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Effectiveness of four types of bandages and kinesio-tape for treating breast-cancer-related lymphoedema: a randomized, single-blind, clinical trial

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Abstract

Objective: To compare the effects of four types of bandages and kinesio-tape and determine which one is the most effective in women with unilateral breast cancer-related lymphoedema.

Design: Randomized, single-blind, clinical trial.

Setting: Physiotherapy department in the Women's Health Research Group at the University of Alcalá, Madrid, Spain.

Subjects: A total of 150 women presenting breast-cancer-related lymphoedema.

Interventions: Participants were randomized into five groups ($n = 30$). All women received an intensive phase of complex decongestive physiotherapy including manual lymphatic drainage, pneumatic compression therapy, therapeutic education, active therapeutic exercise and bandaging. The only difference between the groups was the bandage or tape applied (multilayer; simplified multilayer; cohesive; adhesive; kinesio-tape).

Main measurements: The main outcome was percentage excess volume change. Other outcomes measured were heaviness and tightness symptoms, and bandage or tape perceived comfort. Data were collected at baseline and finishing interventions.

Results: This study showed significant differences between the bandage groups in absolute value of excess volume ($P < 0.001$). The most effective were the simplified multilayer (59.5%, IQR = 28.7) and the cohesive bandages (46.3%, IQR = 39). The bandages/tape with the least difference were kinesio-tape (4.9%, IQR = 17.7) and adhesive bandage (21.7%, IQR = 17.9). The five groups exhibited a significant decrease in symptoms after interventions, with no differences between groups. In addition, kinesio-tape was perceived as the most comfortable by women and multilayer as the most uncomfortable ($P < 0.001$).

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Conclusion: Simplified multilayer seems more effective and more comfortable than multilayer bandage. Cohesive bandage seems as effective as simplified multilayer and multilayer bandage. Kinesio taping seems the least effective.

Keywords
Breast cancer-related lymphoedema, bandages, complex decongestive physiotherapy, taping, volume reduction

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Introduction

One of the most common chronic and remaining side effects of breast cancer treatment is breast cancer-related lymphoedema.[1,2] Complex decongestive physiotherapy is the current standard treatment of breast cancer-related lymphoedema[3,4] and the first choice of treatment recommended by the International Society of Lymphology.[3] The intensive phase combines manual lymphatic drainage to decongest lymphoedema, traditional multilayer short stretch bandaging producing compression of the limb that decreases in the centripetal direction to prevent reaccumulating fluid and, with upper limb exercise, to create a counterforce to muscle contraction in order to reduce swelling volume[5] and self-care procedures.[3] The success of complex decongestive physiotherapy is known lie in the combination of all the techniques. However, compressive bandaging looks to be the most important stage of complex decongestive physiotherapy.[4,6]

A variety of materials can be used for bandaging. Bandages can be elastic (long-stretch bandages) or inelastic (rigid bandages or short-stretch bandages). Inelastic bandages can be applied alone, like cohesive bandage, or in combination with other inelastic bandages (multilayer bandage) and with elastic bandages (simplified multilayer bandage).[7,8] Inelastic multilayer bandages are the most commonly used for treatment of lymphoedema.[3]

Despite different types of bandages or kinesiotape being used in lymphoedema complex decongestive physiotherapy, most of them have not been directly compared[7,9–15] and therefore it is not known which particular bandage is most effective. The aim of our study was to compare the effectiveness of four different bandages and kinesio-tape on upper limb volume. We also measured as secondary variables lymphoedema-related heaviness and tightness symptoms and perceived comfort for the bandages and for the kinesio-tape.

Methods

The study was a randomized, single-blind, clinical trial of women with unilateral breast cancer-related lymphoedema. The study protocol was approved by Príncipe de Asturias University Hospital Clinical Research Ethics Committee in Alcalá de Henares, Madrid, Spain (Ref. 10/018) and was registered at ClinicalTrials.gov (Ref. NCT03250364). The study was performed between October 2014 and January 2020. All procedures were performed in accordance with the Declaration of Helsinki and the CONSORT statement.

