

New approach to evaluate late arm impairment and effects of dragon boat activity in breast cancer survivors

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Abstract

To verify the applicability of a new approach based on the strength curves (SCs) methodology in late arm impairment in breast cancer (BC) survivors and to evaluate the effects of dragon boat (DB) activity on the late regaining of the muscle strength, upper limb impairment, and quality of life in patients undergoing surgery for BC.

Retrospective observational study on 64 subjects (54.5 ± 9.7 years), 47 of them had undergone unilateral mastectomy surgery and were evaluated for late arm impairment. A clinical evaluation of the shoulder and compilation of functional assessment (DASH, Rowe, Constant–Murley) and quality of life (SF-36) scales were carried out. Assessment of muscle strength with SC obtained with isometric assessments and serratus anterior muscle test were performed.

Differences between the SC are evident between healthy and operated subjects. Among the 3 groups of operated subjects the difference in strength is maximum at 0°. Statistically significant difference was found between operated and nonoperated only in SF-36 scale. No significant difference was found between groups for shoulder instability and winged scapula.

The SC can be used in the study of upper limb impairment after surgery for BC: measurements carried out at 1st degrees of the range of motion are more useful for clinicians. DB activity is useful to reduce the late arm impairment.

Abbreviations: BC = breast cancer, DASH = disabilities of the arm, shoulder and hand, DB = dragon boat, PA = physical activity, ROM = range of motion, RPE = rating of perceived exertion, SC = strength curve, SF-36 = Short Form 36.

Keywords: functional assessment scales, physical activity, shoulder evaluation, strength curves

1. Introduction

Breast cancer (BC) is the most common cancer in women and affects more than 1.2 million people a year in the world with a continuous decrease in mortality.^[1] Approximately 89% of women with BC survive at least 5 years after treatment, but the side effects can persist for months or years.^[2] Early and late postsurgical consequences, mainly on the upper limb, are shoulder pain, reduction of the range of motion (ROM), and deficiencies in muscle strength.^[3,4,5–8] Therefore, today oncological teams should

be able to manage and monitor the adverse and late events of the disease related to the increased survival rate in this type of patient with regard to quality of life.^[9]

Reduced mortality is clearly associated with physical activity (PA) in BC survivors, with increased physiological functions and changes in life expectancy.^[2,10] The risk of death due to BC seems to be higher among survivors who have sedentary lifestyles than among the physically active.^[10] Although the relationship between impairment and muscular strength deficit is known in BC survivors, univocal quality of assessment protocols for muscular strength is not present in upper limb dysfunction.

The aims of this study are therefore 2-fold. The 1st is to verify the applicability and the utility of a new approach based on the strength curves (SCs) methodology in late arm impairment in BC survivors. The 2d is to evaluate the effects of dragon boat (DB) activity on the late regaining of the muscle strength, upper limb impairment, and quality of life in patients undergoing surgery for BC.

2. Materials and methods

2.1. Participants

From September 2013 to May 2014, 70 patients who had undergone unilateral mastectomy surgery, carried out by the same surgical team, were evaluated for upper limb impairment. Data of 47 of them were selected and included in the study. All the patients we considered had undergone axillary lymphadenectomy and reconstructive surgery. All had undergone chemotherapy and radiotherapy. None of the patients had undergone rehabilitation. The exclusion criteria were as follows: previous issues of internal medicine, neurological or musculoskeletal

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Table 1
Characteristics of the sample.

N	Group A 15	Group B 16	Group C 16	Group D 17	P
Operated breast side					
Right	57%	46%	40%	–	.56 (Between groups)
Left	43%	54%	60%	–	.180 (Between side)
Dominant side					
Right	93%	91%	100%	98%	.35 (Between groups)
Left	7%	9%	–	2%	.001 (Between side)
Age, years	54.1 ± 5.8	53.7 ± 12.1	60.4 ± 11.3	51.1 ± 8.3	.130 (Between groups)
Weight, kg	61.2 ± 9.9	63.1 ± 10.5	69.7 ± 10.2	68.0 ± 27.4	.570 (Between groups)
Height, cm	162.9 ± 7.9	162.2 ± 7.7	165.4 ± 5.7	163.6 ± 3.4	.690 (Between groups)
Body mass index, kg m ²	22.9 ± 2.6	24.0 ± 3.6	25.5 ± 4.1	25.4 ± 10.1	.670 (Between groups)
Time from surgery, y	8.2 ± 2.3	8.6 ± 2.4	7.2 ± 1.2		.540 (Between groups)
Hours for week of physical activity	2.3 ± 0.7	3.4 ± 1.5	0.2 ± 0.7	2.7 ± 2.9	.001 (Between groups)

