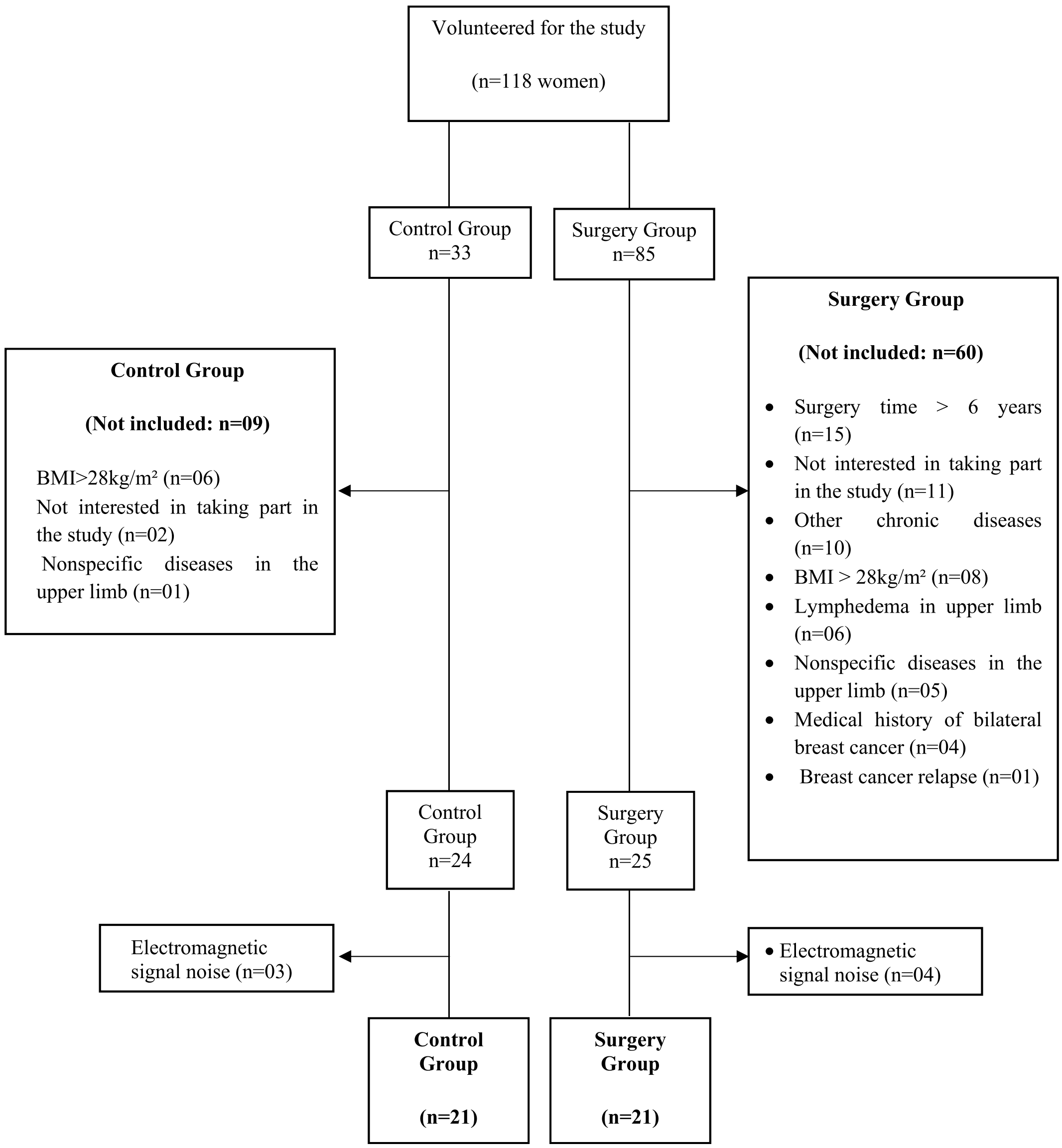

Fig. 1. Flowchart of study participants.

Velcro on a rigid wooden structure attached to the wall and the participants were seated such that the lateral plane of their bodies were parallel to the wall. The height of the dynamometer was positioned in order to have the upper arm of participant alongside the trunk, with 90° elbow flexion.