Consecutive women diagnosed with unilateral breast cancer-related lymphoedema were recruited from the Physiotherapy in Women's Health Research Group at the University of Alcalá (Madrid, Spain). Inclusion criteria were as follows: older than 20 years of age; showing clinical stage I and II breast cancer-related lymphoedema according to the International Society of Lymphology[3] based on a diagnostic criterion of $\geqslant$2 cm difference in at least two consecutive perimeters of the affected upper limb compared to the contralateral limb[16–18] for at least six months; lymphoedema onset at least six months after surgery or radiation therapy; lymphoedema has not been previously treated. Exclusion criteria were as follows: women

who had bilateral axillary lymph node dissection; women with only hand lymphoedema; women with erysipelas or other active skin infection; women with loco-regional cancer recurrence; women with primary or metastatic lymphoedema; women with allergy or intolerance to kinesio-tape (tested by previously applying 1 cm^2 of kinesio-tape to the non-affected arm); women unable to adhere to interventions guidelines due to cognitive impairment and visual impairment for reading; and women who were taking medication that could cause fluid retention. Eligible women gave written informed consent to participate in the study after they had read the study information and fulfilled the inclusion criteria.

After baseline assessment, equal numbers of women ($n=30$) were randomly divided into five groups: traditional multilayer group; simplified multilayer group; cohesive group; adhesive group; kinesio-taping group. A physiotherapist (Pt1), who did not participate in the assessment nor in the intervention, used a computer randomization list at a ratio of 1:1 (EPIDAT v.3.1, Xunta Galicia Spain) to allocate participants consecutively to each treatment group. Allocation was not revealed until each participant had completed their baseline assessment at which time the treating physiotherapist and the participant were informed by phone of their group assignment by Pt1.

A different physiotherapist specialized in women's health (Pt2), who remained blind to participant group allocation, performed all assessments. Baseline assessment was carried out on the day the women agreed to participate in the study and prior to randomization, that is, two days before starting treatment, and three weeks after starting treatment. Participants were instructed not to reveal their allocation, that is, their bandage/tape, to Pt2 to ensure the success of blinding.

We did not consider any follow-up because the maintenance phase did not depend on the kind of bandage/tape used in the intensive treatment phase of complex decongestive physiotherapy, but on participant adherence in their garment and in their skin care in the maintenance phase of complex decongestive physiotherapy.

At the baseline assessment we collected personal data including age, body mass index, breast cancer surgery, adjuvant therapies, number of lymph nodes removed, affected arm (dominant or non-dominant), lymphoedema onset, lymphoedema severity,[3] lymphoedema location (proximal, distal, complete, see Supplemental Appendix 1)[19,20] and latex allergy. The body mass index was also collected in the post-treatment assessment to detect any change that could influence arm volume.

The primary outcome was the percentage reduction in the excess volume of the lymphoedema. To assess the volume of the limb a perimeter measurement was used. Arm perimeters were measured using a standard 1 cm wide, retractable, fiberglass tailor's tape measure (Babel, Spain). With the participant in an upright sitting position with both arms on a table, shoulders in neutral rotation and flexion of 45° and forearms at maximum supination, we measured the circumference at 5 cm intervals along both arms, using the elbow fold as the landmark starting point.[21] To calculate the volume, we considered each segment as a truncated cone and we calculated the segmental volume of each truncated cone using the formula described for it. Total limb volume for the segment between the wrist and the upper boundary was obtained by adding the volumes of the truncated cones between these points.[22] The severity of lymphoedema was defined as the excess lymphoedema volume relative to the healthy arm expressed in millilitre and in percentage as follows: percentage of excess volume = ((volume of lymphoedema arm − volume of healthy arm)/(volume of healthy arm)) × 100%. The volume and percentage reduction in the excess volume was obtained as follows: 100% × ((pretreatment volume of lymphoedema arm − post treatment volume of lymphoedema arm)/pretreatment excess volume).

The secondary outcomes were changes for heaviness, tightness and perceived comfort for the bandages assessed. Each woman stated whether she had heaviness and tightness or not (see Supplemental Appendix 2) and rated her perceived comfort on an 11-point numerical scale from 0 (no discomfort at all) to 10 (no comfort at all).

Adverse events were also documented, including their description, date of onset and their relation to the bandaging.

All the interventions lasted three weeks and were carried out in the intensive phase of complex decongestive physiotherapy. A two-week period with each week running from Monday to Friday, followed by a week comprising three alternate days until the patient received a tailored compression garment. The same physiotherapist (Pt3) who had more than 10 years' experience in the physiotherapy management of breast cancer related lymphoedema, including bandaging, carried out all the interventions and Pt1 and Pt3 were the only study members aware of each participant's group allocation.