The percentage values are expressed as mean value. The other values are expressed as mean ± standard deviation. In the column of significance for the first 2 variables (operated breast side and dominant side) 2 values of significance are reported. The 1st is the value measured between 4 subgroups A (practicing dragon boat), B (practicing other physical activities), C (no physical activities), and D (control) which we have called "between groups". The 2nd is the value measured in individual groups taking into consideration whether the side operated on and the healthy side was the right or the left (between side).

problems, not related to the cancer, that could affect muscle and/or joint function at shoulder level; psychiatric or mood problems previous the diagnosis of the disease; metastatic lesions; and bilateral BC. All the measurements subsequently used for the study formed part of the initial patient evaluation, as reported in the patients' medical records. To the selected patients were added 17 healthy women who made up the control group. All subjects were Caucasian and Italian. As regards PA, the subjects filled out a questionnaire on practiced PAs^[11] and were divided into 4 different groups: 15 operated patients (group A) practising dragon boating, 16 operated patients (group B) practicing other PA (fitness, dance, and running), group C, which included 16 patients not practicing any PA, and finally group D which consisted of 17 healthy women (see Table 1).

The subjects signed informed consent to allow the anonymous use of data collected in any further retrospective study. The study protocol was communicated to the Ethics Committee of the Hospital where the research was carried out. All procedures were carried out in accordance with the Declaration of the World Medical Association and with the Declaration of Helsinki guidelines.

2.2. Experimental procedure

A retrospective observational study was carried out. Initial clinical evaluation was performed by a physician, patients' medical histories and functional assessments were carried out respectively by nursing personnel and motor science graduates. Data analysis was performed by a physician who had not taken part in the initial clinical evaluation. All personnel did not image future use of the data. To complete the initial evaluation all subjects attended the hospital on 2 occasions. On the 1st day the medical history was gathered, subjects were examined medically and evaluation scales were compiled. Clinical tests included a comprehensive assessment of the shoulders (joint mobility, specific tests) and of the cervical spine. Both the shoulder on the operated side and the shoulder on the healthy side were evaluated. On the 2nd day the questionnaire about PAs was carried out, the anthropometric measurements were performed and the muscle strength tests carried out. To evaluate the intensity of PA, practiced session of rating of perceived exertion (RPE) on the CR-10 RPE scale proposed by Borg et al^[12] were administered.

The muscle strength evaluation was carried out, using the typical SCs procedures.^[13] The subjects remained under observation for 1 hour after the muscle strength test. After 2, 24, and 48 hours they were contacted by telephone to ascertain whether they were experiencing musculoskeletal or joint pain.

2.3. Strength test

After a brief warm-up of the upper limbs consisting of arm circling and muscle stretching, the subjects were tested to assess maximum strength with a movement of shoulder flexion (forward elevation of the arm) at various degrees of the joint ROM. The accuracy of this assessment was ensured by the use of 2 tools: an isometric manual dynamometer (Lafayette Instrument, model 01163) and an instrument especially created by our research team.

The instrument adapted conditions of the strength test to the physical size of each subject examined (see Fig. 1). It consisted of a

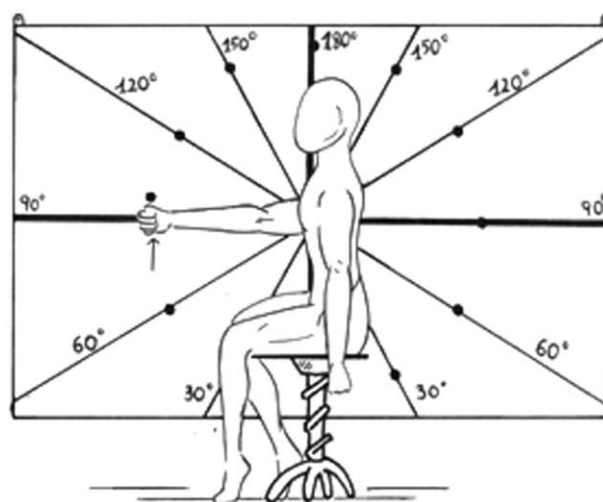


Figure 1. The drawing shows the procedure to assess maximum strength with a movement of shoulder flexion at various degrees of the joint range of motion (ROM). The shoulder joint was positioned in the middle of the panel fixed on the wall, on the lines are reported the ROM values. An isometric manual dynamometer, fixed on the wall was used.

stool, adjustable according to the height of the subject, positioned close to a wall, and a graduated measuring panel hung on the same wall. These served to keep the subject in a sitting position with the soles of both feet on the ground, the trunk aligned perpendicular to the floor that was from 0° to 180° and the shoulder level exactly at the point that marked 90°. The strength tests were performed on both upper limbs. Each patient was asked to perform a maximum isometric contraction in shoulder flexion in 7 positions of the joint ROM (0°, 30°, 60°, 90°, 120°, 150°, and 180°), performed in random order. The push point was standardized for each patient both on the operated side and on the nonoperated side, using an anatomical landmark placed on the radial styloid process as a reference. The dynamometer was set on the measurement table on a suitable sliding support to adapt it to the right position. The joint range was measured with a goniometer used in accordance with the American Medical Association guidelines. At least 1 minute of recovery time was observed between each strength test.

