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THE EUROPEAN JOURNAL OF LYMPHOLOGY AND RELATED PROBLEMS (EJLRP)

The EJLRP - official organ of the European Group of Lymphology (ESL), Czech Society of Lymphology, Romanian Society of Lymphology, Greek Society of Lymphology, the Latin-Mediterranean Chapter of Lymphology (LMCL), the Società Italiana di Linfangiologia (SIL) covers all fields of Lymphology and aims to present a multidisciplinair approach to diseases of the lymphatic system, with information on the analysis, control and treatments of such diseases.

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PODOCONIOSIS IN ETHIOPIA. A PILOT STUDY TO IMPROVE THE MANAGEMENT OF LYMPHEDEMA

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ABSTRACT

Podoconiosis is a non-infectious cause of lymphedema, frequent in Africa. The aim of this study is to implement the management of lymphedema secondary to podoconiosis in a rural hospital in Southern Ethiopia. A call for donation of compression garments was made in Spain, to give any used and retired garment among lymphedema patients. The working plan was to train the staff in the lymphatic system, the causes of lymphedema, prevention strategies, skin care, intensive treatment and maintenance at long-term, Decongestive lymphatic treatment of the patients affected from podoconiosis and the adaptation of the donated garments for maintenance phase. Fifteen patients were treated with 10 sessions of Decongestive Lymphatic Therapy (DLT) consisting of Manual Lymphatic Drainage and multilayer bandages. The Percentage of Volume Reduction was 11.3% (95%CI: 8.8-13.9). Fifty percent of the patients showed an increase of the volume of lymphedema as they did not comply with the compression treatment. This pilot study has had good results in helping lymphedema management in Southern Ethiopia. The donation of used garments by chronic patients can be a feasible and effective step to improving the maintenance phase of patients with lymphedema in places with limited resources.

Keywords: lymphedema, podoconiosis, Decongestive Lymphatic Therapy, compression garments.

BACKGROUND

Lymphedema is a misdiagnosed disease even in occidental countries that leads to chronic and disabling complications when the treatment is delayed [1, 2].
Podoconiosis is a non-infectious cause of lymphedema, frequent in some African countries (Figure 1). In Southern Ethiopia with a prevalence of 5.46%, podoconiosis is an important chronic public health problem affecting both men and women [3].
It is caused by the exposure of bare feet to irritant alkalic clay soils while working [4]. Colloid-sized silicate particles appear to enter through the skin, are taken up into macrophages in the lower limb lymphatics and cause endolymphangitis and obliteration of the lymphatic lumen [4]. It provokes not only medical problems of elephantiasis and repetitive dermatolymphangitis, but also a severe disability and a social stigma.
According to Davey, people with podoconiosis are excluded from school, denied participation in meetings, churches and mosques, and barred from marriage [5].

Figure 1 - Podoconiosis.

There were considerable variations among community members' understanding of the causes of podoconiosis including genetic susceptibility, snakebite, direct contact of feet with clay soil, contagious, curses from God and poor nutrition. Other less commonly mentioned reasons were injuries (e.g., cut with axe), exposure to condensation, washing feet in hot weather and the evil eye [6].

Podoconiosis is unique in being an entirely preventable non-communicable disease [4].

As the International Society of Lymphology states, decongestive lymphatic therapy is the base for conservative treatment of lymphedema [7], and most of the guidelines of different countries follow this model of treatment [8,9,10,11].

OBJECTIVES

This pilot study aims to improve /to implement the management of lymphedema secondary to podoconiosis in a rural hospital in Southern Ethiopia.

METHODS

A call for donation of compression garments was made in Spain, to give any used and retired garment, even if deteriorated, in different associations of lymphedema patients (i.e. ACVEL) and in the Forum of Lymphedema in the internet (http://www.med-foren.de/). The collected garments, principally stockings were sent to the Rural Hospital in Gambo, Southern Ethiopia.

A physiatrist Dr. M Lopez-Agustin worked there for 6 months, between November 2010 to April 2011, sponsored by Fontilles and Fundacion ATA, to start a Rehabilitation centre in the hospital.

Concerning podoconiosis, the working plan was:

– To train the staff in the lymphatic system, the causes of lymphedema, prevention strategies, skin care, intensive treatment and maintenance at long-term;

– Decongestive lymphatic treatment of the patients affected from podoconiosis;

– Adaptation of the donated garments for maintenance phase.

The staff received some theory lessons and instructions were put on the wall to be referred to as needed. The doctor was in charge of the diagnosis, of planning the treatment schedule and of the assessment of the results. At first, she performed the Manual Lymphatic Drainage and the bandages herself (Figure 2) but, then the physiotherapist was employed and she trained him in the bandage technique and in the adaptation of the stockings (Figure 3).

Patients received 10 sessions of Decongestive Lymphatic Therapy (DLT) consisting of Manual Lymphatic Drainage and multilayer bandages [12]. Once volume reduction was achieved, compression was necessary to maintain the reduction of the volume, and another member of the staff helped adapt the stockings using a sewing machine to start maintenance treatment (Figure 4 and 5). He was skillful in this job.

Figure 2 - Dr Lopez performing the bandages.

Figure 3 - The physiotherapist is assessing a patient.

Figure 4 and 5 - The adaptation of the donated compression garments to the patients.

Figure 5.

The assessment of the results was made by taking the volume of the limb (with tape measurements from the foot until the knee using Kunhke formula [13]) and recording the degree of satisfaction with the treatment.

RESULTS

Fifteen patients (14 women and 1 man) (30 limbs) with bilateral lower limb lymphedema secondary to podoconiosis attended the hospital and were treated with DLT.
The mean age was 20 years (range: 11-55), the mean of volume at baseline was 2319 ml (95%CI: 2154-2485) and the volume after treatment was 2083 ml (95%CI: 1889-2277).
The reduction of the lymphedema volume was significant in all the patients, with 10 sessions of treatment.
The Percentage of Volume Reduction, calculated as the reduction of absolute volume related to the volume at baseline, was 11.3% (95%CI: 8.8-13.9).
The maintenance phase was made possible to perform by means of the donated garments that were adapted by the staff.
After one month the Change of Volume was 0.8% from the post-treatment volume (95%CI: -9.1-10.7). Fifty percent of the patients showed an increase of the volume of lymphedema as they did not comply with the compression treatment.

DISCUSSION

The main limitation of this study is the small size of the sample. But it has to be taken into account that medical attendance in Ethiopia is reserved for few people. Therefore, we could only treat patients that were obliged by their husbands to come to the hospital due to their uselessness to work or by their families due to the difficulties in marrying them, or they live in the same village and did not need to travel to the hospital.

The published studies to the date show no difference between men and women affected by podoconiosis [3], but the real situation at Rural Hospital of Gambo is very different. As Dr Lopez treated 14 women and a man with Podoconiosis, she realized that it was the disease of poverty because it affects people with very low resources, with no possibility to buy shoes and that go to work barefoot. It is also a women disease because it affects women that are triple exploited: by their race, their social class and their gender. On the other hand, she observed that their adherence to treatment depended on the possibility to be taken to the hospital by their husband to the prescribed sessions.
Despite the fact that Spanish patients only receive one garment per year, 42 garments were donated. It is nice to see, their disposition to help and their solidarity with poorer countries.
All the patients of our sample showed an improvement of their lymphedema volume, but the effectiveness was smaller than in our country. The main reasons for this smaller effectiveness could be the severity and chronicity of lymphedema in this sample, the presence of cutaneous complications such as hypodermitis and papilomatosis and the several episodes of lymphangitis attacks they have suffered before treatment. Nevertheless, all the patients were very satisfied with the results.
This improvement in the management of lymphedema has generated:

- The appointment of a physiotherapist trained in lymphedema in the Rural Hospital of Gambo.
- An increase in the number of the patients coming to the hospital looking for attendance.
- A start to reduction of the social isolation of patients.
- A start in information and self-care

The most important limitation to the management of lymphedema in Gambo is the lack of patient's adherence to treatment. Possible reasons may include: the belief that there is no effective medical treatment, long distances to the hospital setting, and the little awareness of disease hat these patients have. Moreover, the social status of women does not allow them to spend money and time on their health, considering that the economic cost of the treatment is high for them. The patients have to pay 60 birrs for the treatment (equivalent to 1.78 €) when their salary is 300 birrs per month (equivalent to 8.82 €). The maintenance treatment is also very difficult as patients continue walking barefoot and their garments get easily deteriorated. As other projects have reported in filiarial elephantiasis, and despite the limitations, our results suggest that basic lymphedema management is feasible and effective in podoconiosis areas where resources are limited [14].
As Ryan *et al*. reported after their experience in Ethiopia, also clean water and research in washing materials and soap are essential to improve the management of podoconiosis [15,16],
A randomised controlled trial is being conducted in Ethiopia by Negussie *et al*. to demonstrate that community-based treatment of podoconiosis can reduce the frequency of acute dermatolymphangioadenitis episodes and improve other clinical, social and economic outcomes.

CONCLUSIONS

This pilot study has had good results in helping lymphedema management in Southern Ethiopia. The donation of used garments by chronic patients can be a feasible and effective step to improve the maintenance phase of patients with lymphedema in places with limited resources.
Future projects are ongoing. We are planning to send more compression stockings and bandages, shoes that are essential for the prevention of the disease, and educating material for skin care, prevention, bandages. Education and training in prevention strategies focusing in the importance on wearing shoes at work have to be planned. Given the importance of the problem, other help has been asked to go on with this project.

Table 1 - Patients in Hospital of Gambo.

Patients	(n=15)
Age (mean; 95%CI)	20 (11-55)
Gender: Women Men	14 1
Etiology podoconiosis	15
LL Volume baseline (ml) (mean; 95%CI)	2319 (2154-2485)
LL Volume after treatment (ml) (mean; 95%CI)	2083 (1889-2277)

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DERMAL-EDEMA: THE MICRO-EDEMA

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ABSTRACT

The presence of the lower limbs of "fovea" indicates the objective presence of edema, however, the most recent literature has reported the presence of a subclinical edema called Dermal-Edema or Papillaredema. The relief of this form of edema was the prerogative of ultrasound examinations with high frequeza probes (<20MHz), while today it is possible to identify it with the common ultrasound devices equipped with harmonics already with frequencies of 10-14MHz. This sort of microedema affects above all the papillary part of the dermis more than the reticular part because the particular richness of Glycosaminoglycan (hyaluronic acid, etc) of this dermal zone represents a sort of "dermal sponge" for the storage of water.
The increase in this area that can be identified on the ultrasound as "subepidermail-low-echonogenic-band (SLEB)" immediately below the epidermal line may represent an early sign of future tissue dystrophy and is therefore useful during the execution of a venous echocolordoppler of the lower limbs, dwell on the evaluation, above all comparative between the two arts, of the SLEB.

INTRODUCTION

Edema, also spelled "oedema" is an abnormal accumulation of fluid in the interstitium, in varius tissues localized. The edema arises in just one area, for example a leg, or it can attack/infect different parts of the body, in that case, first the edema needs to be clinically evident, second litres of liquid have to accumulate; for this reason, most of the time, the weight grows before the edema comes out on lower limbs (fovea, etc.)
The formation of fluid in the interstitium, from the Staling's equation:
Net ultradiltration (F) = ***K [(PI cap – PI int) – σ (PO cap – PO int)]*** where **K** = coefficient of capillaty filtration; **PI/cap/int** = hydrostatic and interstizial pressure; ***σ*** = theoretical limitation coefficient to the passage of proteins thourgh endothelial pores; **PO cap/int** = blood and interstitial oncotic pressure.
The pressure ultrafiltration effective, produces an ultrafiltration in extravascolar direction, with a loss water containing smalls cells. On the other hand, **the effective reabsorption pressure** draws the interstitial liquids in the bloodstream. The amount of ultrafiltered water is not the same quantity of the absorbed water: the ultrafiltered water is 10% higher of the absorbed water.

Gross ultrafiltration means the quality of ultrafiltered water and **net ultrafiltration** means the difference between gross ultrafiltration and the quantity of resorbed liquid.
That net ultrafiltration matches to the physiological lymphatic load.
In the end we have a state of non-equilibrium condition, and a state of continuous water movement from the plasma to the interstitial compartment. This slight surplus, so the net filtration, however, is balanced by the amount of liquid who/which returns to the circulation through the lymphatics. So we can talk about the Edema when we have causes of increased oncotic pressure outside the blood vessels (for example, the inflammation), or reduces the oncotic pressure in the blood (for example, the cirrhosis). (Tab. 1)

Table 1 - Edema causes.