All the women received manual lymph drainage using a modification of the strokes described by Leduc. It included resorption manoeuvre in the oedematous areas of the affected limb, in a cranial-to-caudal direction, once the physiotherapist saw a change in the tissue qualities of the oedema.[8,23] Then, women received 30 minutes of five-chamber intermittent pneumatic compression (Eureduc™) with a pressure of 40 mm Hg and a therapeutic educational strategy comprising instruction about lymphatic system anatomy and pathophysiology, the prevention and identification of possible lymphoedema risk factors, complications or infection, how to protect their skin, how to use and exercise this arm, how to deal with trauma, injury, an excess of heat and arm constriction. For every session treatment, before removing the bandage or kinesio-tape, active functional exercises were encouraged for 15 minutes to improve mobility and enhance lymphatic flow.[4]

All women received the same treatment except for their group-specific bandage or kinesio-tape.

Multilayer bandage group

Multiple layers were applied on cleaned and dried skin (see Supplemental Appendix 3). The first one was a 100% cotton tubular bandage directly placed on the skin to prevent any injury (Tubinylex™). The second one was a soft foam (Emulsified Latex Foam™ 8 mm, Thuasne, France) with the purpose of unify and increase pressure; and the third layer of inelastic bandages (6, 8 and/or 10 cm Rosidal K Short Stretch Bandage, Germany) was sequentially applied in a spiral method around the limb, with the smallest bandage starting at the hand and a layer overlap of 50%, so that the greatest compression was located at the distal points, gradually decreasing towards the proximal shoulder part. The inelastic bandages were applied at full stretch.

Simplified multilayer bandage group

Two layers were applied on cleaned and dried skin combining inelastic and elastic bandages (see Supplemental Appendix 3). The first one was an inelastic (rigid) cotton bandage (11 cm Bande coton short stretch; Thuasne, France) and the second one was an elastic bandage (Biflex™ 16 light; Thuasne, France). The inelastic bandage 'contains' oedema and the elastic bandage 'compress' oedema increasing pressure at rest which limits capillary filtration and favours reabsorption due to increased tissue pressure.[8,24] Both were applied in a spiral method around the limb, starting at the hand and a layer overlap of 50%, so that the greatest compression was located at the distal points, gradually decreasing towards the proximal shoulder part. The first one was applied at full stretch, and the second one at 30% stretch.

Cohesive bandage group

Cohesive bandage is a self-adherent lightweight bandage, made of a porous nonwoven polyester material (see Supplemental Appendix 3). A single self-adherent inelastic (short stretch) bandage was directly applied at full stretch on cleaned and dried skin (10 cm 3M Coban™ Minnesota Mining and Manufacturing Co., United States) in a spiral method around the limb, starting at the hand and a layer overlap of 50%, so that the greatest compression was located at the distal points, gradually decreasing towards the proximal shoulder part. Cohesive latex-free bandages were available for those allergic women. This bandage was reused twice in the same subject.

Table 1. Kinesio taping application.

	Fan shape	Participant position	Anchor location	Fan shape application
Upper arm	I (2 straps)	Upright standing Shoulder: external rotation and extension	On the axilla (no tension)	To the anterior, lateral and medial aspects by five tails straps (15%–20% tension)
	I (2 straps)	Upright standing Extended shoulder and elbow	On the lateral end of the clavicle (no tension)	To posterior aspect of the arm by five tails straps (15%–20% tension)
Forearm and wrist	I (2 straps)	Upright standing Extended elbow and wrist	On the medial epicondyle of the humerus (no tension)	To the anterior, medial and lateral aspect of the forearm by five tails straps (15%–20% tension)
	I (2 straps)	Upright standing Extended shoulder and elbow with wrist flexed	On the lateral epicondyle of the humerus (no tension)	To the posterior aspect of the forearm, to the dorsal surface of the hand and to the medial and lateral aspect of the proximal interphalangeal joints by five tails straps (15%–20% tension)

Adhesive bandage group

Adhesive bandage is an inelastic bandage (see Supplemental Appendix 3). An inelastic (short stretch) bandage (10 cm Biplast™ Thuasne, France) over a stretchy thin foam protection bandage (7 cm Foam protection™ Thuasne, France) was applied at full stretch on cleaned and dried skin in a spiral method around the limb, starting at the hand and a layer overlap of 50%, so that the greatest compression was located at the distal points, gradually decreasing towards the proximal shoulder part. In each physiotherapy session, the bandage had to be replaced with a new one.