2.4. *Serratus anterior muscle test*

After the strength tests the serratus anterior muscle test was carried out. This test was administered with the patient in a supine position, with an elbow flexion angle of 90°. Resistance, by means of the dynamometer, was applied on the ulna, olecranon process height along the humerus axis. The patients were encouraged to push with the forearm against the dynamometer, using as much strength as possible. The operator verified by palpation that the triceps brachii muscle was not used.^[14]

2.5. *Constant score*

The Constant–Murley score is a widely used shoulder-specific scoring system.^[15] It proposes a scoring system designed exclusively for a numerical description of the quality of shoulder function. The Constant score includes an analysis of the pain, movement, strength, and functionality of the shoulder.^[16]

2.6. *Rowe score*

The Rowe score consists of a total of 100 points divided into 3 areas: stability, which corresponds to a maximum of 50 points; mobility, 20 points, and function, 30 points. The score is considered excellent when from 90 to 100 points, good from 75 to 89, fair from 51 and 74, and poor below 50 points.^[17]

2.7. *Disabilities of the arm, shoulder, and hand (DASH)*

The DASH questionnaire was developed to measure physical disability and symptoms of the upper limbs in people with upper extremity disorders (hand, wrist, elbow, and shoulder).^[18] It is a 30-item scale that addresses difficulty in performing various PAs that require upper extremity function (physical function, 21 items); pain symptoms, activity-related pain, tingling, weakness, and stiffness (pain symptoms, 5 items); and impact of disability and symptoms on social activities, work, sleep, and psychological well-being (emotional and social function 4 items). The score ranges from 0 to 100, where 0=no disability and 100=most severe disability.^[19]

2.8. *Short Form 36 (SF-36)*

To evaluate the quality of life, the patients completed the SF-36 questionnaire. The SF-36 is a health survey in summary form

with 8 subscales divided into 2 summaries, the Physical Component Summary (PCS) and the Mental Component Summary (MCS). Four subscales describe physical health (PA, health and physical role, body pain, general health, and change in health status) and 4 describe mental health (vitality, social activities, role and emotional state, and mental health). The SF-36 is a generic outcome measure designed to examine a person's perceived health status that can be used for any population or age group.^[20] The items in the SF-36 detect both positive and negative aspects of the patient's health.^[21] For each subscale, scores per item are coded, summed, and transformed into a score ranging from 0 (poor health) to 100 (excellent health).^[20]

2.9. *Statistical analysis*

Results are shown as mean and standard deviation. The percentage values were used to describe the difference in measured strength, occurrence of operated side and dominant side. As fewer than 100 subjects were recruited, percentages were expressed as whole numbers without decimal points. The authors verified that their data fit the normal distribution by means of a normal probability plot and the Shapiro–Wilk test. The Pearson correlation coefficient (and the corresponding 95% confidence interval) was used to examine correlations between the parameters. The paired *t* test was used to evaluate the differences in strength between limbs that had been operated on and limbs that had not been operated on. The multivariate analysis of variance (MANOVA) test and the Bonferroni post hoc test were used to study relationships between other variables. Post hoc evaluation of research sample size and statistical power was calculated as described by Cohen.^[22] Significance was set at 0.05. In the cases where occurrence and comparisons between percentage values had to be measured, data were compared using the test χ^2 or Fischer exact test. The Cohen *d* effect size was used to study the effect size, according to the formula $M1-M2/SD$ pooled, where *M1* is the mean value of the 1st measurement, *M2* the average value of the 2nd test, and *SD* is the standard deviation. SPSS 19 (IBM Inc, Armonk, NY) was used for statistical calculations.

3. Results

Table 1 describes the characteristics of our sample. The whole sample is homogeneous as there were no statistically significant differences. Body mass index confirmed that the women involved in the study were not obese. The majority of the participants involved in the study, on average 96% of the total sample (95% of the operated group A, B, and C and 98% in group D), were right dominant side and between the groups no statistically significant differences were found in this feature ($P=.35$) (see Table 1). In the sample of subjects who had undergone surgery, the disease and thus the surgery did not show a prevalence of side ($P=.56$) and the incidence of side of surgery showed no statistically significant differences ($P=.18$) either within each group (see Table 1). The elapsed time from the surgery in groups A, B, and C (see Table 1) shows no statistically significant differences ($P=.54$). Group C differs from the other 3 groups as regards weekly hours of PA. Intensity of PA measured by session RPE was on average 5.6 ± 1.2 on the CR-10 RPE scale.