For abduction, a 10° range of abduction was considered in the scapular plane and the dynamometer was positioned proximal to the lateral epicondyle of the humerus (Cadogan et al., 2011). For the external rotation, the elbow was positioned at 90° of flexion and the dynamometer was positioned on the dorsal surface of the participant's wrist (2 cm above the styloid process) (Cadogan et al., 2011).

Two maximal isometric contractions were performed for 5 s each with a 60-s interval between the repetitions. The same verbal encouragement was given to all participants (“Push! Push! Push!”).

2.6. Reliability protocol

The intra-rater reliability was assessed for the range of motion and muscle strength assessments in 10 participants of the surgical group and 10 participants of the control group prior to the data acquisition. The rater was a physical therapist with 9 years of postgraduate experience who had 10 h of training prior to the reliability assessment.

The reliability between trials was calculated by comparing the two trials of each ROM and muscle strength movement.

2.7. Pain status

Participants' pain scores were measured in two ways; firstly, the presence of pain in the affected limb was measured by its status (number of participants reporting pain versus number of participants not reporting pain) among participants and secondly, the Visual Analogue Scale (VAS) was used to assess pain intensity in the area where pain was reported at rest and during arm movement (Alburquerque-Sendín et al., 2013), with a score varying from 0 to 10 (0 = no pain). The VAS is a valid and reliable tool for assessing pain in participants with shoulder pain (Mintken et al., 2009) and has an MDC of 1.3 points on the pain scale (95% CI:1.0–1.5) (Bijur et al., 2003).

2.8. Upper limb function

The Brazilian version of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire was used to evaluate upper limb function (Orfale et al., 2005). Scores range from 0 to 100 (0 = no disability). The questionnaire has construct validity and responsiveness in breast cancer

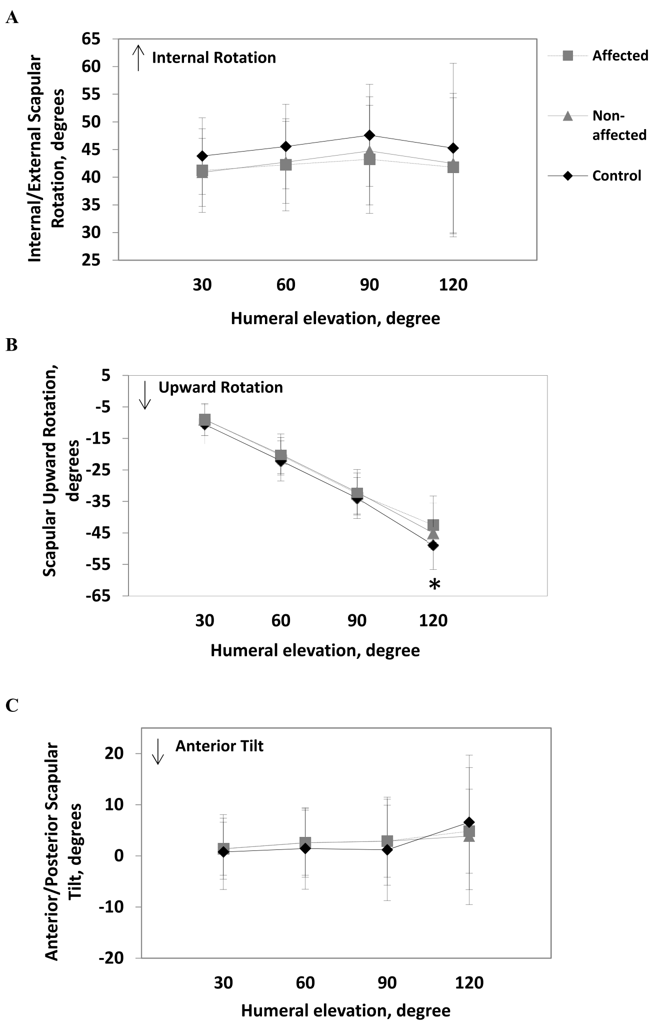

Fig. 2. Internal rotation (A), upward rotation (B), and anterior tilt (C) of the scapula during arm elevation in the scapular plane. The error bars represent the standard deviations. * indicates $p < .05$ when comparing the affected side of the surgery group to the control group.

survivors (Harrington et al., 2014), high test-retest reliability (ICC: 0.93), and an MDC of 10.81 points on its scale (Franchignoni et al., 2014).