Kinesio taping group

Kinesio-tape is made of 100% cotton, 100% acrylic, latex-free and heat-activated and it is more elastic than the conventional rigid tape by 120% to 140% (see Supplemental Appendix 3). It pulls the upper layers of the skin allowing space between the dermis and the muscles relieving pressure on the lymphatic and blood vessels and improving lymphatic drainage of the area.[25,26] Kinesio-tape (5 cm K-Active Tape©, Japan) was applied on cleaned and dried skin as is shown in Table 1.[9] The kinesio-tape was changed every treatment session for a new one.

The women were asked by the Pt3 about continuing to wear the bandage or kinesio-tape until the next treatment session, even during the weekend (Saturday and Sunday).

Power analysis was done to estimate sample size. We estimated that, assuming a 95% confidence level, with a sample size of 26 participants per arm we would have 85% chance of finding a difference of 100 mL in the excess volume difference between the most and least efficient group with a standard deviation of 120 mL as was observed in a previous pilot study carried out ad hoc to test methods and estimate sample size. The current study required a sample size of 26 subjects for each group. A total of 30 participants were recruited in each group to account for dropout rates of 15%.

We summarized categorical variables with proportions and continuous variables with means and standard deviations or median and interquartile interval. The distribution was verified by the Shapiro–Wilk statistical test. To analyze the effectiveness of the excess volume, the difference of the two moments in absolute and percentage values, and the perceived bandage/kinesio-tape comfort were calculated, and the non-parametric Kruskal–Wallis *H* test was used to study the differences between the five bandage/kinesio-taping groups. Post-hoc contrasts were performed on those variables where statistically significant differences were found between the bandage/kinesio-taping groups by applying the Bonferroni correction to the level of significance. If significant differences were found, the Cuzick

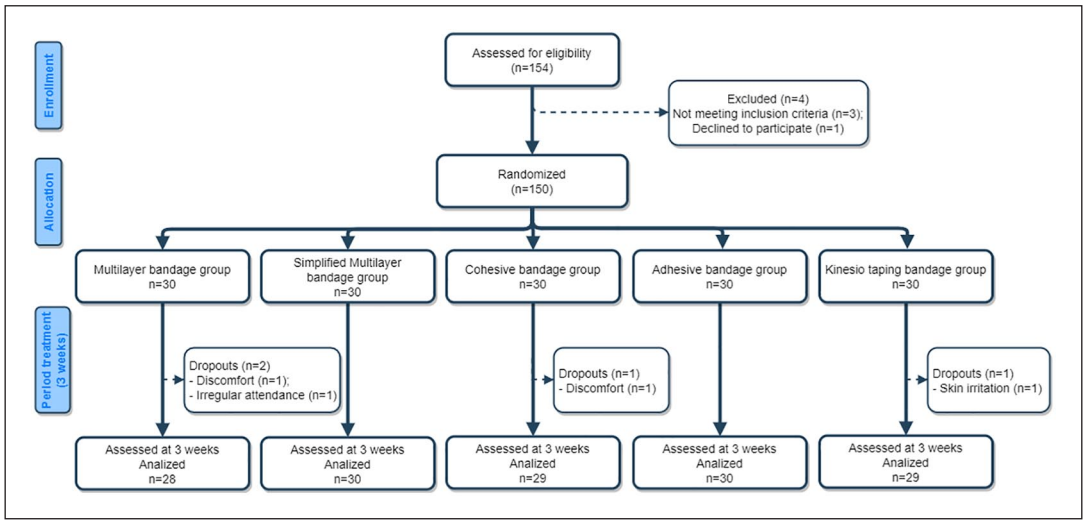

Figure 1. Flowchart of participants throughout the trial.

non-parametric test was used, which contrasted the existence of a trend with the effectiveness according to the type of bandage/kinesio-tape. Regarding the effectiveness of heaviness and tightness, the chi-square test or Fisher's exact test were used for each type of bandage/kinesio-tape. Analyses were performed with STATA/SE v14.0 and values of <0.05 were considered significant. Regarding the effectiveness of heaviness and tightness, the chi-square test or Fisher's exact test were used for each type of bandage/kinesio-tape. Analyses were performed with STATA/SE v14.0 and values of <0.05 were considered significant.