In Table 2, total results of rating scales are shown. With regard to the subscales of the SF-36, for groups A, B, and C our sample showed average values for PA 75.5 ± 22.2 , for emotional role limitations 64.6 ± 23.1 , for physical pain 67.7 ± 21.4 , for general

Table 2**Questionnaires results.**

Questionnaires	Group A	Group B	Group C	Group D	Operated	Not operated	P	Cohen d
SF-36 scale	64.5 ± 16.6	68.1 ± 22.1	69.4 ± 21.3	82.1 ± 11.1*	66.8 ± 16.3	82.1 ± 11.1	.002†	1.4
Constant score	86.9 ± 9.5	88.0 ± 7.7	78.0 ± 11‡	93.3 ± 6	83.1 ± 12.6	93.3 ± 6	.24	0.4
Rowe score	91.5 ± 14.6	94.0 ± 7.6	89.3 ± 12.8	99.2 ± 2.6	91.6 ± 9.4	99.2 ± 2.6	.61	1.1
DASH score	53.2 ± 13.5	49.0 ± 9.4	52.8 ± 18.9	50.3 ± 12.6	51.5 ± 15.1	50.3 ± 12.6	.27	0.08

Values are shown as mean and standard deviation. For the SF-36 scale the total value of the scale is reported. DASH=disabilities of the arm, SF-36=Short Form 36.

* Statistically significant difference between D and all the other groups.

† Statistically significant difference. DASH, SF-36, shoulder, and hand.

‡ Statistically significant difference only between group C and D. Operated is the set of groups A, B, and C.

Table 3**Clinical signs in the 4 groups.**

Clinical signs	Group A	Group B	Group C	Operated (A + B + C)	Not operated group D	P
Winged scapula	29%	24%	26%	26%	28%	.39
Shoulder instability	28%	22%	27%	26%	24%	.12
Lymphedema	32%	32%	36%	33%	0%	.45

Number of subjects presenting the clinical sign. Group A is women practicing dragon boat, B practicing other physical activities, C no physical activities, and D control group. Values are reported as mean percentage value.

health 61.5 ± 15.8 , for vitality 59.2 ± 16.4 , for social activities 74.6 ± 17.2 , and for mental health 64.4 ± 21.1 . There was a statistically significant difference between operated subjects and control subjects for the general health subscale ($P = .04$; Cohen $d = 1.3$), for the PA ($P = .03$, $d = 1.1$), and for that of the role of emotional state ($P = .04$; $d = 0.9$). The subjects in the operated group (in the 76% of cases) reported a limitation of PA associated with impairment of the upper limb on the side of the surgical intervention. In Table 2, differences between operated and not operated are shown.

In Table 3, clinical signs results are shown as percentage of event occurring.

The typical SCs obtained during the movement of arm elevation between 0° and 180° are shown in Fig. 2. The curves are descendants (increasing ROM corresponds to a decrease in muscle strength measured). On observing the 4 curves it can be seen that the differences between the curves of the subgroups are greater in the first half of the curve (between 0° and 90°).

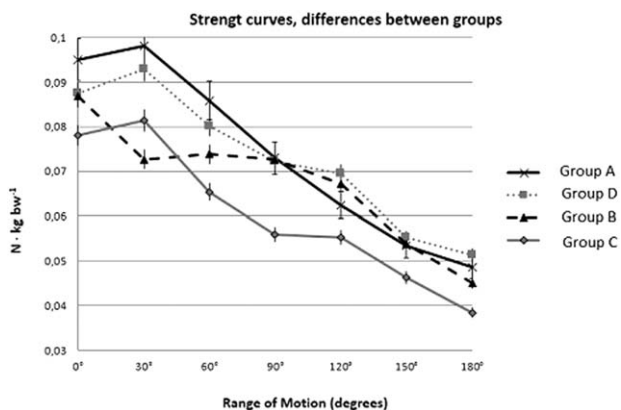


Figure 2. Values strength according to the joint angles in the 4 groups (A, B, and C operated side and D dominant side). Strength value is normalized to the weight. Y axis: N = Newton; kgbw = kg of body weight. X axis: degrees of range of motion of the test.