PHYSIOLOGY	POSSIBLE CAUSE	EFFECTS
↑ Capillary permeability (c)	Cellulite, arthritis, cyclic hormonal edema	Infiammatory edema, "idiopathic edema"
↑ Venous (capillary) pressure (Pc)	Heart failure, venous insufficiency, abstinence syndrome	Cardiac edema, venous edema
↑ Tissue oncotic oncotica (πt)	Insufficiency of lymphatic drainage (albumine increase)	Lymphedema
↓ Capillary oncotic pressure (πc)	Hypoalbuminemia, nephrotic syndrome, liver failure	Hypoproteinemic edema

An increase in hydrostatic pressure within the blood vessels(phlebostasis, orthodontic venous hypertension) or a reduction in the interstitial hydrostatic pressure eventually has the same proedemigenous effect. The lymphatic edema (lymphedema) is a hyperproteic edema and depends on the alteration of the lymphatic vessels. It is characterized by a reduced transport capacity, by a normal lymphatic load and by a high protein content edema. If the permeability of the capillary walls increases, will be releaIn the latter case we speak of inflammatory exudate or edema. Non-inflammatory edema, caused by alteration of the hemodynamic forces, is called "transudate". The transudate has a

lower specific weight to 1012, it is poor in protein and does not contain inflammatory cells.sed very fluid from the capillary, such as when it happens in inflammations. Instead, the exudate is characterized by the other specific weight, greater than 1020, is rich in proteins and cells of inflammation. Venous edema, which is characterized by a normal transport capacity, a normal lymphatic load and a low protein concentration, an example is an edema due to increased hydrostatic pressure. Physiologically, the pressure at the arteriolo-capillary end is about 32-35 mmHg, while at the venular one it is about 12-15mmHg with a gradient of about 25mmHg. When forming a venous stasis for chronic venous insufficiency venular the hydrostatic pressure reaches values of approximately 35-50mmHg with the triggering of interstitial edema, which subsequently may 'cloinicamente become evident. In this way, chronic venous stenosis Microangiopathy is determined, a prelude to trophic sequences such as Lipodermatosclerosis (LDS) and varicose ulcers. When the lymphatic transport capacity (Földi safety valve) exceeds that of drainage of the lymphatic system, there is a stagnation of liquid in the interstitium with the genesis of edema (hyperprotein edema typical of lymphedema).

In the last decade the Starling model enunciated in 1986 has been replaced by the Michel-Weibaum model [1-11] due to the importance of glycocalyx (venous glycocalytic consists essentially of 50-90% of heparan-sulfate and for a lower aliquot of chondroitin-sulfate and hyaluronic acid or Hyluronan) that would function as a sort of molecular sieve. In the new model of Michel-Weinbaum the true osmotic barrier does not correspond to the entire vessel wall with its endothelium, as defined by Starling, but rather to glycocalyx (molecular sieve) while the inter-endothelial pathways represent the preferential pathways of passage for albumin, etc. These recent scientific evidences point out that the damage of glycocalyx (glycocalyx-shedding), is a harbinger of strong increase in permeability with creation of interstitial edema, eritrodiapedesis, passage of albumine, etc. The extracellular and extravascular interstitial fluid represents 15% of the total body fluids (6-7 litres), and essentially consists of water and salts (especially NaCI) with a low protein content (0.3- 0.5 g/dI), ie in practice it is plasma without proteins. Albumins unlike globulins have different osmotic power [12]:

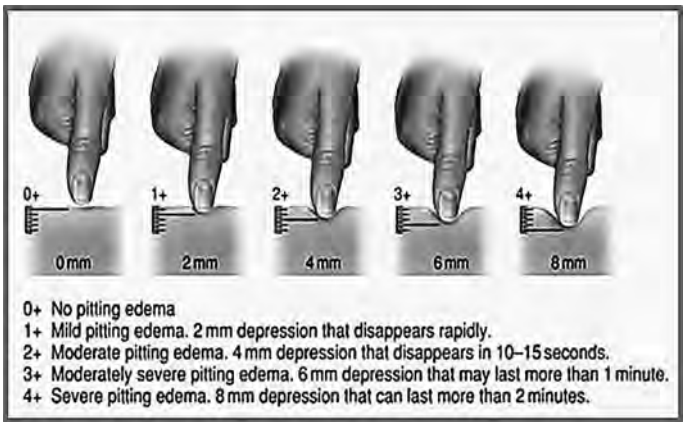
1 gr of albumine = oncotic pressure of 6 mmHg

1 gr of globulins = oncotic pressure of 1.5 mmHg

a lower volume and molecular weight (compared to globulins) and therefore capable of attracting a greater quantity of water. In addition, albumins are proteins with negative electrical charges (anionic protein gap) able to attract cation ions (Fe ++, Fe +++) and to induce tissue acidosis [13,14]. One of the most used formulas for the calculation of "the protein anionic gap" is as follows:

ANION GAP CALCULATION FOR ALBUMIN:
AG = (Na+) – (Cl- + HCO3) (v.n. = 10-10mmmoL/L)
Correzione per i valori dell'albumina = valore AG + [2,5 x (4- albumina)]
AG : Anion Gap

Human albumin is the most abundant serum protein (60% of the total protein) with an average concentration of about 3-5g / 100ml equal to .... it has a half-life of about 20 days and weighs about 69kDa. At physiological pH of the blood, albumin, besides binding fatty acids and various other molecules, binds to water, playing a fundamental role in the determinism of blood protein oncotic pressure. The water is an electric dipole, and is the main constituent of the body and corresponds to 60/65% of body weight in men and 55-60% in women. The total amount of water tends to decrease with age. The total body water is distributed in two compartments, the intracellular and extracellular divided into intravasal and extravasal or interstitial. The interstitial liquid is essentially made up of water and salts (especially NaCI) with few proteins (0.3-0.5 g / dI), so is a plasma without proteins. The interstitial fluid is extracellular and extravascular and accounts for 15% of total body fluids (6-7 liters). As already mentioned before, weight gain, even of several kgs, precedes the appearance of the fovea, the demonstrative sign of edema. Some classifications in use differentiate according to the depth of the fovea and the time of disappearance 4 different stages of edema:



Dermal-Edema or Microedema.

In recent decades, literature has reported a new entity of non-clinically visible edema, therefore not improntabile with the fovea, called "DERMAL_OEDEMA" (DE) or PAPILLARY DERMALEDEMA (PPDE), but can be highlighted with 25MHz echography. The author described this froma edema confined to the Derma as "subepidermail-low-echonogenic-band (SLEB)", a thin hypoechoic band (water) immediately below the epidermis, later also referred to as "Sub- Epidermal- Non-Echogenic Band (SENEB)". The author in his studied had carried out ultrasound findings on the skin of the forearm in a large number of patients with the age between 0 years (newborn) and 90 years, remarking that this type of dermal edema was an early and important sign of skin and fribrosis aging. This form of invisible edema (or invisible swelling) has subsequently become an important marker in some rheumatological diseases, such as dermatomyositis, multiple sclerosis, etc., in which the dermal edema is a prelude to the subsequent dermal fibrosis. Furthermore, other authors (Gniadecka, 1996) reported the importance of Dermal-Edema (DE) in both lipodermatosclerosis from chronic venous insufficiency, in lymphedema [16-19] and in venous ulcers [20]. The dermis (thickness varying from 0.3 to 4mm depending on the different anatomical sites) consists of two different layers, the one near the epidermis called "papillary or superficial dermis" that contains cells (fibroblasts, masticites, histiocytes, etc.) and fibers (collagen fibers and elastin) also the amorphous substance

consisting of electrolytes, glycoproteins, proteoglycans, etc., (known as GAGs or mucopolysaccharides) strongly hydrophilic and therefore able to absorb water (hyaluronic acid an unperforated GAG) equipped with the highest hydrophilicity, 1 gram of hyaluronic acid is able to retain a volume of 3 liters of water). The concentration of hyaluronic acid varies with the years, in fact when we have 20 years old, the hyaluronic acid that we have in our body captures about 100% of the water, while at 30 years old it drops to 65% of the concentration of water held back by the fabric skin, at 50 years old at 45% and infinite at 65 years old the value drops to 25%. The papillary dermis is more cellular and less fibrillary and is constituted prevalently by loose connective fabric skin with collagen fibers, elastic fibers, rich in blood-lymphatic vessels and nerve endings (amyelinated nerve fibers, tactile corpuscles of Meissner, etc.). The Reticular Derma, is or deep or fibrillary, and is constituted mainly by robust collagen and elastic fibers oriented in a spatial way (so in the same direction) instead. This spatial organization ensures resistance to deformation of the skin. One need only think that the surgical incisions along the lines of orientation of these fibers, called Langer lines, have a better cicatrization. The organization and composition of the papillary edema explains why it is also called "dermal sponge", as it has the ability to retain a lot of water is maximum in this segment of the dermis. Therefore the connective fabric skin (Derma Papillare) is essential for the storage of water in the body:

– a man with a body weight of 70 kg this storage is 3-6 lt. and the extracellular matrix holds 2/3 of it;
– in the healthy subjects in the ortho-clinostasis passage, the SKIN-THICKNESS or DERMAL THICKNESS (the thickness of the whole dermis measured between the epidermis and the hypodema) varies from 6-20% and after the physical activity the DERMAL-OEDEMA is reduced.

So, when water accumulates inside the skin, especially in PAPILLARY DERMAL-EDEMA (PPDE),will also increase the DERMAL THICKNESS or SKIN-THICKNESS, and if this increase in thickness exceeds 50-100% (mm) of its thickness, edema can be clinically visible, this is how invisible edema turns into visible edema (fovea). The presence of "DERMAL-EDEMA" determines the disruption of the collagen bundles (spatial orientation of the collagen fibers) with reduction of the density to the ultrasounds (low echodencity) and such reduction of the dermal density to the ultrasounds (as consequence of the "DERMAL-EDEMA") has been confirmed both with MRI and spectroscopy [21-23]. This storage of water in the dermis (in particular in the papillary dermis) with the presence of the "DERMAL-EDEMA" is also confirmed by other authors [24] which point out the marginal in terms of the hypodermis in water storage. Postural edema, which tends to increase with age [25], may be visible (fovea) or remain invisible (dermal-edema) and this may depend on the reduction of the absorbing capacity of the papillary dermis for the progressive reduction of hyaluronic acid. Another aspect is the fact that the edema to be able to reabsorb with the position of the lower limbs antideclive requires a time not less than 3 hours [24]. So in the end we become more susceptible to developing postural edema with the years and, moreover the edema is formed faster than its disappearance with the antideclive position.

An example of what is described is shown in fig. 1.

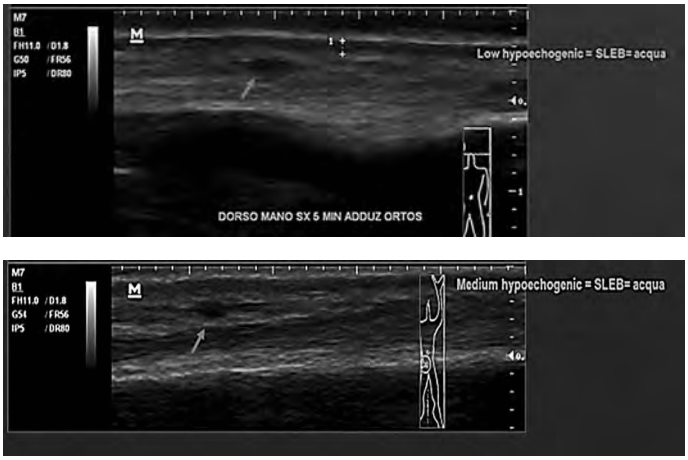


Fig. 1 - In (A) and (B) we can see how is changing rapidly (5min.) the echogenicity and thickness of the SLEB detected on the back of the hand after 5 minutes of adducted and abducted upper limb (14MHz with THI: Thissue Harmonic Image). Today with the modern ultrasound equipment equipped with the harmonic frequencies (THI: Tissue Harmonic Image) with frequencies 10-14 MHz, it is possible to see the SLEB that corresponds to the Dermal-Edema (DE).

HYPODERMIC EDEMA: ECOGRAPHIC DIFFERENCES

The edema of the subcutis, even if it is not able to give exact information, can manifest itself with different ultrasound images as reported in Fig. 2.

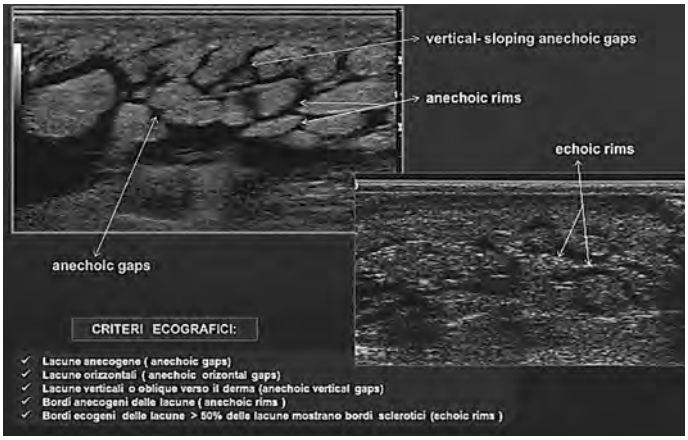


Fig. 2 - The different possible ultrasound images of the subcutaneous edema.