Results

In total 150 women were included in this study, of whom, 146 completed the interventions of the study systematically. Four participants withdrew from the study and their data were not statistically analyzed (see flow diagram in Figure 1). Clinical and demographic characteristics at baseline are shown in Table 2. No statistically significant difference pre-post treatment was found in body mass index ($P=0.988$).

The main findings of this study showed significant differences between the groups in absolute value and in percentage reduction of excess volume ($P<0.001$, Figure 2, Table 3). Specifically, the difference between the most effective (simplified multilayer bandage) and least effective (kinesio taping) was 107.7 mL and 54.6% as presented in Table 3. The groups with the least differences were kinesio taping and the adhesive bandage (64.1 mL, 30.8%). We performed trend analysis and found that there was indeed an increasing trend among the different groups ($P<0.001$). We found significant differences in all groups regarding absolute value and percentage reduction of excess volume ($P<0.001$) except for cohesive versus simplified multilayer ($P=0.456$), cohesive versus multilayer ($P=0.792$), adhesive versus multilayer ($P=0.232$) and adhesive versus kinesio taping ($P=0.071$; Tables 3 and 4).

Regarding heaviness and tightness symptoms, they decreased significantly after treatment (χ^2 $P=0.031$ and $P=0.026$, respectively); however, there were no significant differences between groups. In relation to the perceived comfort, kinesio-tape was the most comfortable and multilayer the most uncomfortable (5.3 points less comfortable on an 11-point numerical scale, $P<0.001$) as shown in Table 3.

Regarding adverse effects, they were recorded in the multilayer; cohesive; and kinesio taping groups as follows: two participants withdrew the bandages due to unspecific discomfort (one in the multilayer group and one in the cohesive group)

Table 2. Baseline characteristics of participants.

Outcomes	Multilayer group ($n = 28$)	Simplified multilayer group ($n = 30$)	Cohesive group ($n = 29$)	Adhesive group ($n = 30$)	Kinesio taping group ($n = 29$)	Total sample ($n = 146$)
Age (years), X (SD)	58 (11.4)	56.2 (11.5)	58 (13.8)	59.8 (9.4)	59.6 (10.6)	58.4 (11.4)
Body mass index (kg/m^2) X (SD)	29.7 (5.9)	29.1 (5.8)	29.2 (5.5)	30.8 (6.3)	27 (7.6)	29.2 (6.3)
Lymphoedema onset (months)	15.3 (5.4)	16.7 (9.6)	14.3 (6.1)	16.3 (15.3)	17.7 (9.1)	16.1 (9.8)
Lymphoedema stages, *n*° (%)						
Stage I	22 (78)	23 (77)	23 (79)	23 (77)	24 (83)	115 (74)
Stage II	6 (22)	7 (23)	6 (21)	7 (23)	5 (17)	31 (26)
Type of surgery, *n*° (%)						
Modified mastectomy	10 (36)	12 (40)	11 (38)	10 (33)	11 (38)	54 (37)
Quadrantectomy	10 (36)	10 (33)	9 (31)	10 (33)	10 (34)	49 (34)
Lumpectomy	8 (28)	8 (27)	9 (31)	10 (33)	8 (28)	43 (29)
Adjuvant therapy, *n*° (%)						
Radiotherapy	24 (86)	27 (90)	26 (89.65)	27 (90)	25 (86)	129 (88)
Chemotherapy	27 (96)	28 (93)	28 (96.55)	29 (97)	27 (93)	139 (95)
Hormonotherapy	17 (61)	18 (60)	16 (55.17)	17 (57)	15 (52)	83 (57)
N° lymph nodes removed X (SD)	15.6 (4.4)	14.8 (5.6)	15.2 (4.7)	15.6 (3.2)	13.6 (5.2)	15 (4.7)
Affected upper limb, *n*° (%)						
Dominant	8 (29)	10 (33)	6 (21)	10 (33)	5 (17)	39 (27)
Non-dominant	20 (71)	20 (67)	23 (79.31)	20 (67)	24 (83)	107 (73)
Lymphoedema location, *n*° (%)						
Proximal	4 (14)	4 (13)	5 (17)	5 (17)	4 (14)	22 (14)
Distal	11 (39)	12 (40)	11 (38)	11 (36)	12 (41)	57 (39)
Complete	13 (46)	14 (47)	13 (45)	14 (47)	13 (45)	67 (46)
Lymphoedema severity, *n*° (%)						
Mild	7 (25)	6 (20)	7 (24)	7 (23)	7 (24)	34 (23)
Moderate	17 (61)	19 (66)	18 (62)	19 (63)	19 (66)	92 (63)
Severe	4 (14)	5 (14)	4 (14)	4 (14)	3 (10)	20 (14)
Lymphoedema volume (mL) Md (IQR)	2306.3 (456.4)	2370.6 (614.6)	2270.9 (546)	2505.4 (662.7)	2343.7 (610.5)	2359.9 (582.3)
Excess volume (mL) Md (IQR)	446.4 (354.1)	326.5 (285.4)	363.7 (351.3)	513.7 (518.1)	395.3 (213.8)	409.6 (339.9)
Heaviness, *n*° (%)	18 (64)	25 (83)	22 (76)	20 (69)	24 (83)	109 (75)
Tightness, *n*° (%)	20 (71)	24 (80)	19 (66)	18 (62)	21 (72)	102 (70)