In Fig. 3 (values of Fig. 3 are shown in Table 4), it is possible to see that at 0° the group practicing DB (A) shows a difference between the operated side and the healthy side of 14% ($d = 4.5$); 4% in the group of other PA (B) ($d = 0.1$); 14% ($d = 0.4$) in the group no PA (C), and 18% ($d = 0.5$) in the control group (D). At 30° the group A shows a difference of 1% ($d = 0.01$); the group B 16% ($d = 0.35$); the group C 11% ($d = 0.24$), and the group D 10% ($d = 0.29$). To better understand the differences measured between pathological and healthy subjects, Table 5 shows the values of strength measured and analyzes the differences using the Cohen d effect size and the P value. Table 5 shows as in the 3 groups A, B, and C (operated) the difference is maximum between 0° and 30° ($0.7 = \text{large}$ and $0.4 = \text{medium}$ Cohen d effect size) with a statistical significance of this difference with values of $P = .02$ and $.04$, respectively. The measured values to successive degrees of ROM are much smaller (small effect size and not statistically significant). There was a positive association between the values of strength measured along the ROM and the values of SF-36 total ($0^\circ r = 0.57$, $P = .003$; $30^\circ r = 0.45$, $P = .002$; $60^\circ r = 0.41$, $P = .003$; $90^\circ r = 0.42$, $P = .002$; $r = 0.40$ to 120° , $P = .002$; $150^\circ r = 0.38$, $P = .003$; $r = 0.36$ to 180° , $P = .006$).

The comparison of the SCs of the limb of the operated side and the healthy side, normalized for the weight, shows that in the groups A, B, and C the curves are never overlapping, while in group D the 2 curves intersect at multiple points. In groups A, B, and C, the differences in strength between the limb on the operated side and the healthy side are highlighted. In group A, there is a significant statistic difference at 0° . No significant statistic difference in group B and in group C at several degrees. In group B and C, on average, there is a greater distance between the SC of the limb on the operated side and the healthy one.

In Table 6, serratus anterior muscle test results. There were no significantly lower values in operated compared to the healthy subjects ($P = .93$). No statistically significant differences between the operated side and the healthy side even between groups ($P = .80$) were found. Among pathological subjects a lower and statistically significant value ($P = .03$) in group C (sedentary) was measured.