Some authors [27] in the lymphedema of the lower limbs describe, with an 11 MHz ultrasound probe, different degrees of echogenicity (SEG: Subcutaneous Echogenicity Grade) of the hypodermic edema (Fig. 3).

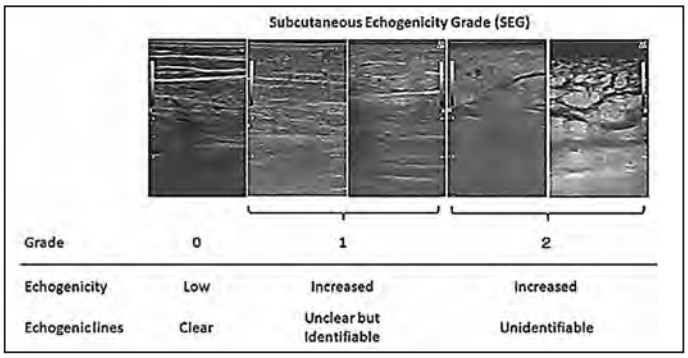


Fig. 3 - Different degree of echogenicity (grade 0, 1, 2) of the subcutis in secondary limb secondary lymphedema (from Suehiro K, 2013).

With ultrasound equipment with a higher frequency (20MHz) some authors [17] show that intradermal echogenicity shows characteristic patterns in different types of edema (lymphedema, lipodermatosclerosis secondary to chronic venous insufficiency, heart failure edema) which indicates that the localization of fluid (water) can be disclosed in different ways:

– SURFACE PAPILLARY DERMA in Lipodermatosclerosis (LDS);
– DERMO-HYPODERMIC in Lymphedema;
– DEEP RETICULAR DERMA in heart failure.

These differences can help to understand the etiology but above all to prevent the possible temporal skin sequelae that edema can induce. The presence of Dermal-Edem (SLEB: subepidermal-low-echogenic-band) constant in a patient with chronic venous insufficiency is a marker of dystrophic risk and of dermal elastosis and therefore it is necessary to get used during the execution of the ecodoppler test, which is normally performed in such phlebopathic patients, the presence of Dermal - EDEMA (SLEB: subepidermal-low-echogenic-band) so the subepidermal hypoechoic band and compare it with the other healthy limb or with different zones of the same limb (Fig. 4).

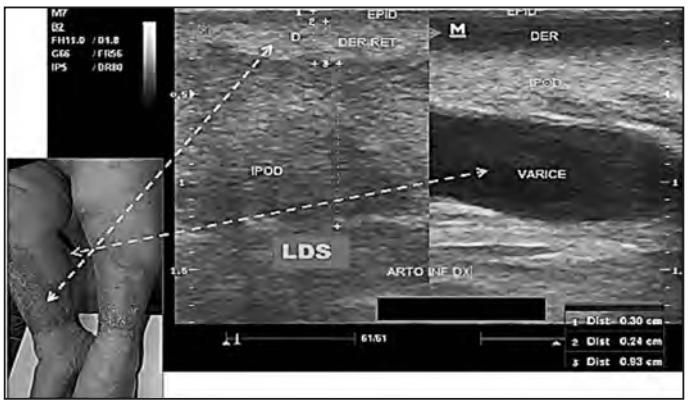


Fig. 4 - Comparison between peri-lipodermatosclerosis (LDS) and lipodermatosclerotic tissue, on the right note the presence of dermal- edema above the image of the varices, while in the left image the disappearance of SLEB with replacement of hyperechogenic reticular dermal tissue (fibrosis) with increased dermis (DERMAL THICKNESS or SKIN-THICKNESS). D2 = papillary dermis = 2.4mm; D3: reticular dermis = 9.3 mm.

Recently, some authors [28] report the importance of early echographic skin changes in the different CEAP-C states of chronic venous disease (MVC), highlighting the importance of the evaluation of SLEB (Dermal- Edema) sometimes present in the CEAP-C2 stage. as an early marker with respect to subsequent ultrasound alterations typical of the more advanced stages (Fig. 5).

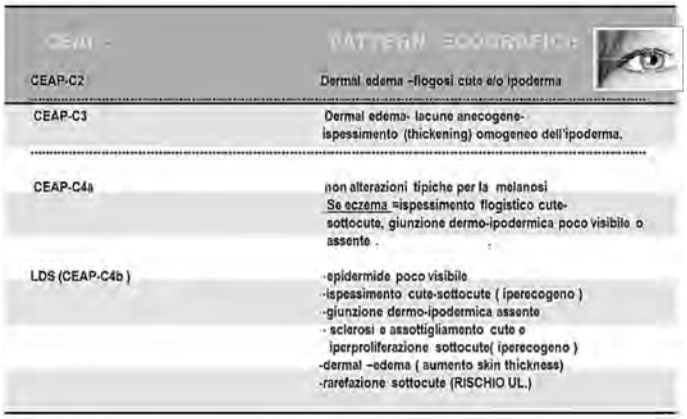


Fig. 5.

It is also reported that patients in the CEAP-C2 class who have dermal-edema (SLEB) would be more symptomatic than those who do not have this form of edema and also that a small difference in diameter (+ 1.0mm) of a varicose vein may be responsible for the appearance of dermal-edema (Fig. 6).

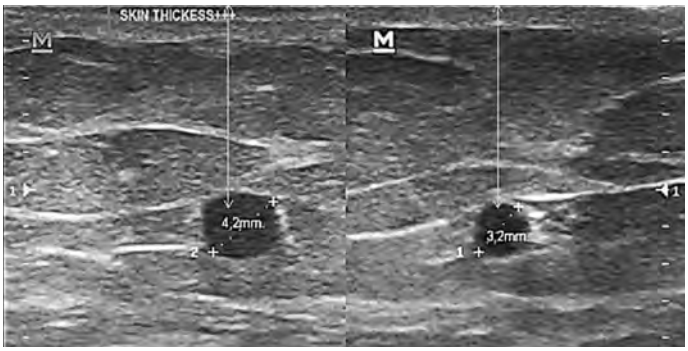


Fig. 6 - In orthostatism the evaluation of the SLEB and the subsequent SKIN or DERMAL-THICKNESS of two varices positioned at the same height with respect to the plantar support surface and the same cutaneous depth in the two limbs in the same patient, where the minimum increase of diameter (+ 1.0mm) determines the appearance of dermal thickening.

In conclusion, with the arrival of modern ultrasound equipment equipped with harmonics it is possible to highlight early extravenous alterations of the surrounding peri-varicose tissues, premonents of possible dystrophic disturbances already with 12 12 MHz frequencies. Moreover, as previously mentioned, the presence of greater damage to glycocalyx (Michel-Weibaum model) may lead to greater permeability with edema stasis.
So today, For all these reasons, the ecocolordoppler study of phlebopathic patients must include in addition to hemodynamics, also the evaluation of perivenous tissues with comparison with

other skin areas and / or between the two limbs. This ultrasound evaluation allows to go beyond the clinical evaluation until now (CEAP-C) representing a sort of "ultrasonic biopsy" and the microedema (DERMAL-EDEMA) is certainly an important datum to consider useful also for therapeutic monitoring [30].

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SUGGESTIONS FOR EDUCATION - TRAINING IN LYMPHOLOGY - DO WE NEED IT?

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ABSTRACT

The European Society of Lymphology (ESL) is a society for lymphology in Europe and it is the official European scientific organ on Lymphology. The educational level of the Lymphology among the European countries varies from very low –poor until very high. The ESL must stimulates and gives incentives to the persons, societies, countries in order to develop the lymphology in Europe Lymphology has begun to develop in Europe and generally all over the world especially after the establishment and the big efforts of the International Society of Lymphology, European Society of Lymphology and others very significant relevant societies. But in our days have begun to appear bad phenomena concerning malpractice both for the diagnosis and treatment of the lymphatic diseases and for the management of the patients. So it is more needed to have educational program accepted from all the Europe in order to establish limits and to define the terms of certified lymphologists and/or the therapists of lymphology and to exclude not certified persons. In this article are described some suggestions for the educational program of the scientific lymphology: what, how and why to give education and training and in Lymphology.

Key words: Lymphology, Education, Training, Program

INTRODUCTION

The European Society of Lymphology (ESL) is a society for lymphology in Europe and it is the official European scientific organ on Lymphology. There are many countries in Europe without any educational level Lympology or educational Lymphology with a very low level. The ESL must stimulates and gives incentives to the persons, societies, countries in order to develop the lymphology in Europe. Lymphology and general the lymphatic diseases with the most known lymphedema employs many health professionals and especially surgeons, plastic surgeons, pathologists, oncologists, internists, vascular internists, vascular surgeons, radiologists, radiotherapists, dermatologists, medical persons that are specialized in Infectious Diseases, gynecologists, anesthetists and more other medical specializations and nurses, physiotherapists, psychologists, persons for diet and for gymnastic [1]. Lymphoedema is a serious disease that since its appearance not only creates intense psychological problems to the patients but it changes their lifestyle and relationships with other people and it affects very significantly in the quality of life of the patient. Unfortunately, the above complications- mainly occur after surgical or conservative treatment of cancer- has been abandoned by physicians and health professionals all over the world. Patients feel helpless and disappointment when they find out that lymphedema could have been prevented and now they have the disease and moreover they have no someone specialist to advise and guide them.

The lymph is drained to the lymph vessels and lymph nodes to the bloodstream via the thoracic duct. When the lymphatic system is malfunctioning then the fluid accumulates in the interstitial space and increases the osmotic pressure resulting in edema and swelling of the limb. Lymphedema is the abnormal accumulation of protein-rich fluid in the interstitial space which creates chronic inflammation and reactive fibrosis tissue array [2].

Thus edema increase slow but steady increase the weight of the limb, decrease the mobility of the limb, it will appearance pain, weakness, stiffness and finally leads to the loss of functionality of the limb.

Once the patient is to display or has been diagnosed as suffering from lymphedema should then come in contact directly with the specialist physician or medical professionals to provide the appropriate treatment. Lymphedema is a medical condition with many other diseases and complications! We need a close cooperation of a specialist of Lymphology (which can be anyone as long as he specialized in Lymphology) with other medical specialists as well as nurses, physiotherapists, trainers, psychologists, nutritionists and other specifications for the proper and efficient treatment of lymphedema [3]. It is prohibited any treatment unless it is under the close supervision of qualified physician of lymphology or of qualified specialist of lymphology! [3]

The treatment aims to decrease the edema (fluid, fibrosis),

restoring the mobility of the limb, the prevention of infection, improve the aesthetics of the limb and generally improve the quality of life of the patient.
According the ISL consensus the treatment of the lymphatic disorders is separated in conservative and in surgical treatment [3]. In addition, according to internationally accepted guidelines the conservative treatment of choice is the Complete Decongestive Therapy (CDT). The treatment is divided into two stages, the intensive phase that lasts at least two to four weeks with at least one session a day and the maintenance phase to maintain the results achieved in the first stage. The first stage consists of:

a) the care of the skin and nails,

b) manual drainage of lymphatic fluid,

c) elastic bandage,

d) exercises,

e) education of the patient.

The last element of CDT is very important and should always be taught to the patient.
The second stage, conservative, takes place in the patient's home where the same applies with the first stage only the position of strapping the patient has an elastic glove or sock scheduled. Because lymphedema is a chronic disease, the patient should be monitored regularly by a qualified physician of lymphology or of qualified specialist of lymphology and its team and many times, if it is necessary, repeat the first intensive stage.
It is forbidden to carry out the above treatment if physicians, therapists and other trainers are not specially trained [3]. Effective treatments are those that lead to a reduction of more than 50% of the initial swelling at the end of the intensive phase. It should be noted that treatment failure when followed only one or two of these components of CDT as reported in the literature [4,5,6].
Lymphology has begun to develop in Europe and generally all over the world especially after the establishment and the big efforts of the International Society of Lymphology, European Society of Lymphology and others very significant relevant societies. But in our days have begun to appear ugly phenomena concerning lymphology and malpractice of the treatment of lymphedema. Phenomena involving malpractice both for the diagnosis and treatment of the lymphatic diseases and for the management of the patients. So everyone has to follow some necessary Lymphology instructions which are involved in the diagnosis and the treatment of Lymphatic Disorders. Moreover the World Health Organization (WHO) wants everyone will be educated with special guidelines [7]. Below are suggestions according WHO according National Lymphedema Network, according ISL and ESL and according the educational programs-seminars existing in Europe [8]:

1. Everyone who is involved in the diagnosis and the treatment of Lymphatic Disorders must be certified and expertise in them. Because currently there is no systematic training in Europe proposed, for the time being, to be certified those that they have already certification from seminar or faculty as Foeldi, Leduc, Vodder and many others famous and unknown 'schools'. These training centers must meet some of the criteria listed below and must have the approval of ESL.
2. When someone takes a certification from any above specialized center (approval by ESL) can provide it to the specially committee of ESL in order to be a member of ESL and to be recognized by all over the Europe and especially in his local place.
3. He will take a Diploma called European fellowship on Lymphology. If the committee of ESL believes that the candidate or the center that has graduated has any deficiency can suggest more examination or anything else more.
4. In order to help to spread out the lymphology the ESL needs more instructors and specially in the countries with low level of Lymphology. For the begging ESL can define 2-3 instructors in each country (national members of ESL and/or national or local committee can decides or suggests about the number and names of the instructor). After that the every new instructor has to meet some of the criteria listed below.
5. The treatment should be done by a certified team of lymphology (must be at least a collaboration of a one physician and a physiotherapist).
6. Each treatment on any lymphatic disease which is made by other certified therapists (except physicians) should always be done under the close supervision and recommendations of a certified physician.
7. Every bad, false and immoral practice concerning the treatment of the lymphatic disorders without the certification and the appropriate experience and it will lead to the impairment of lymphatic disease of the patients and their quality of life, should be punished by the special committee of ESL and his local lymphology society.
8. The special committee of ESL for the recognation of the diploma is required to have: at least three members where all members are already certified and include at least one physician. The committee will examine all relevant certification and training of Lymphology in Europe. All require approval by the Board of Scientific Committee of ESL and from the general assembly of ESL.
9. In the event that questions arise regarding treatment or education or anything else related to the Lymphology can be solved if officially asked the ESL.
10. The certifications must be given during the European Congress of ESL and/or in other event (if executive committee of ESL decides) with a celebration.

