Muscle strength and functional exercise capacity in patients with lipoedema and obesity: a comparative study

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Key words

Lipoedema, muscle power, obesity, physical endurance, women

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Abstract

Background: Lipoedema is a chronic disorder of adipose tissue typically involving an abnormal build-up of fat cells in the legs, thighs and buttocks. Occurring almost exclusively in women, it often co-exists with obesity. Due to an absence of clear objective diagnostic criteria, lipoedema is frequently misdiagnosed as obesity, lymphoedema or a combination of both. The purpose of this observational study was to compare muscle strength and exercise capacity in patients with lipoedema and obesity, and to use the findings to help distinguish between lipoedema and obesity. **Design:** This cross-sectional, comparative pilot study performed in the Dutch Expertise Centre of Lympho-vascular Medicine, Drachten, a secondary-care facility, included 44 women aged 18 years or older with lipoedema and obesity. Twenty-two women with lipoedema (diagnosed according the criteria of Wold et al, 1951) and 22 women with body mass index ≥30 kg/m^2 (obesity) were include in the study. No interventions were undertaken as part of the study. **Results:** Muscle strength of the quadriceps was measured with the MicroFET™, and functional exercise capacity was measured with the 6-minute walk test. The group with lipoedema had, for both legs, significantly lower muscle strength (left: 259.9 Newtons [N]; right: 269.7 N; p<0.001) than the group with obesity. The group with lipoedema had a non-significant, but clinically relevant lower exercise-endurance capacity (494.1±116.0 metres) than the group with obesity (523.9±62.9 metres; p=0.296). **Conclusions:** Patients with lipoedema exhibit muscle weakness in the quadriceps. This finding provides a potential new criterion for differentiating lipoedema from obesity. We recommend adding measuring of muscle strength and physical endurance to create an extra diagnostic parameter when assessing for lipoedema. **ClinicalTrials.gov Identifier:** NCT01759004

Lipoedema is a disorder of adipose tissue that occurs almost exclusively in women; the pathophysiology and aetiology are yet not well understood (Wold et al, 1951; Child et al, 2010; Fife et al, 2010). The condition was originally described in 1943 by Allen and Hines (Wold et al, 1951). The exact prevalence of lipoedema in women is unknown; its presence in the general female population has been estimated at 11% (Földi and Földi, 2012). It is a chronic, progressive condition that is associated with considerable morbidity, including discomfort, easy bruising and tenderness of the disproportionately enlarged legs, which may progress to high-intensity pain and limited mobility, along with psychological morbidity (Langendoen et al, 2009).

Guidelines exist to differentiate between disorders that present with swelling and fat deposits, including lipoedema, lipohypertrophy, lymphoedema and obesity (Wold et al, 1951; Langendoen et al, 2009; Child et al, 2010; Fife et al, 2010) (*Table 1*). Symmetrical, disproportionate swelling is normally first noticed at puberty, pregnancy or menopause, times at which women experience pressure-induced pain at even slight contact and a tendency to develop apparently spontaneous haematomas (Wold et al, 1951; Wienert et al, 2009; Schmeller and Meier-Vollrath, 2007). Genu valgus, pes planus, and complaints about general fatigue and physical impairment are often observed. In later stages, body mass index (BMI) ≥30 kg/m^2 (obesity) may also develop.

Clinical characteristics of lipoedema include swelling and symmetrical enlargement of the lower limbs due to abnormal deposition of subcutaneous fat, with a sharp transition area of affected to unaffected tissue occasionally accompanied by over-hanging lipoedema tissue (*Box 1*). This is recognised as the typical 'cuff-sign', also called as 'inverse shouldering' or the 'bracelet effect'.

Lipoedema often co-exists with obesity, and obesity may be misdiagnosed, although

Table 1. Diagnostic aids in the differential diagnosis of lipoedema, lipohypertrophy, lymphoedema and obesity.

Characteristics	Condition			
	Lipoedema	*Lipohypertrophy*	*Lymphoedema*	*Obesity*
Sex	Female	Female	Male and female	Female predominance
Age of onset	Puberty	Puberty	Any decade	Any decade
Family-history positive	In approximately 15% of cases	Possible	In approximately 20% of primary lymphoedema cases	Approximately 65%
Proven heredity factor	Absent	Absent	Primary lymphoedema	Absent
History of erysipelas	Absent	Absent	Usually	Absent
Causal effect of diet	None	None	None	Present
Effect of elevation on symptoms	Minimal (limited to pitting component)	Initially effective	Initially effective	Ineffective
Physical examination				
Bilateral	Always	Always	Primary: often Secondary: seldom	Always (android or gynoid*)
Involvement in feet	Absent	Absent	Common	Common
Pitting oedema	Absent (initially)	Absent	Present	Absent
Retromalleolar fat pad	Present	Absent	Absent	Absent
Consistency on palpation	Soft-firm	Soft	Firm	Soft
Easy bruising of affected skin areas	Common	Absent	Absent	Absent
Tenderness of affected skin areas	Common	Absent	Absent	Absent
Stemmer's sign	Absent	Absent	Present	Absent