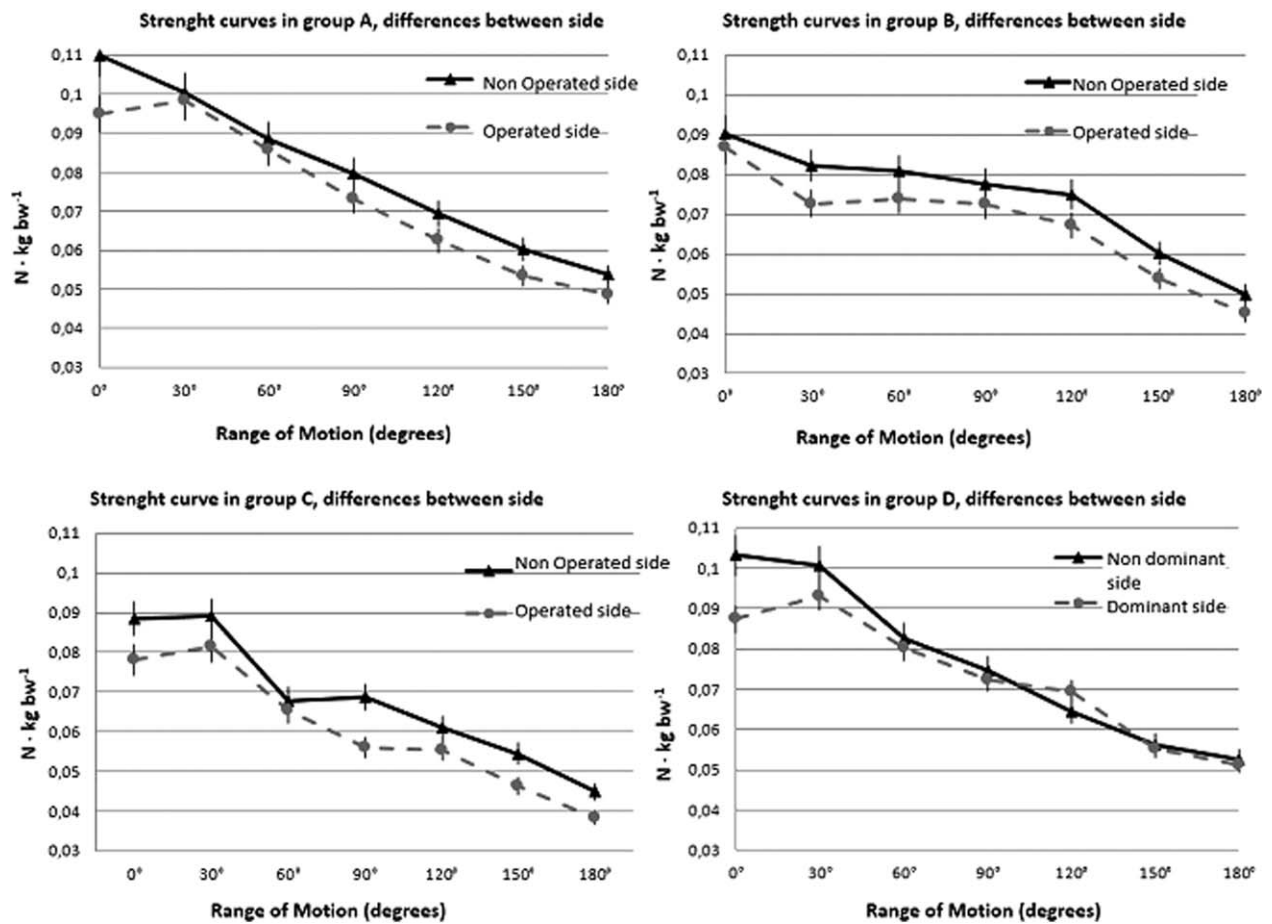


Figure 3. Strength curves on healthy side and operated-on side in groups A, B, and C; dominant and not dominant side in group D. Strength value is normalized to the weight. Y axis: kgbw=kg of body weight, N=Newton. X axis: degrees of range of motion of the test.

4. Discussion

The use of the SCs made it possible to identify a late strength deficit in the upper limb on the operated side particularly at 1st degrees of ROM. DB seems more beneficial in reducing the functional strength deficit of the upper limb in patients after breast surgery rather than improving daily living activity (SF-36 and other scales).

Data related to the side dominant distribution show evidence that, to measure differences between the operated side and the nonoperated side, the analysis can be carried out neglecting limb dominance for the analysis among the groups. Comparison between healthy subjects and subjects who had undergone surgery was performed on the same side. Elapsed time as well as limb dominance and the side of surgery can be excluded from

Table 4
Strength evaluation data at different degrees of range of motion.

	0°		30°		60°		90°		120°		150°		180°	
	OS	NOS	OS	NOS	OS	NOS	OS	NOS	OS	NOS	OS	NOS	OS	NOS
Group A (N)	0.96±0.13	1.08±0.14	0.96±0.13	0.99±0.11	0.84±0.13	0.87±0.15	0.72±0.14	0.78±0.16	0.61±0.14	0.68±0.09	0.52±0.10	0.59±0.11	0.48±0.09	0.53±0.10
P		.02		.5		.56		.28		.11		.08		.20
Group B (N)	0.85±0.15	0.89±0.13	0.71±0.16	0.81±0.14	0.72±0.16	0.79±0.14	0.71±0.13	0.76±0.15	0.66±0.13	0.74±0.14	0.53±0.11	0.59±0.12	0.44±0.10	0.49±0.12
P		.4		.06		.19		.32		.10		.15		.21
Group C (N)	0.77±0.14	0.87±0.10	0.80±0.14	0.87±0.11	0.64±0.16	0.67±0.12	0.55±0.14	0.67±0.13	0.54±0.16	0.6±0.12	0.45±0.15	0.53±0.14	0.38±0.12	0.44±0.10
P		.02		.12		.55		.02		.23		.02		.13
Group D (N)	0.86±0.15	1.01±0.13	0.91±0.13	0.99±0.15	0.79±0.12	0.81±0.15	0.71±0.14	0.73±0.16	0.68±0.15	0.63±0.13	0.54±0.10	0.55±0.11	0.50±0.10	0.52±0.07
P		.006		.10		.67		.70		.30		.78		.50

Group A is women practicing dragon boat, B practicing other physical activities, C no physical activities, and D control group. Strength value is normalized to the weight. Numbers are: N=Newton kgbw (kg of body weight). °=degrees of range of motion of the test. The values are expressed as mean and standard deviation. DOM=dominant limb, NDOM=not dominant limb, NOS=not operated side, OS=operated side.

Table 5
Strength evaluation data between operated and not operated.

	0°	30°	60°	90°	120°	150°	180°
Operated (N)	53.0±17.6	52.6±18.9	46.7±18.8	41.9±18.3	38.9±20.7	31.7±16.5	27.8±13.7
Control (N)	66.0±18.0	60.0±19.6	49.1±17.4	45.9±18.5	41.2±16.9	35.4±15.6	30.6±11.9
Effect size	0.7	0.4	0.1	0.2	0.1	0.2	0.2
P	.02*	.04*	.03*	.07	.34	.08	.11

Operated is the set of groups A, B, and C. Control are the subjects of group D. The numbers are the total strength values measured and are expressed as mean and standard deviation.

* Statistically significant.

having any effect on our findings in the study of upper limb functionality.

The SF-36 scale in subjects who had undergone surgery showed mean values confirming a reduced quality of life compared to the control group as already shown by other authors.^[2,3] Furthermore, it was possible to show a statistically significant difference for the general health subscale, for the PA, and for that of the role of emotional state. The subjects in the operated group frequently associated the limitation of PA with impairment of the upper limb on the side of the surgical intervention.