As the knowledge and technical approach to diagnosis and treatment for lymphatic diseases develops we need continuing education from certificate training centers with high level of standards for those persons dealing with lymphatic diseases and generally with the Lymphology.
To have an adequate knowledge base in pathophysiology of lymphatic function and its disorders, as well as adequate training in the techniques and principles of manual massage, compression bandaging, together with other components of complete decongestive therapy, the minimum-criteria for training in the treatment of lymphedema are as follows:

A) Students in the treatment of patients with lymphedema have successfully completed at least 135 hours of complete

decongestant therapy into a single program. The hours should not be confused with others hours that one can do: additional course or courses at advanced levels. It is important to have a single education program and that must have at least the following topics:

- Anatomy, physiology and pathophysiology of the lymphatic system
- The classification and staging of lymphedema
- Diagnosis and differential diagnosis of lymphedema
- Manual lymphatic drainage (mld)
- Bandaging and compression therapy
- Practice of bandaging of upper and lower extremities
- Indications and contraindications of manual lymphatic drainage and CDT
- Exercises for patients with lymphedema
- Patient evaluation and weekly measuring (circumference and volume)
- Basic and advanced techniques and sequences of mld
- Treatment of primary and secondary lymphedema of the extremities
- Other methods of treatment except CDT
- Treatment of head and neck cancer and genital lymphedema
- Skin care and nail for patients with lymphedema
- The importance of healthy skin and nail care for lymphedema
- Measurement techniques and how to wear gloves and stockings
- Teaching and training the patient to continue treatment at home.

B) It is necessary that one third (1/3) of hours of training, at least 45 hours, be theoretical training. The rest (2/3) of hours of training, at least 90 hours should be practical training with patients. During the course there will be oral and written examinations to assess the adequacy of the skills of the learner, while at the end of the study will be the final exam on the theoretical and practical part of education.

C) The book study of the students could be either the text book of lymphology of Foeldi or other book (it depends on each country) or the book of the VAS which is preparing. VAS is the official organ of UEMS for the specialization of European Angiology. ESL has strong collaboration with VAS and the VAS with the UEMS. All the books must be approval by ESL.

D) The trainee after the completion of the examination should continue to follow courses, seminars, congresses related to lymphology and with credits of CME.

E) The trainee shall be good after the end of his training to become member of ESL.

F) To be Instructor must a) be trained according to international standards and at least according to above basic program, b) be certified as a member (if there is in each country) in local or national society, c) to be member of ESL, d) be certified in lymphatic diseases by ESL with the diploma of European Fellowship on Lymphology, e) have proven at least 5 years experience in dealing with lymphatic disorders and proven credits of continuing education (CME), f) have proven teaching experience in Lymphology least two years at the local level (each country), g) to make teaching courses in recognized educational centers abroad in European educational congress as ESL as workshops, conferences related to lymphology or teaching educational courses under the auspices of Foeldi or Leduc or Vodder or anything else - always all approval by ESL. The instructor will take a certification called European Fellowship on Lymphology-Instructor.
If someone has already the certification of instructor of Lymphology from recognized schools he must be recognized by ESL also, with the above criteria, in order to take the above certification.

Concerning the surgical educational side of Lymphology:
There are different techniques regarding to the surgical management of lymphedema and of others lymphatic disorders and different official centers. Surgical techniques could be microsurgery, transplantation of lymph vessels and or lymph nodes, liposuction or others techniques.

A) The trainee must attend, study and follow the works of the surgical center.

B) The duration of the training depends on different specialization (ex microsurgery or transplantation) of surgical center. The centers must send its program of training to ESL and the center must has the official approval of training of ESL.
The material that the trainee has to study depends on each center but it must be approval by ESL.

C) After having complete the training the student, the head of the center must give a certification of attendance.

D) The student will have the possibility to take a more Diploma from ESL called European Fellowship on Microsurgery of Lymphology or European Fellowship on Liposuction of Lymphology ecc.

E) To be Instructor must a) be trained according to international standards and at least according to basic surgical program of the official center, b) be certified as a member (if there is in each country) in local or national society, c) to be member of ESL, d) be certified in lymphatic diseases by ESL with the diploma of European Fellowship on 'Surgical' Lymphology, e) have proven at least 5 years experience in dealing with lymphatic disorders and proven credits of continuing education (CME), f) have proven teaching experience in Lymphology least two years at the local level (each country), g) to make teaching courses in recognized educational centers abroad in European educational congress as ESL as workshops, conferences related to lymphology or teaching educational courses under the auspices of Campisi, Brosnor, Baumeister, Bacer or anything else - always all approval by ESL. The instructor will take a certification called European Fellowship on 'Surgical' Lymphology-Instructor.

F) If someone has already the certification of instructor of 'Surgical' Lymphology from recognized schools he must be recognized by ESL also, with the above criteria, in order to take the above certification.

G) The special committee for diploma of surgical training of ESL

is required to have: at least three members where all members are already certified and include at least two physician of surgical specialization. The committee will examine all relevant certification and training of Lymphology in Europe. All the latter is required approval by the Board of Scientific Committee of ESL and from the general assembly of ESL.

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MEASURING LEG VOLUME IN LYMPHOEDEMA USING OPTOELECTRONIC VOLUMETRY AND THE SEQUENTIAL TAPE METHOD

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ABSTRACT

Objective: To assess the level of agreement between two techniques for measuring leg volume, infrared optical volumetry (OEV) (Perometer 400T, Pero-System GmbH, Wupertal, Germany) and a sequential tape measure (STM) method in lymphoedema patients.

Design: Data were collected during a 6 month randomised control feasibility trial which assessed the effect of intermittent pneumatic compression (IPC) plus standard lymphoedema versus standard lymphoedema treatment alone, on lower limb volume.
Leg volume data were categorised into three groups, A) controls, non-oedematous legs from those patients with unilateral disease, B) legs with lymphoedema from patients with unilateral and bilateral lymphoedema but not receiving IPC, and C) oedematous legs as B, but receiving IPC.

Setting: Lymphoedema outpatient clinic, Dewi Sant Hospital, Pontypridd, UK.

Participants: Twenty adults (age range: 25-78 years, male/female: 30:70) with stage II or III lower limb lymphoedema were recruited. Ten participants had bilateral lymphoedema, and 10 unilateral lymphoedema. Non-oedematous legs were assigned to be control limbs (Group A).

Interventions: Observational data.

Main Outcome Measures: Lower limb volume.

Results: The range of leg volume measured by both methods were 2862 to 7021 mls. The level of agreement between the OEV and STM methods was 7.2% with lower limb volume underestimated by 324 mls using the STM method. The correlation between the two measurement techniques was strong with a fitted linear regression correlation coefficient, r, 0.99.

Conclusion: The study shows that the two methods are strongly correlated however between the STM and OEV methods there is an offset of 324 mls'. Both methods are easy to use, both for the patients and health staff, but the automated OEV method is quicker and provides an instant measure, while the STM is slower, it is more economically suited for the clinic.

Keywords: Perometer, tape measure, lymphoedema, leg, volume.

INTRODUCTION

Lymphoedema is a chronic condition that causes swelling in the body tissues due to an excess accumulation of protein rich fluid called lymph. While it is more commonly seen in the arms and legs, it can affect any part of the body with a key characteristic being an increase in limb volume (Lymphoedema Framework, 2006).
An accurate measurement of limb volume is essential for both clinical and research settings. Current treatment for lymphoedema is based on decongestive lymphatic therapy (DLT); there are four components to such therapy, compression, skin care, exercise and manual lymph drainage (Lanski, 2013). More recently, pneumatic compression devices have been considered as an additional treatment modality for treating lymphoedema (Zaleska et al., 2014). Thus, limb volume is an important outcome measure to ascertain the effectiveness of such decongestive treatments, such as compression therapy (Williams and Whitaker, 2015).
The gold standard technique considered for measuring limb volume is water displacement (Kaulesar et al., 1993). However, this method is time consuming and is not always seen as a practical technique to measure limb volume in a clinical setting. Circumferential measurements using a tape measure are more commonly used in clinical settings and have been shown to correlate with the water displacement method (Tewari et al., 2008). The preferred technique for circumferential measurements involves measuring the circumference of the leg just above the malleolus and then at 4cm intervals ascending the leg up to a point that is clinically significant for each patient (Lymphoedema Framework, 2006). Measurements can then put into preprogrammed calculators or computer software to calculate limb volume. The most common formula to calculate limb volume is the volume of a truncated cone; this is where the limb is seen as a series of frustum shaped segments ($segment\ volume = L/12\pi(C1^2 + C1\ C2 + C2^2)$). C1 and C2 are the circumferences at either end of the segment length (L). Total limb volume is the sum of the segment volumes (Williams and Whitaker, 2015). However, the reliability of this method is reliant on the technique, with a tendency to overestimate or underestimate limb volume (Deltombe et al., 2007).

Alternative measurements of limb volume can be obtained from an optoelectric volumeter, otherwise known as a perometer. The perometer was first developed in the 1980s and validated using geometric objects (Stanton et al., 1997). It has been used in many clinical studies but recently Tan et al., (2013) questioned its level of agreement with the widely used tape measure method, albeit they tested a healthy population.
An aim of this feasibility study was to assess the agreement between the two methods of volume measurement in patients with unilateral and bilateral lymphoedema in a clinical setting.

METHODS AND MATERIALS

Participants

Twenty adult participants (Age range: 25 -78 years, mean ± SD, 50 ± 15; male to female ratio = 30:70, weight 94 ± 36 Kg, BMI 33 ± 11) with stage II or III lower limb lymphoedema were recruited onto the study. Half of the participants (n=10) had unilateral and half bilateral lymphoedema (n=10). Population data were taken at baseline, along with measured leg volumes which were repeated at 3 month and 6 month time-points. Ethical approval for this study was obtained from the local NHS Research Ethics Committee (LREC No 17/WA/0076). All participants provided written consent. Three participants withdrew from the study at 3 months and one at 6 months.

Protocol

Participants' gender, age, height and weight were recorded at baseline (Table 1).
Next participants underwent both right and left leg volumes (including the nonoedematous legs in participants with unilateral lymphoedema) measurement using the two different methods, optoelectronic volumetry, OEV (Perometer 400T, Pero-System GmbH, Wupertal, Germany) (Figure 1) (Stanton et al., 1997) and the sequential tape measure method, STM. With OEV, the exposed leg to be scanned is positioned on a platform with the person standing. Each leg was scanned from the ankle to the upper thigh in a single vertical sweep of the optoelectronic measuring frame (Stanton et al., 1997). A plastic cylinder with a geometric volume of 2833ml was scanned during each clinic to provide a standard.
The sequential tape measure method used a metric non-stretch tape measure (Medi Germany) to measure the leg circumference at 4cm intervals from the top of the malleolus up the leg to 40cm from the first mark. To assure consistent measurement a registered nurse with experience in circumferential leg measurements using a tape measure performed the measurements. The volume of each segment was calculated from the leg circumference measures (LymCalc V 4.0, UK), and combined to provide the overall leg volume (Williams and Whitaker, 2015). The recorded OEV scans, allowed the selection of the same leg length as used by STM method, ensuring that the same leg sections were compared.

Table 1 - Participant demographics at baseline.