2.9. Quality of life

Quality of life was assessed with the Brazilian version of the 36-Item Short Form Survey (SF-36) questionnaire, with scores ranging from 0 to 100 (100 = best quality of life) (Ciconelli et al., 1999; Campolina and Ciconelli, 2008). An increase of 10 points in physical functioning shows a clinical change in participants with chronic diseases (Wyrwich et al., 2005).

2.10. Data analysis

Data were analyzed using the Statistical Package for the Social Sciences Version 17 software (Chicago, IL, USA). The Kolmogorov-Smirnov test was used to verify the data normality. The descriptive analysis was performed with either mean, standard deviation, and 95% confidence interval, or with median and interquartile range on the quantitative variables, according to the data normality.

In order to compare the sociodemographics between groups, the following tests were performed: independent *t*-test for age and Mann-Whitney test for body mass index (BMI). A p value less than 0.05 was considered significant for all analyses.

Separate 2-factor mixed ANOVA's were conducted for each scapular rotation (upward rotation, internal rotation, and tilt) during arm elevation. For each analysis, group was the between-subject factor and angle (30°, 60°, 90°, 120°) was the within-subject factor. Comparisons of interest were interactions of group by angle. If no interaction was observed, the main effect of group was analyzed. The effect size, Cohen's d, was calculated for the kinematic variables to estimate the magnitude of the difference between groups and was classified as small ($d < .2$), moderate ($d \geq 0.5$), or large ($d \geq 0.8$) (Cohen, 1988). Effect size has been used in a case control study in order to provide measures of practical significance (Rebelatto et al., 2017).

Two tests were used to compare values for the ROM variables and shoulder muscle strength. The Wilcoxon signed rank test was used to compare intra-group (affected x non-affected) values and the Mann-Whitney test to compare inter-group (affected x control, non-affected x control) values. The Mann-Whitney test was also used to compare upper limb function and quality of life between groups. Finally, the effect size of non-parametric data was evaluated with Cliff's delta for shoulder ROM, muscle strength, upper limb function, and quality of life. A Cliff's delta of 0 shows no effect or no differences between groups while deltas close to −1.0 or +1.0 indicate an absence of overlap in measures between two groups. When a significant p value is obtained, the effect size near +1.0 or −1.0 is considered important (Macbeth et al., 2011).

For shoulder ROM and strength reliability analysis, the intraclass correlation coefficient ($ICC_{2,1}$) (Altman et al., 2001; Wu et al., 2011), standard error of measurement (SEM), and minimal detectable change (MDC, confidence interval [CI] of 90%) (Weir, 2005), were calculated as follows:

$$SEM = SD\sqrt{1} - ICC$$

$$MDC = SEM \times 1.64 \times \sqrt{2}$$

3. Results

Twenty-one participants of the surgery group (mean age ± standard deviation, 50.2 ± 9.8 years; median body mass index ± interquartile range, 26.7 ± 3.9 kg/m^2; median elapsed time since surgery ± interquartile range, 24.2 ± 20.5, months) and 21 of the control group (mean age ± standard deviation 50.7 ± 10.1 years; median body mass index ± interquartile range, 24.8 ± 4.9 kg/m^2) participated in the study. Twelve participants were left-handed and nine right-handed in both groups. No difference was found between groups for any of the sociodemographic variables ($p > .05$).

3.1. Scapular kinematics

For scapular upward rotation, there was a significant interaction of group x angle during elevation ($p = .022$, $F = 2.572$) of the arm. Pairwise comparisons indicated that the affected side of the surgery group showed less upward rotation compared to the control group at 120° of arm elevation ($p = .010$, mean difference = 7.3°, Cohen's $d = 0.47$) (Fig. 2).

For scapular internal rotation, there was no an interaction of group x angle as well as a main effect of group during elevation of the arm ($p = .830$, $F = 0.469$, and $p = .589$, $F = 0.534$, respectively).

For scapular tilt, there was an interaction of group x angle as well as a main effect of group during elevation of the arm ($p = .179$, $F = 1.517$, and $p = .657$, $F = 0.423$, respectively). Effect size was considered small intra- and inter-group for internal rotation and scapular tilt (d ranged from −.08 to .30 during arm elevation) (Fig. 2).