Other authors have demonstrated impairment of the upper limb several years after surgical intervention and the need to analyze the outcome in relation to the treatment.^[24] Upper limb impairment can have several causes. A muscular deficit that impacts indirectly on shoulder functionality (trapezius, rhomboid, pectoralis major, and minor) has been highlighted, but not in the direct field of surgery or radiotherapy.^[25] Muscular deficit contributes to a shoulder movement disorder, highlighting the need to focus treatment not only on regaining ROM but also on best muscular performance and posture correction. The same author described late muscle dysfunction after BC as alterations of the scapula humeral rhythm required during elevation of the arm (movement we used to construct the SCs). He supported the need for surveillance systems for the shoulder in oncology units.^[26] Surveillance should be oriented toward checking: reduction on ROM, reduction in muscle strength, pain, lymphedema, and reduction of daily activities.^[24] In our study, we evaluated ROM and muscle strength by means of the SCs; pain, lymphedema, and daily living activity with the rating scales.

Clinical evaluation also included the assessment of winged scapula, shoulder instability, and lymphedema. Winged scapula and shoulder instability could be considered either as results of the operation or as alterations before surgery, therefore affecting our measurements. Lymphedema instead could be a postsurgical consequence only. The differences shown in winged scapula occurrence between groups are not statistically significant. The same applies to shoulder instability. We can rule out that muscle strength measurements were influenced by winged scapula and instability and that several years after surgery these clinical signs are characteristic of the patient who has undergone surgery. Therefore, these tests (winged scapula and shoulder instability)

Table 6
Serratus anterior muscle test results.

	Group A	Group B	Group C	Group D
Operated limb (N)	71.7±8.0	71.3±10.1	51.1±5.2	64.6±13.8*
Healthy side (N)	74.2±15.3	79.8±16.1	55.7±9.1	73.5±9.1†
Mean (N)	72.9±12.1	75.5±10.8	53.4±11.6	68.8±13.2

* Nondominant side.

† Dominant side. The values are expressed as mean and standard deviation.

could be more useful for assessing the short-term consequences of the operation.^[4]

As an other author has shown,^[27] when muscle strength measurements are analyzed it is useful to express these measurements related to body weight (Newton kg body mass⁻¹) rather than absolute (Newton m). In Fig. 2, in fact, we reported the SCs obtained during the shoulder flexion movement of the upper limbs expressed in relation to the body weight. The curves in the group who had undergone surgery and in the control group graphically maintain the same type of downward trend (see Fig. 2). As demonstrated by Kulig et al,^[13] muscle strength decreases at the shoulder flexion degrees increasing, and surgery did not affect the physiological functioning of the shoulder joint. In other works,^[28] it is demonstrated that even joint replacement does not affect the shape of the SC. Analyzing muscle efficiency in patients who had undergone BC surgery with the aid of the SCs, the clinician can therefore expect a typical descending trend. An altered shape of the SC, no longer descending, may be a first sign of altered efficiency of the upper limb not only correlated with the breast surgery. The clinician can, at first, base his examination on observation of the curves and then move on to the evaluation of the difference in measured strength. The evaluation of muscle strength measured in the ROM is then a second and more thorough analysis level.

It was possible to carry out the measurement of muscle strength of all subjects involved and none of the women tested showed musculoskeletal injuries or acute muscle pain during the test or within 48 hours. Therefore, the SCs seem to be usable to measure muscle strength in women several years after BC surgery. Further studies are needed to verify the applicability of these tests at an earlier stage than this.

In our study, as regards the SCs we can analyze 2 aspects: differences between healthy and pathological subjects (see Fig. 2); significant differences between the healthy and the operated side (see Fig. 3 and Table 4).

About the 1st aspect, Fig. 2 shows that the differences between the pathological groups and the healthy are greater in the first 90° of movement and then decrease in the remaining part of the joint range. The measured differences between the control group and pathological subjects are greater between 0 and 30° (see Fig. 2 and Table 5). These data suggest that as regards our type of sample, the clinician might make their analysis more appropriate and more quickly by choosing to measure between 0 and 30° where the difference between healthy and pathological subjects is greater. Further studies on the sensitivity and specificity of the test, however, are needed. In our analysis on SCs (see Fig. 3), a difference of upper limb functionality in the subgroups can be perceived.