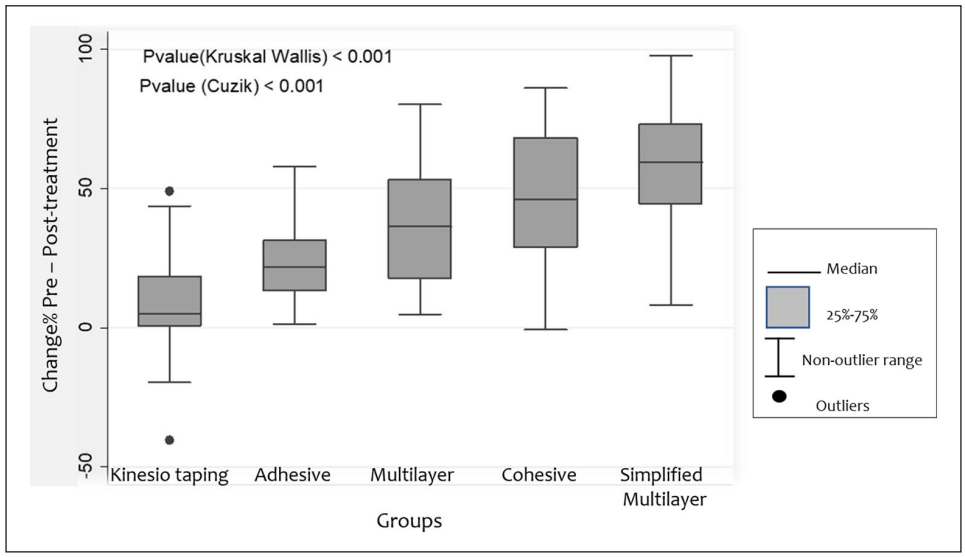

Figure 2. Percentage volume reduction between pre- (baseline) and post-treatment (three weeks after baseline) between groups.

Table 3. Change from pre- (baseline) to post-treatment (three weeks from baseline) for excess volume and perceived comfort.

Group	Excess volume mL	Excess volume %	Perceived comfort	*P* value*
Simplified multilayer	126.0 (89.4)	59.5 (28.7)	5 (1.8)	<0.001
Cohesive	124.2 (157.1)	46.3 (39)	4.8 (1.9)	<0.001
Multilayer	120 (168.2)	36.3 (35.5)	6.7 (3)	<0.001
Adhesive	61.9 (85.8)	21.7 (17.9)	4.3 (1.9)	<0.001
Kinesio taping	18.5 (43.4)	4.9 (17.7)	1.4 (2)	<0.001

Data are presented as median and interquartile range; significance at $P \leq 0.05$.
*Kruskal–Wallis.

Table 4. Post treatment between groups comparison.