3.2. Range of motion and muscle strength

Table 1 presents shoulder range of motion and muscle strength in

Table 1
Shoulder range of motion and muscle strength of the participants.

Range of Motion (Degrees)	Surgery Group (N = 21)		Control Group (N = 21)	Cliff's Delta
	Affected Side	Non-Affected Side		
Flexion	171.00 (159.00–176.00)	172.50 (169.25–175.25)	168.50 (165.87–173.75)	Affected x control = −.37 Non-affected x control = .24 Affected x non-affected = −.12
Internal Rotation	81.00 (75.75–85.75)	81.50 (78.00–91.50)	83.25 (80.12–91.25)	Affected x control = −.21 Non-affected x control = −.11 Affected x non-affected = −.14
External Rotation	78.00 (72.25–81.25)*£	87.50 (82.50–91.25)	86.75 (82.25–94.00)	Affected x control = −.64 Non-affected x control = −.11 Affected x non-affected = −.62
Abduction	166.00 (155.75–175.00)	170.00 (165.25–174.25)	171.25 (169.00–175.87)	Affected x control = −.33 Non-affected x control = −.22 Affected x non-affected = −.10
Muscle strength (Kgf)				
External Rotation	5.05 (3.77–6.30)*	5.65 (4.82–6.80)*	7.82 (7.22–8.37)	Affected x control = −.73 Non-affected x control = −.62 Affected x non-affected = −.19
Abduction	6.70 (4.75–8.17)*	8.50 (5.55–9.25)*	10.82 (8.57–12.43)	Affected x control = −.75 Non-affected x control = −.60 Affected x non-affected = −.25

Abbreviations: * indicates $p < .05$ when compared to control; £ indicates $p < .05$ when compared to non-affected side.
Values are expressed as median (First quartile -Third quartile).

both groups. The participants in the surgery group presented decreased range of external rotation in the affected limb when compared to both the non-affected limb ($p = .001$, $Z = -3.355$, Cliff's delta = −0.62) and controls ($p = .013$, $U = 122$, Cliff's delta = −0.64). There were no significant differences for range of abduction, flexion, and internal rotation ($p > .05$, Cliff's delta ranged from −0.010 to −0.24).

The participants in the surgery group presented decreased shoulder abduction muscle strength in the affected limb compared to both the non-affected limb ($p = .031$, $Z = -2.155$, Cliff's delta = −0.62) and controls ($p < .001$, $U = 44.50$, Cliff's delta = −0.75). Also, the affected side of the surgery group presented decreased external rotation muscle strength when compared to both the non-affected limb ($p = .012$, $Z = -2.521$, Cliff's delta = −0.60) and controls ($p = .013$, $U = 122$, Cliff's delta = −0.73).

3.3. Range of motion and muscle strength reliability

For all ROM movements, the intra-rater reliability was considered moderate to very good in both groups. For the muscle strength, reliability was considered very good for the surgery group and moderate to high for the control group (Table 2).

3.4. Pain, function, and quality of life

Table 3 presents data regarding pain intensity, upper limb function, and quality of life. The surgery group reported perceived pain in the affected arm and, when compared to the control group, worse upper limb function ($p < .001$, Cliff's delta = 0.97) and poorer quality of life related to physical capacity ($p = .003$; Cliff's delta = 0.09). Physical aspects, pain, vitality, social aspects, and emotional aspects of quality of life were higher in the surgery group when compared to the control group ($p < .05$, Cliffs delta ranged from 0.09 to 0.52).

4. Discussion

Results of the present study showed that in general there was no significant difference between cases and controls for scapular kinematics. Moreover, women who had undergone operations for breast cancer presented decreased range of external rotation in the affected arm and decreased external rotation and abduction muscle strength bilaterally. Moreover, self-reported pain in the affected limb as well as poor upper limb function and quality of life were also identified up to six years after the surgery.

The decreased scapular upward rotation (7.1°) at 120° of elevation of the affected arm is an important finding of the study. Breast cancer treatment is a known risk factor for pain development (Hidding et al., 2014). Additionally, the presence of rotator cuff disease (Ebaugh et al., 2011) and winged scapula has already been reported in some patients two years after breast cancer surgery (Mastrella et al., 2009). Since there is evidence of decreased upward rotation and shoulder instability in shoulder impingement syndrome (Keshavarz et al., 2017), decreased scapular upward rotation may precede the development of future symptoms in the shoulder joint.