	Control (n=10)	Intervention (n=10)	All (n=20)	P value
Mean age (years) (SD)	41.3 ± 13.2	58.3 ± 11.5	49.8 ± 14.9	0.16*
Gender (M:F) (%)	50:50	10:90	30:70	0.14
Weight (KG) (SD)	92.9 ± 29.2	95.5 ± 43.8	94.2 ± 36.2	0.88*
Height (CM) (SD)	169.6 ± 8.5	162.9 ± 10.4	166 ± 9.8	0.16*
BMI (SD)	30.2 ± 8.4	36.2 ± 12.2	33.2 ± 10.6	0.21*

Comparison of means ± SD, differences between groups were made using a T-test or a Mann Whitney Rank sum test. A Chi-squared test was used to calculate ratio.

Figure 1. Perometer 400T, Pero-System GmbH, Wupertal, Germany.

Statistical Analysis

Comparison of means and correlation between groups was performed using computer software (IBM SPSS, version 22, New York, USA and Sigmaplot, Version 14, Sysstat, UK). Agreement plots were used to determine the agreement between the two methods (Bland and Altman, 1986), linear regression was used to test for correlation and ANOVA's to test for significance between groups. Statistical significance was set at $p < 0.05$.

RESULTS

In the twenty bipedal participants measured on three occasions, a total of 104 paired measures were collected, 16 measurements were not collected due to participant withdrawal from the study (Table 2). Measured leg volumes were allocated to one of three groups, normal legs (non-oedematous legs from patients with unilateral oedema, group A, n = 24), oedematous legs acting as controls not receiving the intervention, (from uni and bi lateral cases, untreated group B, n=37), and oedematous legs receiving the intervention (from unilateral and bilateral cases, treated group C, n=43). The model cylinder with a calculated volume of 2833 ml was scanned on ten occasions with the OEV, recording a mean volume of 2946 ± 10 ml (range: 2935 – 2960), with the OEV typically overestimating the volume by 113 ± 10 ml.
A comparison of the agreement between the OEV and STM measures of leg volume in the three groups showed a difference of 437, 412 and 458 mls in groups A,B, and C respectively (Figure 2, Table 2). In all cases the OEV provided the largest measure; the mean difference of the combined data (Groups A, B and C) being 437 ml (Figure 2 and Table 2). This offset was consistent across all leg volumes, large and small, and irrespective of group. Despite this offset, the correlation between the two methods was strong, a fitted linear regression analysis produced a correlation coefficient, r, of 0.99 (Figure 3).

Table 2 - Comparison between methods.

Groups	Agreement between two measurements (LymCalc, Pero) mean offset (mls) ± 1.96 SD	Median volumes Percentiles 25-75% shown (LymCalc, Pero)	Coefficient of variation (%) (LymCalc, Pero)
A) Lymphoedema free legs (n = 24)	–437 ± 201	3363 (2862-4175) 3853 (3223-4624)	28, 26
B) Oedematous Legs Untreated (n= 37)	–412 ± 259	3764 (3052-6426) 4054 (3417-7021)*	38, 36
C) Oedematous Legs Treated (n=43)	–458 ± 239	3711 (3222-5604) 4217 (3772-6114)	38, 35
All data (n=104)	–437 ± 239	3643 (3031-5372) 4084 (3454-5811)	39, 36

*Significantly different from Group 1, lymcalc measurement, see text (Figure 4).

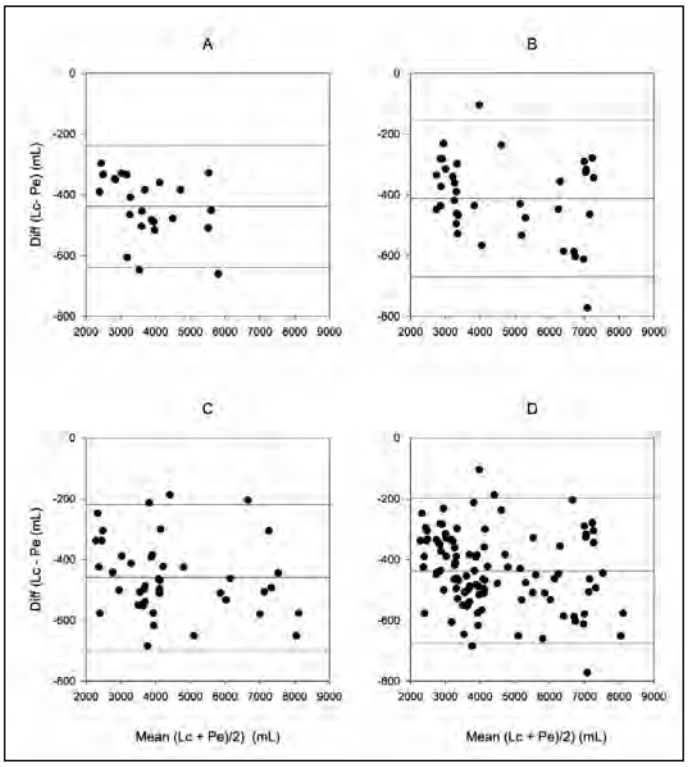

Figure 2. Agreement plots between STM (LymCalc) and OEV (Perometer) measurements in A; unaffected legs with no lymphoedema, B; legs with lymphoedema but untreated with Lymphassist, and C; legs with lymphoedema and treated with the Lymphassist. Panel D shows all data. Note, for all plots baseline, 3 and 6 month data are shown together. See Table 1 for details.

The range of leg volumes for the three groups are shown in Figure 4. A Kruskal-Wallis one way ANOVA on ranks was performed (data not normally distributed). There was a difference between the medians of group A and B, between the OEV and STM measure (p 0.046). Otherwise there were no notable differences between techniques or three groups, despite Group B (oedematous legs, not treated), exhibiting the larger volumes and Group A (non-oedematous legs), the smallest, this observation is reflected in the coefficient of variation (Table 2).

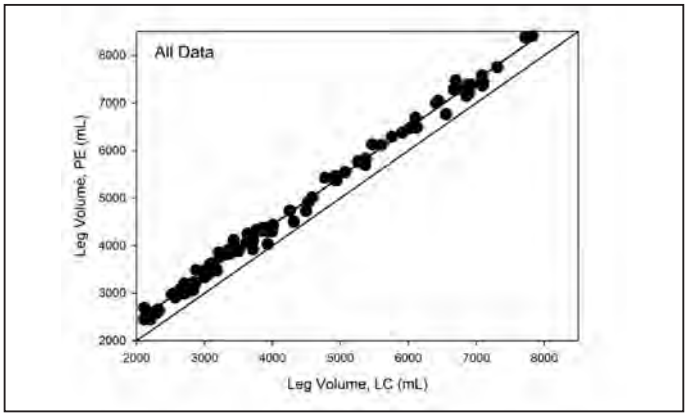

Figure 3. Correlation between the two methods, all data shown, fitted with a linear regression line. The line of identity is shown.

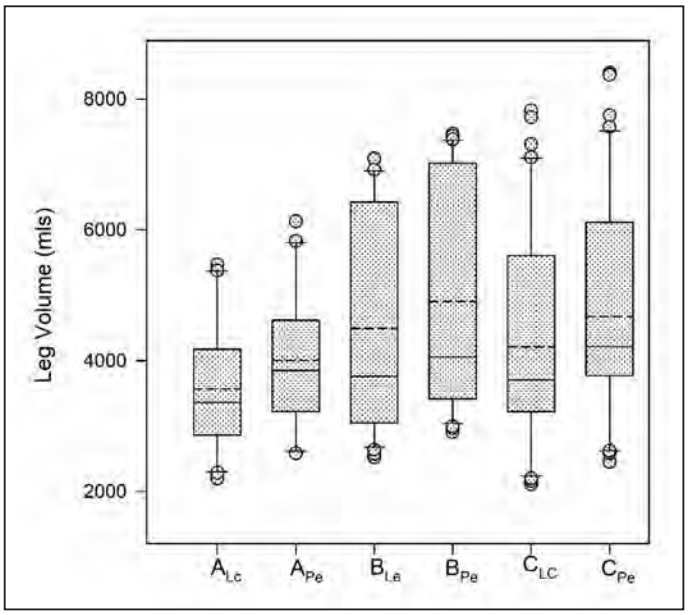

Figure 4 - Box plots showing the distribution of data, the median and mean, for 3 groups, A, lymphoedema free legs, B, lymphoedema legs untreated, C legs with lymphoedema and treated. The subscript LC and PE denote Lymcalc (STM) and perometer (OEV) measures respectively.

DISCUSSION

The agreement comparisons (Figure 2) show that the OEV method overestimated lower limb volume by around 437mls compared to the STM, a difference of 9.5 %. The OEV also overestimated the cylindrical model volume by 113 ml, if this OEV based error is subtracted from the limb OEV measures; the agreement between the methods is closer, with a difference of 324 mls, or 7.2%. The correlation between the two measurement techniques is strong and linear, so for the two techniques to agree in this study then a constant, of 324 mls should be extracted from the OEV data, assuming the STM to be the reference standard.

Mayrovitz et al., (2000) found the tape measure method and perometer were closely correlated (r = 0.98) in patients with both upper and lower lymphoedema. A total of 184 measurements were included in their study, however a horizontally orientated perometer was used. Overall, the volumes obtained by the tape measure and perometer methods differed by less than 5% for legs and less than 7% for arms. Stanton et al., (1997), found a 6.8% difference in oedematous arms. These results are similar in magnitude to the results in our study, hence showing that the perometer consistently overestimates limb volume compared to the tape measure method. This may be partly explained by the different formula used to calculate the leg volume. With STM the 4 cm limb segments are treated as truncated cones. Both Mayrovitz et al., (2000) and this feasibility study used the truncated cone formula (*segment volume* = $L/12\pi\,(C_1^2 + C_1\,C_2 + C_2^2)$, where L is the segment length and C1 and C2 are the circumference at the end of each segment). The perometer uses a cylinder or disc formula, $V = \pi r2L$ (where r = segment radius). Tiereny et al., (1996) compared the horizontally orientated perometer with the tape measure method but using the disc model formula and showed that the tape measure overestimated limb volume. The truncated cone formula calculates a relatively smaller volume in comparison to the cylinder formula. This indicates that a correction factor of 7% is required to compare the two techniques as the actual difference will depend on the total limb length scanned or measured.

Tan et al., (2013) found that the tape measure method overestimated lower limb volume in healthy volunteers compared to a vertically oriented perometer, with a mean volume difference of 157mls. The coefficients of variation were 0.14 and 0.13 for the tape measure and perometer method respectively. This has also been supported by Labs et al., (2000) suggesting the two methods need a different correction factor, however these studies used the cylinder formula to calculate the volume for the circumferential measurements.

An accurate measurement of limb volume is essential for lymphoedema patients in both clinical and research settings. Limb volume is an important marker of both disease progression and effectiveness of prescribed treatments. Although the OEV method is a quick and efficient way of obtaining leg volume and allows a digital image of the scanned limb, financial considerations may prohibit its use as a typical perometer costs in the region of £16,731. The tape measure circumferential method in the hands of a skilled person is also simple, and requires little equipment, but only provides an answer after a series of calculations. This study shows that a perometer is not necessarily needed as the tape measure produces reliable results and enables whole legs to be measured when patients have a limited range of motion.

The limitations of this study were that leg volume measurements were performed only once at each assessment period. Participants were lymphoedema patients so it cannot be assumed that the same results would be found in healthy participants (Burton et al., 2012).

CONCLUSION

Results have demonstrated that OEV and STM provide comparable measures of lower limb volume in people with lymphoedema, with a 7% difference between the methods; this corroborates the existing base relating to this subject. The advantage of the OEV method is that it is fast, non-operator dependent and automatically provides a limb volume. The disadvantage is that it is not a portable system and cost issues may prohibit its use in many settings. The tape circumferential method is easy to use by a trained person but can be time consuming and requires manual calculation of leg volume. Further studies on leg volume using these techniques should focus in creating predicted leg volumes, allowing swollen limbs to be compared with non-oedematous legs.

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Ethical Approval: Wales 6 (LREC No 17/WA/0076)

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Conflict of Interest: None declared

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THE PATIENT WITH PRIMARY AND SECONDARY LOWER EXTREMITY LYMPHEDEMA; A 1-YEAR FOLLOW-UP STUDY

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ABSTRACT

Purpose: The aim of this study was to investigate the 1-year results of the complex decongestive therapy (CDT) in patient with stage 3 primary and secondary lymphedema in the lower extremities.

Methods: A 24-year-old female patient (body mass index-BMI 83 kg/m^2). Her height of 1.68 cm and weight of 255 kg. CDT program was administered for 8 weeks, 7 days a week. As a home program, compression garment for day time and compression bandage at night was recommended.

Conclusion: Regularly repeated CDT in patients with severe lymphedema is important for softening of fibrotic tissue, improvement of skin folds, and reduction of extremity volume.