Our data concord with the literature and show how strength deficit linked to upper limb impairment persists some years after surgery. If rehabilitation treatment is indicated immediately after surgery,^[25] taking social, psychological, and general health

aspects into consideration, PA is preferable at greater time distance from surgery and can be considered to be a treatment for female cancer survivors.^[29] Our data and the characteristic trend of the SCs in the different groups highlight the fact that not all PA has the same effect on impairment recovery in the shoulder and further studies would be useful, extending the use of the SCs to other PA. As could be expected, the subjects not practicing any PA and those practicing activities with a predominant involvement of the lower limbs have lower muscle strength values than the control group and than those practicing DB. Surprisingly, women practicing other PA have shown lower values than those who do not practice any PA. This result may suggest a local effect of the specific type of PA but further studies on larger samples are needed to confirm this hypothesis. To confirm what is known^[10] on the effectiveness of PA, the women who had undergone surgery and practiced DB showed higher values compared to the control group. The effectiveness of DB on the upper limb in women treated for BC is confirmed by other authors.^[30]

With regard to the 2nd aspect we evaluated the differences in the SCs between the limb on the operated side and the limb on the healthy side using the same system: first the shape of the curves, and then the differences in measured strength. Figure 3 and Table 4 show that in the 4 groups, on the healthy and operated side in groups A, B, C and in dominant and nondominant in D, the curve has the same descending trend and the differences seem to be greater in the 1st degrees of ROM. The curve of group A, practicing DB, has a more similar shape to that of healthy subjects (D). In the curve of those who do not do any PA (C) the differences are greater at 0° and more frequent throughout the joint ROM. The weekly hours and the intensity of PA practiced were similar in groups A and D (see Table 1). Therefore, the higher values of strength measured in group A is conceivably a positive effect specific to DB. This hypothesis seems to be confirmed by the fact that in group B, which performs other types of PA and more hours per week compared to group A, the strength level of the upper limb was lower than the DB group. It is important to note that the difference between operated side and nonoperated side in group A is smaller than the difference between operated side and nonoperated side in group B (Fig. 3). This leads to think that DB is better than other PA in strengthening the operated arm. The differences shown in Table 5 between the groups were statistically significant ($P=.02$) and confirm the generally positive role of PA on upper limb functionality in patients after BC surgery.^[10]

Other authors have demonstrated^[14] the efficacy of the serratus anterior muscle test and we used this test for the study of the consequences of late upper limb functional impairment in BC. Some authors have shown that this type of surgery can result in degradation of the serratus anterior muscle.^[31] Overall, our results did not show significantly lower values in patients who had undergone surgery compared to the healthy subjects ($P=.93$). There were no statistically significant differences between the operated side and the healthy side even between groups ($P=.80$). According to our data, the test does not seem to be useful in assessing the effects of mastectomy on the functionality of the upper limb several years postsurgery. With regard to pathological subjects the lower and statistically significant value ($P=.03$) measured in group C (sedentary) still seems to highlight the positive effect of PA in general muscular efficiency after BC surgery.

Among outcome variables commonly used for clinical assessment of these patients there are rating scales. The rating scales concern often the shoulder and the upper limb functionality (DASH, Constant, and Rowe) generally used in a clinical

setting.^[15-17] The difference between healthy and pathological subjects in the DASH scale was not statistically significant, and no statistical significance was found in the differences between subgroups of pathological (P between groups = 0.20). As regards the Rowe scale, measured difference with the control group was not statistically significant ($P=.61$) and no statistical significance was found between subgroups of pathological but values between healthy and pathological subjects show an important effect size which should be considered carefully ($d=1.1$). It is possible that the sample size may have influenced the lack of significance measured and studies with a larger number of participants should be carried out. The large effect size value shows, however, a difference between the 2 values. With reference to the data of the measured effect size the Rowe scale seems preferable to the DASH scale and its use could be considered in the late evaluation of these subjects. Of the scales specific for the shoulder, the Rowe scale is to be preferred.

As regards the Constant scale, no statistical significance was found in the differences between subgroups of pathological and healthy ($P=.57$). The only statistically significant difference ($P=.03$) was found between group C and D. This difference is not present among the groups practicing PA and the control group, but is evident only between nonactive subjects who had undergone surgery and the control group. This supports the argument for the positive role of PA.

SCs, unlike DASH and Constant scales, despite the considerable length of time after surgery, allow to better highlight a deficit of muscle functionality on the operated side. There is correlation between the strength values measured and the values of the SF-36. Calculating the coefficient of determination value (R^2) it can be considered that the total values measured in SF-36 are explained between 33% (at 0°) and 12% (at 180°) from the strength values measured in the curves.^[22] These values underline the importance of PA in the quality of life of these patients and confirm that the measures at 1st degrees of the ROM can be used for a rapid analysis of muscle performance in patients undergoing surgery for BC.

A limitation of this study is that only patients who had not undergone rehabilitation after surgery were considered, therefore, further studies are required.

5. Conclusions

Among the outcome variables which can be used in the study of upper limb impairment in patients undergoing surgery for BC, a new approach based on the SCs can be recommended in BC survivors. Strength measurements carried out between 0 and 30° are more useful for clinicians. Taking into account the aims of our work, DB is useful to reduce the late arm impairment after surgery due to BC.

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