Some studies reported an increase in scapula upward rotation (Crosbie et al., 2010; Shamley et al., 2009). These findings are not in agreement with our study. However, it is important to consider that the inclusion of only one type of surgical procedure (Crosbie et al., 2010) and the absence of a control group (Shamley et al., 2009) may affect the comparison of results.

It is suggested that a reduction in range of motion and muscle strength may explain the higher incidence of shoulder dysfunction after surgery (Harrington et al., 2013). The reduction in range of motion has already been observed after breast cancer surgery (Hayels et al., 2010; Hidding et al., 2014). There is also evidence for lower strength of internal rotation twelve months after surgery (Monleon et al., 2016) and temporary weakness of the serratus anterior muscle associated with anterior thoracic nerve injury (Rizzi et al., 2016). In the present study, participants showed a lower range of external rotation and decreased muscle strength of abductors and external rotators in the affected side when compared to both the non-affected side and the control group. Moreover, it is important to consider that ROM and strength measurements presented moderate to excellent intra-rater reliability with narrow 95% CI values. Thus, the alterations in range of motion and muscle strength identified in the current study may contribute to the high indices of upper limb disabilities presented following breast cancer surgery and, since shoulder morbidity is bilateral and lasts for up to six years following the surgery (Shamley et al., 2012), it is important to consider that treatment of breast cancer has a well-known systemic effect (Hopkins et al., 2017) and that bilateral impairments may result from the reorganisation of motor control and adaptive movement patterns.

Previous research has shown that perceived pain can also contribute

Table 2
Intra-rater reliability, standard error of measurement, and minimal detectable change among repeated measures for assessing shoulder range of motion and muscle strength in both groups.

Range of motion (degrees)	ICC (95%CI)	SEM (degrees)	MDC (degrees)
Flexion	Affected side = .94 (.88; .99)	Affected side = 3.87	Affected side = 10.73
	Non-affected side = .76 (.50; .89)	Non-affected side = 5.00	Non-affected side = 13.85
	Control side = .78 (.30; .94)	Control side = 4.01	Control side = 11.12
Internal Rotation	Affected side = .95 (.81; .99)	Affected side = 4.17	Affected side = 11.56
	Non-affected side = .90 (.66; .97)	Non-affected side = 2.05	Non-affected side = 5.68
	Control side = .95 (.80; .99)	Control side = 2.34	Control side = 6.50
External Rotation	Affected side = .94 (.87; .99)	Affected side = 3.69	Affected side = 10.23
	Non-affected side = .76 (.51; .89)	Non-affected side = 3.18	Non-affected side = 8.82
	Control side = .99 (.94; 1.00)	Control side = 2.52	Control side = 6.99
Abduction	Affected side = .93 (.75; .98)	Affected side = 7.17	Affected side = 19.88
	Non-affected side = .97 (.89; .99)	Non-affected side = 2.38	Non-affected side = 6.61
	Control side = .61 (.40; .84)	Control side = 4.37	Control side = 12.13
Muscle strength (KgF)			
External Rotation	Affected side = .92 (.84; .99)	Affected side = .51	Affected side = 1.42
	Non-affected side = .81 (.41; .95)	Non-affected side = .80	Non-affected side = 2.22
	Control side = .67 (.14; .90)	Control side = .64	Control side = 1.78
Abduction	Affected side = .96 (.85; 1.00)	Affected side = .47	Affected side = 1.30
	Non-affected side = .96 (.83; .99)	Non-affected side = .47	Non-affected side = 1.29
	Control side = .86 (.55; .96)	Control side = .64	Control side = 1.78

Abbreviations: ICC, intraclass correlation coefficient; SEM, standard error measurement; MDC, minimal detectable change; CI, confidence interval.