Key words: Lymphedema, Liposuction, CDT, Complex Decongestive Therapy, Edema

INTRODUCTION

Lymphedema, described as abnormal accumulation of protein rich fluid, due to lymphatic disfunction. It can be present in extremities, the head and neck, trunk, abdomen, external genitalia, and inner organs. The most common reason for lymphedema in the U.S. are surgical interventions in combination with dissection of lymph nodes due to breast cancer (12.5% in the US). Approximately 40% of patients who underwent treatment for breast cancer develop some degree of upper extremity lymphedema. LE can be categorized as congenital LE or secondary LE. Congenital LE is caused by abnormal lymphatic system formation due to a genetic mutation. Meanwhile, secondary LE is caused by damage to the lymphatic system due to infection, damage, cancer, lymph node incision, or radiotherapy. Lymphedema, in most cases, will gradually progress through stages – see Table.

Stages	Phase I (decongestion)	Phase II (self-maintenance)
Latency	Patient Instruction	
Stage I	MLD daily short-stretch bandages skin care decongestive exercises patient instruction	MLD if necessary compression garments skin care decongestive exercises
Stage II	MLD daily short-stretch bandages skin care decongestive exercises patient instruction	MLD compression garments bandages at night skin care decongestive exercises repeat Phase I
Stage III	MLD daily short-stretch bandages skin care decongestive exercises patient instruction	compression garments (in combination w/ bandages) bandages at night skin care decongestive exercises repeat Phase I if indicated: reduction surgery

Therefore, we report the case of patient with primary and secondary lower extremity lymphedema.

CASE REPORT

We report a 24 year old female was consulted to our department of physical and rehabilitation medicine for the bilateral lower extremity swelling and difficulty in walking. The patient ‘s parents report a sudden onset of swelling in her left lower extremity when

she was 3 years old. She was diagnosed with lymphedema at that time. She has never been any treatment before.She had morbid obesity (body mass index-BMI 83 kg/m^2). Her height of 1.68 cm and weight of 255 kg.When she was 14 year old, developed lymphedema in the right lower extremity resulting from conduction excision. Her family's past medical history was unremarkable.In her physical examination she had skin folds under the knee and fibrotic tissues in the lower dorsum and under the knee. Her diffuse edema was non pitting. Stemmer was positive. The skin was dry and intact. However but there was no evidence of any infection. There was no pain but she had difficulty walking alone. The patient had liposuction and debulking operation 6 years ago We started to Complex Decongestive Therapy (CDT) program which include manuel lymphatic drainage, skin care, multilayered bandaging (with short tension) and exercisses techniques, were applied daily for a duration of eight weeks (Figure 1). The circumferences of the right and left lower extremity were measured before and after treatment. During this time she was taught self manual lymph drainage, skin care, and breathing and leg exercises.

Figure 1. Multilayered bandaging (with short tension).

The patient responded very well to her MLD/CDP. After the treatment, both lower extremity edema was reduced (Figure 2, 3). The compression garment was planned as special measurement panty, class 3 (Figure 4). BMI was also reduced 57.1 kg/m^2. As a home program, compression garment for day time and compression bandage at night was recommended. After 6 months, BMI of the patient who applied to our clinic for compression garment control was measured as 29.4 kg /m^2. CDT was performed again for 4 weeks, 6 days a week.

Figure 2. a) Before CDT (anterior), b) After CDT (anterior).

Figure 3. a) Before CDT, b) After CDT (Right leg).

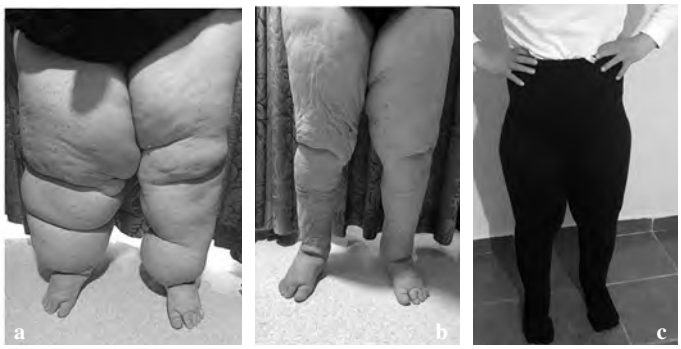

Figure 4. a) Before CDT, b) After CDT, c) special measurement panty compression garments.

RESULTS

After Complex Decongestive Therapy (CDT), both lower extremity volumes decreased significantly (table 1). Fibrotic tissues and skin folds of extremites were improved positively (Figure 5). Body Mass Index (BMI) of 83.2 kg/m2 to 29.4 kg/m^2 and her weight of 255 kg to 72 kg decreased. By the time she was discharged, the patient had new, well fitted compression garments. While the patient was discharged, she stated that she now had hope and that her daily life activities (ADL) were more independent.

Figure 5. a) Before CDT, b) After CDT, c) compression garments.

Table 1 - Before and 6 months after right and left leg circumference measurement (cm).

Left lower extremity (cm)	Before treatment	After treatment
Malleol (0)	36	34
+10	53	37
+20	60,7	42
+30	63,4	47
+40	88	54
Left lower extremity (cm)	**Before treatment**	**After treatment**
Malleol (0)	35	31
+10	55	35
+20	67	41
+30	74	50
+40	94	56

DISCUSSION

Complex decongestive therapy (CDT) which has individual components of skin care, manual lymph drainage, compression bandages, exercises and compression garments, is the golden standard treatment for reducing both primary and secondary lymphedema. In this case we aimed to indicate the long term effects of manual lymphatic drainage and multilayer bandaging in the both lower extremities. Regularly repeated CDT in patients with severe lymphedema is important for softening of fibrotic tissue, improvement of skin folds, and reduction of extremity volume.

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VALUES AND LIMITS OF SURGERY IN PRIMARY AND SECONDARY LYMPHEDEMA

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SUMMARY

Surgical treatment in Lymphedema is an approach proposed in synergy with the physical treatment that still requires further investigation regarding the actual indications. 95 patients with lymphedema were studied (23 males and 72 females), aged between 19 and 74 years, 31 primary and 64 secondary, 35 to lower limbs, 60 to upper limbs with average period between clinical onset of the disease and surgery for 3.8 years (0.3 to 11 years). The observation was performed on a minimum follow-up of 1 year from the intervention.
The observed results suggest that the indications for intervention must be further investigated in order to avoid (taking into account same technique, operator and clinical status) the high incidence of non-success compared to the persistent clinical improvement (though maintained also with the continuation of the physical treatment and of the permanent elastic garment); the observation is in line with what is recommended by the ISL Consensus Document and other guidelines and partly justifies the decision of some states not to recognize the surgical treatment itself as effective.

Key words: Primary and secondary lymphoedema. Surgical treatment.

INTRODUCTION

The surgical treatment in the primary and secondary lymphedema is becoming more frequent in its various techniques. From the demolitive surgery, always less employed, to derivative or reconstructive microchirurgy, to supermicrosurgery to lymphatic transplantation to liposuction, there are many therapeutic proposals that the medical and scientific world present. Professor BBLee, introducing this field in the Consensus Document of International Union of Phlebology, remember us: *"A new approach to restore normal lymphatic flow with direct surgical correction of disabled lymph transport has been a dream among lymphatic/vascular surgeons since Tosatti, Donini, Olszewski et al. made a landmark report on direct anastomosis between lymphatic and venous system using microscopic surgical technique a half century ago. This breakthrough gave new hope to the management of chronic lymphedema.*

This new approach became popular throughout the past century because of its potential to restore normal lymphatic flow when performed properly, providing a chance of a "cure" in theory. However, over the past several decades, an often cavalier approach with limited knowledge of lymphatic anatomy and physiology, adopted by many surgeons, resulted in disastrous outcomes and added more confusion with erroneous prejudice. Many surgeons condemned the procedure due to the poor outcomes, which were believed to be a result of the surgery itself rather than an ill-planned treatment strategy and lack of proper knowledge regarding lymphatic anatomy and physiology.
I (B.B.L.) was no exception, being among the first group of surgeons who began performing lympho-venous anastomosis (n = 15, patients operated) in early 1980s. Interim follow-up results were embarrassingly poor despite technical success in performing flawless surgery without a clear explanation. It took almost a decade to figure out why and what went wrong to make ourselves better prepared before resuming lymphatic reconstructive surgery" [(1)]. The consensus document of the International Society of Lymphology underlines the importance of the methods and recommends that these are being performed in specialized centers and asks even more evidence of results in long time [(2)].

MATERIALS AND METHODS

The study includes ninety eight subjects who underwent surgery after surgical treatment 31 affected from primary lymphoedema and 64 from secondary one). 35 of lower limbs, sixty of upper limbs. Follow up was performed at least one year after surgical treatment.
They hade been considered the following aspects:

- Modifications of Volume of treated limb,
- Modifications of tissue consistancy,
- Incidence of phlogistic complications,
- Patients expectations.

All patients undergone combined physical treatment after surgery and had worn the prescribed garment. in this regard, must underline the tendency to better respect the garment after surgery respect to after only physical treatment.

RESULTS

The data emerged regarding the various types of intervention undergone demonstrated:

– The most frequently controlled type of intervention is represented by Supermicrosurgery (47/98, 47,9%). Less often: Microsurgery (38 cases of which 34 'derivative microsurgery' and 4 'reconstructive microsurgery', 38,7%), Liposuction (11 cases 11,2%) and Lymphatic transplantation (5 cases 5,1%) (Tab.1) [3,4,5,6].

– In relation to the reduction of volume, Secondary shapes demonstrated best results, compared to the primary (Fig. 1).

– Similar results we have observed about the tissue consistency (Fig. 2).

– Best results, absolute, for both the forms, primary and secondary, have been observed regarding the decrease of the episodes of lymphangitis (Fig. 3).

– Results of the decongestive physical treatment after surgical therapy seem to be encouraging, especially in secondary shapes. analogy to other therapies with the passing of time the same decreases (Fig. 4).

– The patient's judgements on clinical results after surgical treatment, on average, did not reflect adequate satisfaction with expectations.This is highly listened by patients with primary lymphedema when you ask them for hundred percention of expectations as soon as they have obtained by surgical intervention (Fig. 5).

	Reconstructive Microsurgery	Derivative Microsurgery	Limph node transplantation	Supermicrosurgery	Liposuction
Primary OK		2		3	1
Primary indifferent	2	8	1	7	1
Primary KO		3	1	2	1
Secondary OK		8	1	11	5
Secondary indifferent	1	6	1	10	1
Secondary KO	1	7	1	10	1

OK: persistent volume and consistency reduction - limphangitis regression
Indifferent No changes in volume and consistency or incidence of lymphangitis
KO Increase in volume and / or consistency - lymphangitic complications

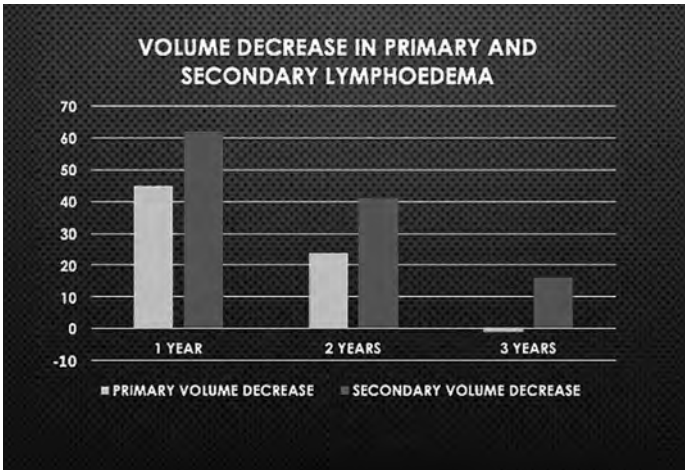

Fig. 1 - Medium Volume decrease in primary and secondary lymphoedema.

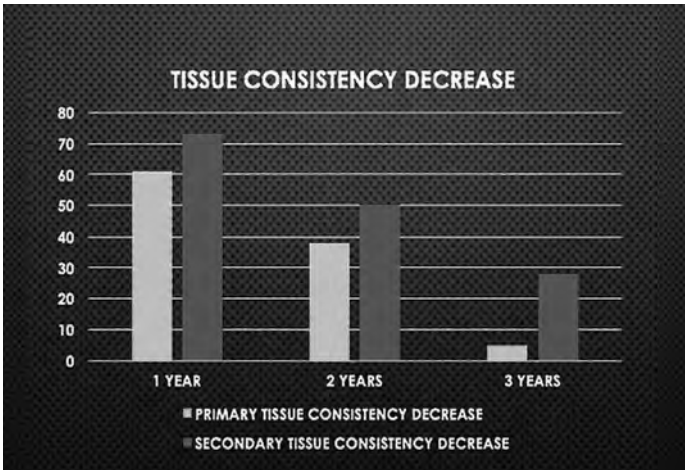

Fig. 2 - Medium tissue consistency decrease.