Groups	*P* value*	
Kinesio taping vs Cohesive	<0.001	Cohesive > Kinesio taping
Kinesio taping vs Multilayer	<0.001	Multilayer > Kinesio taping
Kinesio taping vs Simplified multilayer	<0.001	Simplified multilayer > Kinesio taping
Adhesive vs Cohesive	<0.001	Cohesive > Adhesive
Adhesive vs Simplified multilayer	<0.001	Simplified multilayer > Adhesive
Multilayer vs Simplified multilayer	<0.001	Simplified multilayer > Multilayer
Adhesive vs Kinesio taping	0.071	
Adhesive vs Multilayer	0.232	
Cohesive vs Multilayer	0.792	
Cohesive vs Simplified multilayer	0.456	

Significance at $P \leq 0.05$.
*Post-hoc using Bonferroni correction.

and one participant had skin irritation (kinesio taping group).

Discussion

Our findings showed that four type of bandages and kinesio-tape, all associated with manual lymph drainage, intermittent pneumatic compression, therapeutic educational strategy and active functional exercises in the intensive phase of complex decongestive physical therapy of upper limb lymphoedema, significantly decreased in absolute value and percentage reduction of excess volume, as well as in symptoms. However, some bandages/kinesio-tape seemed more effective than others in reducing the volume of the oedema, and specifically, simplified multilayer and cohesive bandages seemed the most effective. Simplified multilayer seemed as effective as cohesive bandaging ($P=0.456$); and cohesive bandaging seemed as effective as multilayer bandaging ($P=0.792$). Nevertheless, simplified bandaging seemed more effective than traditional multilayer bandaging ($P<0.001$), in addition to being the only bandage that obtained a decrease in excess of volume of >50%, consistent with successful lymphoedema treatment.[27] These findings may lead to greater versatility in the compression bandaging treatment of breast cancer-related lymphoedema, to adapt them to the characteristics of each patient.

To our knowledge, as we have found no studies comparing all these bandages and kinesio-tape, this is the first trial to test the effectiveness of four different bandages and kinesio-tape in the intensive phase of complex decongestive physiotherapy of breast cancer-related upper limb lymphoedema stage I and II, this being the largest patient group.[28] Many studies finding positive effects of some of the bandages and kinesio-tape proposed in the present study are found in the literature. However, these studies either do not compare bandages and kinesio-tape to each other,[29] or compare only two bandages,[7,9,15] or compare one bandage versus kinesio-tape,[26,30] or compare one bandage/kinesio-tape versus compression garment.[11,12,14]

Bandages are an important part of oedema reduction, which is why they are used in the intensive phase of complex decongestive physiotherapy.[3] External compression increases the interstitial pressure preventing capillary filtration, increasing capillary reabsorption, increasing lymphatic reabsorption and lymphatic transport and improving lymph drainage.[24,31] Although the traditional multilayered inelastic (short-stretch) bandage is the most widely used,[3] there are other types of bandages or kinesio-tape that could be used,[6–15,26,29,30,32] and our findings may also allow a legitimate use of some of these bandages.

The combination of the properties of the elastic and inelastic material would explain why the simplified multilayered bandage seemed the most effective. In fact, the excess volume mean reduction was >50%, consistent with successful lymphoedema treatment.[27] According to Laplace's equation, the pressure applied is related to bandage tension, width, number of layers and radius of the limb.[8,31] All the inelastic bandages were applied at full stretch in a spiral method around the limb, with a layer overlap of 50%, so the number of layers was comparable in all bandages. Regarding the method of bandaging, although the study of Oh et al.[10] seems to show that the spica method could obtain a better volume reduction than the spiral method, in the present study spiral method has been used in all the bandages since the spica method cannot carry out with the cohesive and adhesive bandages.

In this sense, the difference between the bandages used may be due to the differences in their elastic properties. Inelastic material exerts a lower resting pressure and high-pressure peaks during muscle contraction. Elastic material provides continuous pressure with little variation between resting and working pressure, and resting pressure is greater than the resting pressure of the inelastic material.[33]