to disabilities in the upper limbs 1.5 years after surgery (De Groef et al., 2017). The present study found that 38.1% of cases reported having pain that was restricted to the affected side (mean of 1.3 in VAS) of surgery, which could have contributed to the restrictions in range of external rotation and decreased strength of abduction and external rotation of the shoulder found between the groups. Moreover, deficits in shoulder range of motion and muscle strength may have contributed negatively to the kinematic changes found among the participants of the surgery group. The presence of pain may have also contributed to the decrease in the function of the upper limbs (Assis et al., 2013) and the reduction of quality of life (Caccia et al., 2017). Therefore, it is important to consider that the current study also identified high indices of upper limb disabilities and poor quality of life related to functional capacity up to six years post-surgery. However, despite of the fact that the non-parametric tests found a significant difference in the quality of life, there was very little difference in the medians between cases and controls and it was not considered to be clinically relevant, since that it was not observed an increase of 10 points in physical functioning domain (Wyrwich et al., 2005). Thus, the measurement error negates these findings.

Our study presents some implications for physiotherapists' clinical practice in the preoperative and postoperative period. According to the findings, we recommend preparatory treatment prior to surgery to prevent kinematics alteration and loss of range of motion and muscle strength in the long term following surgery. Following the surgery, full range of external rotation and strength of abductors and external rotators is required after drain removal. Thus, following surgery, some kinematics changes may simply be adaptive changes of the arm movement caused by decreased shoulder range and muscle. With these adaptive changes in mind, after discharge of breast cancer treatment, patients should be encouraged to incorporate daily exercises focused on scapular intervention (Saito et al., 2018) in order to prevent shoulder morbidity in the long term.

Some limitations of the present study should be considered. The variability of the elapsed time since surgery, the different types of surgical approaches, the small sample size, and the non-blinding of the evaluator in terms of the assessment of measures in the affected side, which was due to the visibility of the surgical scar in the participants. Although the ROM and strength measurements would not have to involve disrobing and exposing the surgical scar, all evaluations were done by the same evaluator and this is the most important limitation to be considered. However, the intra-rater reliability previously reported for these measurements revealed real changes and could give additional strength to the study in order to minimize the influence of this factor.

Although no differences were found between the surgical procedures used, the elapsed time since surgery should be considered to be an important factor for maintaining changes in upper limb functionality. Since that shoulder morbidity was evident for up to six years post-surgery, it is not known how long these alterations in the upper limbs last. However, the findings show that further investigations with longitudinal studies, stratified by elapsed time since surgery, types of surgical procedures, and age are still needed in order to address

Table 3
Pain intensity, upper limb function, and quality of life of the participants.

	Surgery Group (N = 21)	Control Group (N = 21)	p Value	Cliff's Delta
VAS (Rest) 0–10	.00 (.00–2.65)	–	–	–
VAS (Arm movement) 0–10	.90 (.00–3.05)	–	–	–
DASH 0–100	26.66 (5.83–46.24)	.00 (.00–.83)	< .001	.97
SF36 – Physical capacity 0–100	48.70 (48.65–48.90)	48.55 (48.52–48.65)	.003	.09
SF36 – Physical aspects 0–100	99.00 (98.90–99.90)	98.00 (98.90–98.25)	< .001	.52
SF36 – Pain 0-100	19.38 (19.06–19.48)	18.98 (18.86–19.28)	.010	.42
SF36 – Health condition 0–100	23.93 (23.83–24.10)	23.93 (23.81–23.98)	.820	.09
SF36 – Vitality 0–100	19.25 (19.15–19.37)	19.10 (18.92–19.27)	.004	.28
SF36 – Social aspects 0–100	24.00 (23.93–24.25)	23.75 (23.75–23.93)	.001	.52
SF36 – Emotional aspects 0–100	98.66 (98.90–99.90)	98.00 (98.90–98.33)	.003	.38
SF36 – Mental health 0–100	19.17 (19.02–19.36)	19.04 (18.94–19.18)	.089	.14

Abbreviations: VAS, Visual Analogue Scale; DASH, Disabilities of the Arm, Shoulder and Hands questionnaire; SF36, Short Form Health Survey questionnaire. Data are expressed in median (First quartile -Third quartile).

whether there are other kinematics and shoulder outcome changes related to these issues.

5. Conclusion

The findings of this study indicate altered scapular kinematics, particularly during arm elevation in the scapular plane, restriction of range of motion, and deficits in muscle strength. Of note is the fact that participants did not report shoulder symptoms, since the area of pain was reported in the affected arm, not the shoulder. These alterations were followed by self-reported upper limb disability and poor quality of life.

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