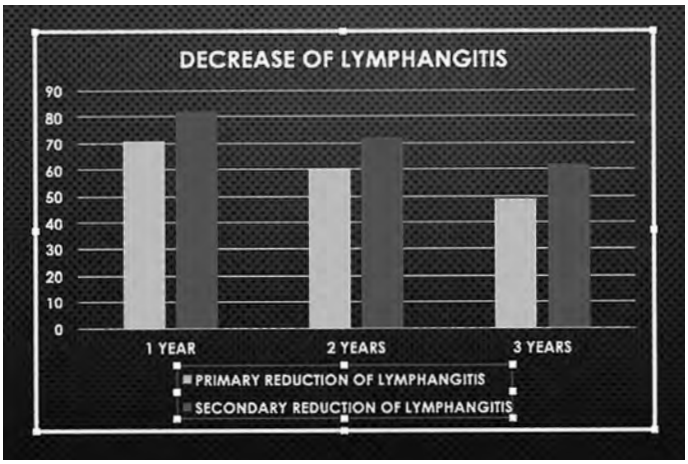

Fig. 3 - Decrease of lymphangitis episods.

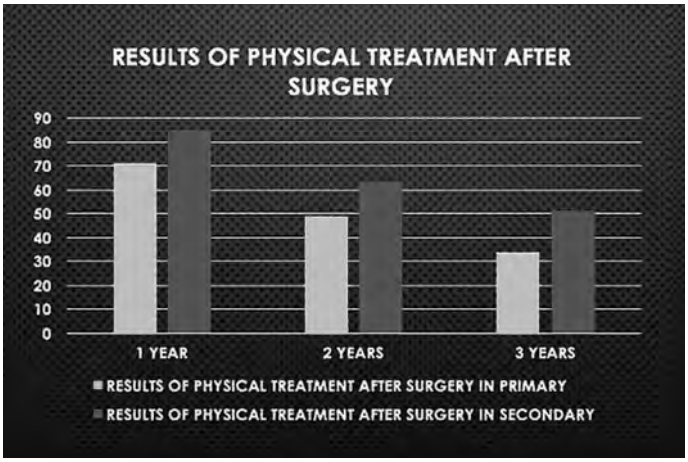

Fig. 4 - Results of physical treatment after surgery.

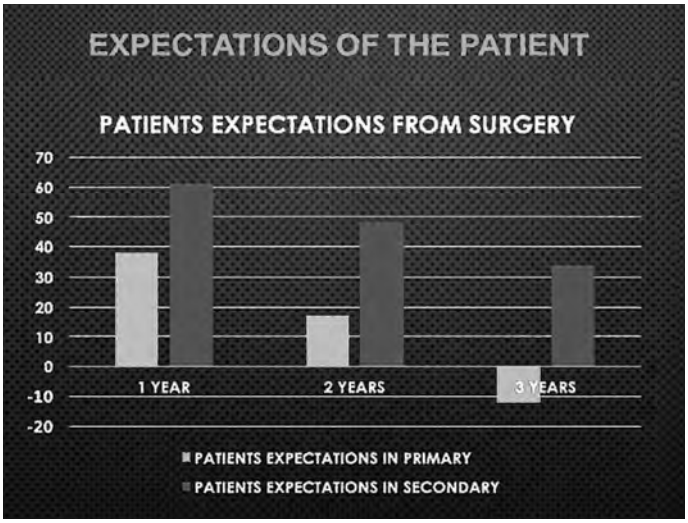

Fig. 5 - Espressed expectations of patient by the surgical treatment.

DISCUSSION AND CONCLUSIONS

In this preliminary study (that's still going on) the first observation is that by surgical treatment, on the contrary with other kind of surgery, there is not the surely clinical result, at least according with the medium expectations of patients. Best results are obteined in Lymphangitis decrease, as in a paradigmatic case (Fig. 6).
53 years patient, with secondary lymphedema of the upper limb starting from over 9 years ago, with considerable increase of tissue consistency and up to nine lymphangitis per year, despite antibiotic therapies. At follow up, after three years from the surgical treatment (supramicrosurgery), the patient demonstrated excellent results below all points of view, but in particular in the total disappearance of lymphangitis [7,8]. But, some other considerations must do. In some cases the indication to surgery is a mistake, incorrect. How in a case of inguinal lymphadenitis (Fig. 7) in which the presurgical lymphoscintigraphy and clinic before the surgical treatment of lymphatic venous derivative microsurgery was 'normal'; after the intervention the lymphoscintigraphy showed important dermal back flow and disappearance of left inguinal lymphoneds, corresponding to an important increase of the edema, especially of left thigh. In other case of Klippel Trenaunay Syndrome two lymphoscintigraphyes, carried out in an incorrect way, had made the diagnosis of hypogenesia of the inguinal left lymphonods [3,9,10,11]. A third exam, carried out with the 'Bourgeois method' with further injection of the tracer at the third lower of thight, showed the presence of inguinal left lymphonods and, according with ultrasound exam, the prevalent role of venous insufficiency in the etiopathogenesis of vascular malformation. A possible surgical treatment would have made worse the clinical picture (Fig. 8). In a last case of Lipedema of the lower limbs a lymphatic derivative microsurgery intervention has been performed in the right lower limb and it transformed the lipedema in lipolymphoedema of the right lower limb, with the pre-operative lymphoscintigraphy absolutely normal. In this case the indication to the surgical treatment is absolutely a mistake (Fig. 9). The observed results suggest that the indications for intervention must be further investigated in order to

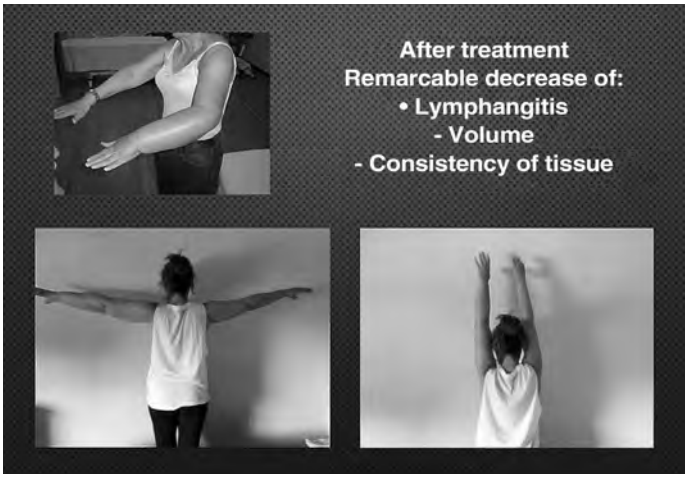

Fig. 6 - Large arm three years follow up after supramicrosurgery.

Fig. 7a,b,c,d - Lymphoscintigraphy and clinical aspect before and after derivative microsurgical treatment.

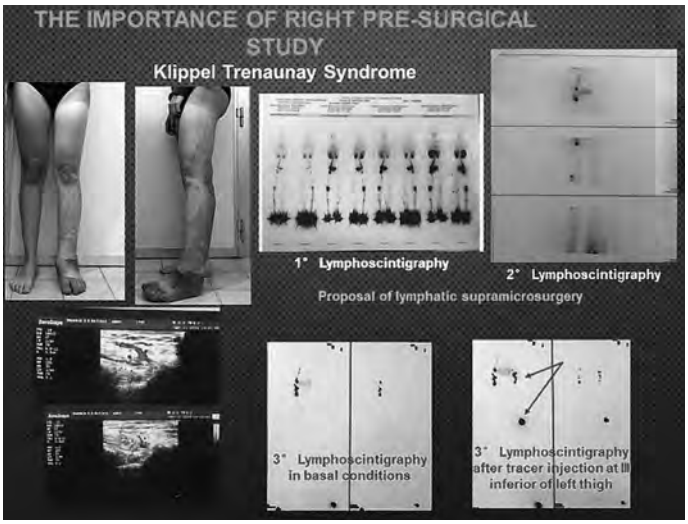

Fig. 8 - No Lymphatic surgery indication.

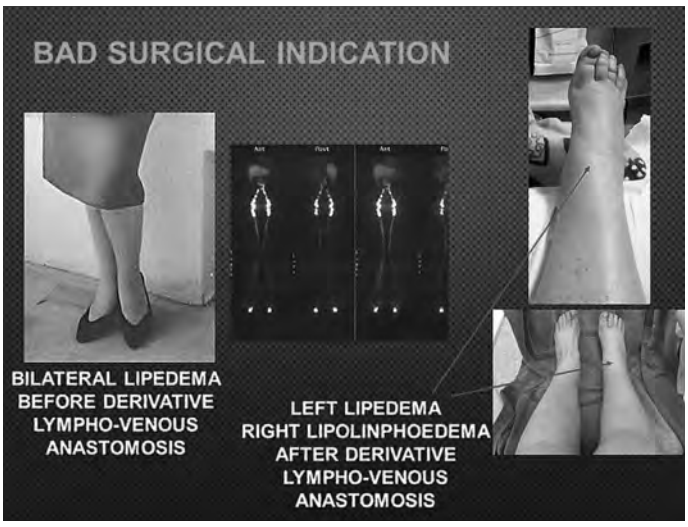

Fig. 9 - Bad surgical indication (Lipedema of lower limbs): preoperative lymphoscintigraphy showed normal transport capacity of lymphatic system of both lower limbs. After microsurgery evidence of Lipolymphoedema in right lower limb.

avoid (with the same technique, the same operator and the same clinical picture) the high incidence of non-success compared to the persistent clinical improvement (though maintained also with the continuation of the physical treatment and of the permanent elastic garment) [12,13,14]; The observation is in line with what is recommended by the consensus document of International Society of Lymphology and other guidelines and partly justifies the decision of some countries of not recognize the surgical treatment itself as an average effective (ie: Belgium who removed the intervention from the National Sanitary System of derivative and / or reconstructive surgery from November 2017). On the basis of these observations can conclude that in the lymphedema the clinical variables are many and not always the indications to a types of therapy or to the other are discounted regarding the clinical results. Probably, it will be useful to study together (surgeons, clinicians and radiologists) which are the factors which, according to the clinical picture, surgical treatment, operator and general conditions of the patient and adhesion to the entire proposed protocol, positively or negatively influences the final outcome of the treatment with the aim to highly select the candidates to safe positive result.

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THE EFFECT OF LOWER LIMB LYMPHEDEMA ON POSTURAL STABILIZATION

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ABSTRACT

Objectives: Lymphedema is a chronic and serious condition that causes asymmetric weight dispersion between extremities. Patients commonly report symptoms such as decreased mobility of the limb, pain, tissue fibrosis and associated skin changes due to the swelling. These symptoms may involve postural disorders that affect the whole body. The aim of this study was to investigate whether there is a change in overall postural stability and limits of stability in patients with unilateral lower limb lymphedema.

Methods: Fifteen (10 female, 5 male) patients (43.2±13.08 years) diagnosed with lower limb lymphedema were included in the study. The mean volume difference between the two extremities was 548±492 ml. Lymphedema severity was evaluated and classified as mild, moderate and severe for 2, 7 and 6 patients respectively. Fifteen healthy people with similar ages (43.33±8.29) were recruited for the control group. All the participants were assessed by using the Biodex Balance System. Postural stability, which is the ability of the patient to maintain a static postural balance, and limit of stability, which is the ability of directional control of the body by displacing the center of gravity, were assessed. All evaluations were carried out on a firm and stable platform with open eyes. The data were analyzed with the SPSS 21.0 program. Mann-Whitney U Test was used for intergroup comparisons.

Results: There was no significant difference between the patients and the control group in overall, anterior-posterior and mediolateral postural stability indexes ($p<0.05$). However, the lymphedema group had worse overall, forward and backward limits of stability scores in comparison to the control group (42.33±12.5 vs 60.29±14.1; 50.73±18.6 vs 73.93±16.08; 49.60±22.8 vs 67.79±21.2 respectively) ($p<0.05$).

Conclusion: These results lead us to think that asymmetric fluid distribution in the lower body parts deteriorate directional control in patients with unilateral lymphedema in comparison to the healthy group. Further studies are needed to confirm the changes of postural stability and limits of stability in these patients.