Although no statistically significant differences were found between the cohesive and the traditional multilayer bandage, both inelastic (short-stretch), the greater excess volume mean reduction of the cohesive bandage may be due to following: (1) the elastic retraction is greater than that of the traditional multilayer bandage, being the greater the pressure at rest and therefore being able to improve resorption at rest; and/or (2) muscle contraction,

exercise, mobility is an important requirement for oedema reduction.[24] With bandaging in place, mobility can be compromised compared with the unbandaged condition. Thus, traditional multilayered bandage, perceived as less comfortable by the participants, may have compromised upper limb mobility more than the cohesive bandage and more than the simplified multilayer bandage. This could also explain the greater comfort perceived by the participants with the adhesive bandage. The adhesive bandage is also considered inelastic (short-stretch), being a flexible and malleable material and offering excellent tolerance.[8] This flexibility and malleability make it more elastic than the cohesive and the traditional multilayered bandages, which would explain why it was not as effective as them in reducing the excess of volume. Studies as well as a consensus on the real pressure exerted by each of the bandages are needed.[33]

As for kinesio-tape, its little effectiveness may be due to the fact that its objective is not external compression but increasing the gap between the connective tissues which enhances fluid movement,[13,34] so it does not exert any pressure preventing filtration and improving reabsorption. These results seem to support that compressive bandaging looks to be the most important stage of complex decongestive physiotherapy.[4,6]

Consistent with our results, previous studies have found that the simplified multilayer bandage was more effective in reducing excess volume than the traditional multilayer bandage in the intensive phase treatment of upper limb lymphoedema in breast cancer patients.[7] Moffat et al. found a higher volume reduction in favour of the cohesive bandage, comparing it to the traditional multilayer bandage in patients with upper and lower limb lymphoedema.[15]

However, previous studies comparing the kinesio-tape with the multilayer bandage showed conflicting results.[13,26,34,35] Although Tsai et al.[26] found no difference in volume reduction between kinesio-tape and traditional multilayer groups, Smykla et al.[13] found that traditional multilayer bandage was significantly more effective in volume reduction than kinesio-tape, in accordance with the results of the present study. The differences may be due to the participants' lack of compliance with the multilayer bandage, as they wore it for an average of 7.8 hours (it was supposed to be 16 hours).[26]

Consistent with our results, previous studies have found improvements in heaviness and tightness.[11,12] In our study, no differences were found between groups. The excess volume decreased in all groups, which could explain that all groups improved subjective feelings of tightness and heaviness.

There are some limitations to be considered. Although the number of bandages and kinesio-tape used and their price were recorded to know the cost of the material of all treatments in the different groups, with the most expensive being the kinesio-tape and the least expensive being the simplified multilayer bandage, cost-effectiveness was not considered. The sub-bandage pressure measurement was not considered, which would have helped us to understand the 'dose' of compression and the stiffness of the bandage. Future studies should take this into account. The quality of life and the function of the upper limb were not assessed either. Finally, even though the lymphoedema development rates (15%)[21] determined the study enrolment of women with this condition, the power of this research is greater than most of the studies assessing the effectiveness of bandages in the treatment of breast cancer-related lymphoedema. Despite this, although this study suggests that these different bandages and kinesio-tape may not be equivalent, there is still a need for more powered and multi-centre studies that could support our results.

These findings have several potential clinical implications. Simplified multilayer bandage seems more effective and more comfortable than traditional multilayer bandage, and cohesive bandage seems as effective as simplified multilayer and traditional multilayer bandages, which could indicate that the use of traditional multiple layers compression bandaging in the intensive phase of related breast cancer lymphoedema stage I to II should be reconsidered with a focus on increasing patient function and general mobility. Multicentre clinical trials that are adequately powered and cost-effectiveness research combining different types of bandages depending on the degree and treatment phase of breast cancer

related lymphoedema are needed. This will help to define which bandaging systems are most appropriate for different patient groups and it also allow us to better determine the optimal dose and length of the treatment regime.

Clinical messages

- Simplified multilayer bandage seems more effective and perceived as more comfortable than multilayer bandage.
- Cohesive bandage seems as effective as simplified multilayer and multilayer bandages.
- Adhesive bandage seems less effective than multilayer bandage and is perceived as more comfortable.
- Kinesio taping seems the least effective bandage but the most comfortable.

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Author contributions

M.T.L. conceived the study, participated in its design and coordination, collected the data, supported the data analysis, interpreted the data and wrote the article. B.N.B. provided interventions, interpreted the data and wrote the article. V.P.G. provided interventions and interpreted the data. H.R.B. participated in its design and coordination, supported the data analysis, interpreted the data and wrote the article. J.C.F. supported the data analysis and interpretation. J.Y.B. supported the data analysis and interpretation. All authors have read and approved the final manuscript.

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Supplemental material

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