Abbreviations: BW = body weight, CoG = center of gravity, LLL = lower limb lymphedema, LoS = limits of stability, PoS = postural stability

Keywords: Unilateral Lower Limb Lymphedema, Biodex Balance System, Postural Stability,

1. INTRODUCTION

Lower limb lymphedema (LLL) is a chronic condition with no cure. The impact is not only limited to the related region, but it can also negatively affect other systems in a multidirectional way. Balance is a skill of total body performance, which depends on somatosensory, vestibular and visual systems, on the motor output and a central processing system [1]. Any deficit of these systems could be responsible for poor balance control. Maintaining upright stance in humans is a complex task as it provides postural stability. Postural stability may deteriorate due to any change in the center of gravity (CoG), and the asymmetric distribution of body weight (BW) is one of the causes [2]. Asymmetric distribution of BW such as amputation or unilateral volume change, plays a specific role in disruption of the postural stability in the lower body. Postural sway may be defined as all deviation in the location of the CoG.[3]. It is assumed that asymmetric BW distribution increases postural sway and therefore, it is important to emphasize that postural asymmetry is characterized by postural disturbances and balance problems. In other words, such balance problems are expressed as an individuals' stability limitation problem and may be evaluated with limits of stability (LoS) tests, one of the related evaluation methods [4]. Review of studies in the literature provided inadequate studies investigating the effects of unilateral volume increase on postural stability in lower limb lymphedema. A similar study,

which described the effects of unilateral upper extremity lymphedema on postural stability, was found [3].
Most studies in the literature focused on lymphedema severity, volume reduction and subjective sensations such as pain, heaviness or tension. Problems such as balance and postural stability disorders should be a part of general assessment. Studies have extensively assessed upper limb lymphedema [4,5]. In this study, we aimed to assess the effects of unilateral LLL on postural stabilization.

2. MATERIALS AND METHODS

2.1. Sample

Fifteen patients aged 18-63 years old who were clinically diagnosed with unilateral LLL and fifteen healthy people were included in the study. A volume difference of the lower limb of more than 200 ml compared to the contralateral limb was defined as lymphedema.
The lymphedema severity levels of the patients were evaluated and classified as Stage 1 (mild), Stage 2 (moderate) and Stage 3 (severe). The clinical stages of lymphedema of our cases were classified based on the International Society of Lymphology [6].
All participants were informed of the study, and written consent was obtained. Based on the Declaration of Helsinki, the Ethics Committee approved this study, which was performed in accordance with the ethical principles for human research. The study was designed as a prospective and single-center trial. All tests were applied by the same physiotherapist. Static postural stability and limits of stability were evaluated by the Biodex Balance System.
The inclusion criteria were:

- Diagnosis of unilateral lower limb lymphedema
- Minimum of 200 ml volume difference between lower limbs
- Conserved lymphedema with a duration of at least 6 months

The exclusion criteria were:

- Diagnosis of bilateral lower limb lymphedema
- Having vestibular or visual problems
- Having a previous diagnosis of neurological disorders or severe arthritis
- A history of spinal surgery

2.2. Biodex balance system

The Biodex Balance System (Biodex Medical Systems, Shirley, New York) is a testing machine which has a multiaxial standing platform to evaluate situations relevant to balance, proprioception and neuromuscular control [7]. To achieve a static situation, a proper stable platform surface is selected. The patients' ability of maintaining static postural balance on this stable platform was assessed.
(1) anterior/posterior index, (2) medial/lateral index and (3) overall index are electronically generated. The overall index is assumed to be the best indicator of the general ability of the patient's balance. The total duration of evaluation of the test takes about 10 minutes on average.

2.2.1. The postural stability test

Deviations from the center create the test score of the patient, thus a lower score is more creditable than a higher score. The patients stood for 20 seconds on both legs in the most stable position while the test was being performed. After the patient had accommodated to the platform, 3 trial repetitions were performed. The patients' performance was noted as a stability index. It was made in 3 directions (overall, anterior-posterior and mediolateral) and 1 condition with open eyes. The stability index represents the change in grade from the initial level of platform displacement. A high score means the individual had difficulty to maintain their balance.

2.2.2. The limits of stability test

This test assesses the movement and control of patients' CoG within their base of support. In the test, patients must switch their weight to move the cursor from the center to a blinking target. Return to the starting position should be in a short time and with as little deviation as possible. For all targets, the same process is valid. Targets blink randomly.
Scores are based on the patient's time to complete the test and the effort to reach the goal. Low scores indicate that the patient needs more effort and time to complete the test.

2.3. Statistical analyses

The data were analyzed using the "Statistical Package for the Social Sciences (SPSS) Version 20.0" (SPSS Inc., Chicago). Sample size calculation was performed by using G*Power version 3.1.9.2 for Windows (Universitat Kiel, Germany). The survey and test results of the individuals were analyzed by calculating frequencies, minimum and maximum values, and 95% confidence intervals. Data distribution was assessed with Shapiro-Wilk test. Independent-Samples t-Test was used for intergroup comparisons. The results were considered significant with P values <0.05.

3. RESULTS

Fifteen patients (10 female, 5 male) diagnosed with lower limb lymphedema were included in the study. The mean duration of lymphedema was 74 months [7-360] ([min-max]). The mean volume difference between the two extremities was 548±492 ml. Lymphedema severity was evaluated and classified as mild, moderate and severe for 2, 7 and 6 patients respectively. Fifteen healthy people (12 female, 3 male) with similar ages were recruited for the control group. The subjects' characteristics are shown in Table 1. There were no significant differences in the demographic data between the groups ($p > 0.05$).
The results of postural stability tests and limits of stability tests in a static and eyes open condition for the lymphedema group are presented in Table 2. There was no significant difference between the lymphedema group and the control group in overall, anterior-posterior and mediolateral postural stability indices ($p>0.05$). However, the lymphedema group had worse overall, forward, backward, forward/left, forward/right, backward/left and backward/right limits of stability scores in comparison to the

Table 1. Demographic characteristics of the lymphedema and control group.

Demographic characteristics	Lymphedema Group (n = 15)	Control Group (n = 15)	p
	X ± SD	X ± SD	
Age (years)	43.27 ± 13.08	42.00 ± 9.3	0.51
Body weight (kg)	86.22 ± 13.31	79.35 ± 10.4	0.13
Body height (cm)	167.22 ± 9.31	169.17 ± 5.67	0.24
BMI (kg/m^2)	30.04 ± 4.57	25.13 ± 4.82	0.07

Table 2. Results of postural stability and limits of stability tests for lymphedema group.

Tests Indexes	Lymphedema Group (n = 15), X ± SD	Control Group (n = 15), X ± SD	p
Overall PoS index	0.96 ± 1.27	0.46 ± 0.25	0.14
Anterior-posterior PoS index	0.78 ± 1.28	0.40 ± 0.19	0.27
Mediolateral PoS index	0.26 ± 0.29	0.21 ± 0.16	0.54
Overall LoS index	42.33 ± 12.57	61.06 ± 14.00	**0.001**
Forward LoS index	50.73 ± 18.65	73.53 ± 15.57	**0.001**
Bacward LoS index	49.60 ± 22.82	69.46 ± 21.50	**0.001**
Left LoS index	57.53 ± 17.92	65.66 ± 11.19	0.14
Right LoS index	59.80 ± 18.25	62.86 ± 20.72	0.67
Forward/Left LoS index	48.00 ± 12.77	69.60 ± 13.46	**0.000**
Forward/Right LoS index	49.86 ± 15.24	71.86 ± 16.07	**0.001**
Backward/Left LoS index	42.73 ± 16.95	66.06 ± 17.05	**0.001**
Backward/Right LoS index	50.66 ± 16.44	69.93 ± 12.22	**0.001**
Abbreviation: PoS – Postural Stability; LoS – Limits of Stability; X – Mean; SD - Standard Deviation (p< 0.05)			

control group (p<0.05). In addition to all these significant differences, the changes in the LoS scores for the right and left sides were not statistically significant (p>0.05).

4. DISCUSSION

The main objective of this study was to evaluate postural stabilization changes in unilateral LLL patients in comparison to healthy individuals. Our results indicated that, while unilateral LLL affected the overall, forward and backward limits of stability indices negatively, it did not affect CoG and the overall, anterior-posterior and mediolateral postural stability indices.
Preservation of postural stability is related to control over the center of gravity and resulting momentum [8]. Momentum may be explained as a sway that is actively trying to stay in the best position. Stability while standing upright may be affected by weight asymmetry, unilateral volume change and weight bearing [9].

Although lymphedema is a chronic and widespread problem that negatively impacts patients' functional status [10,11], there was not enough evidence about the changes in postural stability, postural sway and directional control in patients with LLL. In this study, the results demonstrated that there was no significant displacement of CoG when the lymphedema group and healthy individuals were compared.
Similarly to the findings in this study for asymmetrical weight dispersion in the literature, Bakar et al. found no significant differences overall for anterior-posterior and mediolateral postural stability indices with eyes opened in a breast cancer-related lymphedema group in comparison to healthy individuals, but we found different results in our study showing a significant difference between the eyes closed test and a foam surface [12]. Visual and specific sensory inputs are important to compensate balance impairment. Standing with eyes closed or standing on different surfaces may make it difficult to maintain an upright

stance posture. Nadollek et al. reported that increased CoG sway with and without visual input affected patients with lower leg amputation [13]. Arifin et al. showed significant postural instability of amputees in an eyes-closed condition, followed by standing on a foam surface [14]. In contrast to these studies of unilateral weight bearing, similar changes were observed in CoG sway for patients with chronic subdural hematoma and unilateral lower limb amputees for the open and closed-eyes tasks [15,16]. We think that there are a few factors that may be effective on maintaining postural stability in unilateral LLL. One of these factors is that our patients were very young. The other one is that there were no abnormalities in the patients' visual, vestibular and somatosensory systems. Additionally, we think patients with chronic lymphedema may have developed adaptive responses to maintaining postural stability.

Limits of stability tests assess dynamic balance control during voluntary movement in daily activities such as climbing stairs, getting up or walking. Dynamic balance failures that increase postural sway occur as a result of the absence of motor and proprioceptive senses, asymmetrical body weight distribution and posture. It is known that individuals with increased postural sway have less ability to maintain balance control [17]. On the other hand, some studies showed that high BMI may impair dynamic postural control and be a risk factor of balance loss [18,19]. According to the results of the evaluation, the lymphedema patients had a higher body mass index than the healthy individuals. All these findings confirm the decline of dynamic balance control in unilateral LLL patients because of weight gain and asymmetric mass distribution.

In the literature, we could not find any study which has been done on static and dynamic balance for unilateral lower limb lymphedema patients. Nevertheless, similar results were found in previous studies that focused on postural stability and postural sway in unilateral upper extremity lymphedema in breast cancer survivors. Angin et al. found that, in the case of positional changes, it the dynamic balance was distorted due to increased volume towards the lymphedema and a heavier upper extremity3. Similarly, Basar et al. [12] assessed the postural stability between lymphedema and healthy groups, and significant differences were observed in all displacement parameters. Despite the difference in the upper and lower extremities, these results indicate that unilateral lymphedema may have effects in the way that it may impair the dynamic balance.

As in the results of our study, in other studies where postural stabilization and dynamic balance in individuals with asymmetric body weight distributions were discussed, dynamic balance parameters deteriorated [2,20]. Factors that were thought to be the cause of these disturbances were deterioration in vestibular, visual, tactile and proprioceptive senses and reduced control of adaptive strategies to maintain an upright stance.

Based on our study, we think limits of stability impairments in unilateral LLL patients could be associated with weight bearing problems due to asymmetric body weight distribution and increased postural sway. So, treatment programs should be planned accordingly, not only by focusing on volume reduction approaches but also considering all other possible balance problems.

One of the limitations of the study was that the Biodex Balance System assessments were not evaluated for closed-eyes and foam surface conditions. The other one was that postural disorders that may develop due to musculoskeletal problems were not evaluated. By evaluating these parameters in future studies and using a larger sample size, it will be possible to increase the level of knowledge in this subject and obtain more objective results.

5. CONCLUSION

According to the results of this study, asymmetric fluid distribution may be related to balance distortions. Static and dynamic balances, which are related to postural stabilization, may be impaired in patients with unilateral lower limb lymphedema. The authors declare no conflicts of interest.

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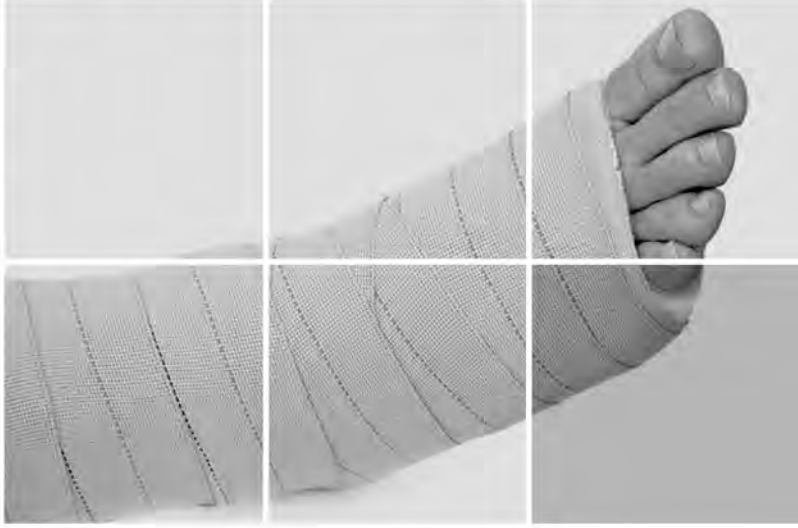

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