Adapted from tables proposed by Wold et al, 1951; Langendoen et al, 2009; Child et al, 2010; Fife et al, 2010. *Android: centralised or 'apple-shaped' obesity; gynoid: generalised or 'pear-shaped'.

the conditions are different (Schmeller and Meier-Vollrath, 2005). Lipoedema affects only the lower limbs, whereas obesity may affect the whole body (Forner-Cordero et al, 2012). Patients with lipoedema often have an elevated BMI (Child et al, 2010). However, although the obesity component in lipoedema will respond to dietary changes, the disproportionate leg shapes will not — upper-body mass will reduce, while the lower body retains the same shape from the waist to the ankles (Child et al, 2010; Fife et al, 2010).

Patients with lipoedema may have a medical history that includes onset of lower-limb thickening at puberty; lack of effect of exercise, diet changes or elevation of the affected extremities; fatigue; family history; and limitations in functioning, such as inability to work and loss of activity level (Langendoen et al, 2009; Damstra and Lamprou, 2011; Forner-Corder et al, 2012). As lipoedema progresses, patients become even more obese and limited in their mobility due to mechanical obstruction in movement. Patients experience limitations in their daily activities and difficulties with walking, reporting significant physical distress and loss of motivation (Damstra and Lamprou, 2011).

Treatment of lipoedema is challenging and can be conservative or surgical in nature; the latter is reserved for lipoedema cases that are non-responsive to conservative treatment or that present severe mechanical restrictions in everyday life (Damstra and Lamprou, 2011). Conservative treatment often comprises manual lymphatic drainage (MLD) and compression hosiery or bandages, which consists of combined physical therapy and decongestive physiotherapy (CDT; Schmeller et al, 2012). Surgical therapy of lipoedema using tumescent liposuction to reduce the subcutaneous fatty tissue has become an integrated part of therapy, and is included in the guidelines of the German Society of Phlebology (Rapprich et al, 2002; Sattler, 2002; Wienart et al, 2009).

Increasing muscle strength, re-conditioning and re-activation of the patient, combined with lifestyle changes may be essential components of conservative treatment to improve quality of life (QOL; Damstra and Lamprou, 2011). However, clinical examination of patients with lipoedema often reveals loss of muscle strength and exercise capacity compared to patients with obesity, posing a challenge to activity regimens. Early recognition of lipoedema and functional limitations can enhance the ability of patients to engage in physical activity as part of conservative management (Langendoen et al, 2009; Child et al, 2010).

The purpose of this study was to compare muscle strength and exercise capacity in patients with lipoedema and obesity, to determine an objective and discriminant diagnostic criteria that helps distinguish between lipoedema and obesity. The study sought to find out whether there is a difference in muscle strength between women with lipoedema and women with obesity. In addition, the study sought to understand if there is a difference in functional exercise capacity between women with lipoedema and women with obesity. It was hypothesised that these endpoints would differ between the groups.

Study design

This study was a cross-sectional pilot study performed in the Dutch Expertise Centre of Lympho-vascular Medicine, a secondary-care unit in Drachten (the Netherlands). Data for the group with lipoedema were collected from 2008–2012 as part of routine outpatient care. Data for the group with obesity were collected prospectively from February–April 2013. The medical ethics committee of Nij Smellinghe Hospital approved the study, and all patients provided their signed informed consent. The study was registered under the ClinicalTrials.gov identifier NCT01759004.

Patient selection

Forty-four women aged 18 years or older were included in the study; there were 22 in the lipoedema group, and 22 in the obesity group. The participants in the group with lipoedema had already been diagnosed and measured according the criteria of Wold et al (1951), from 2008–2012. The participants in the group with obesity (BMI ≥30) were recruited and measured in 2013. Dermatologists and physical therapists of Nij Smellinghe Hospital performed the recruitment in the outpatient clinic. Patients in the group with lipoedema were excluded from the study according to the criteria of Reich-Schupke et al (2013; *Box 2*). Participants in the group with obesity were excluded if they had participated in an obesity-training programme ≤12 months before the time of measurement.

Study parameters

Demographic characteristics, including age (years), and anthropometric characteristics — including height (cm), weight (kg) and BMI (kg/m^2) — of all participants were collected following a standardised protocol. The measurements were performed by three trained physical therapists. The primary outcome parameter was the strength of the quadriceps muscle of the left and right leg measured with the MicroFET™ (FET= Force Evaluating & Testing; Biometrics, Almere) using the break-method (Bohannon, 1998).

Muscle strength

Muscle strength of the quadriceps is measured as a guideline for overall muscle condition of the lower extremity (Damstra and Lamprou, 2011). Participants sat on a treatment table with crossed arms. Participants were instructed to perform knee extensions three times with each leg. The test result in Newton (N) is the highest score of each leg (Schaubert and Bohannon, 2005). The MicroFET had been shown to be a valid measurement with the break-method (Rockson et al, 1998; Damstra and Lamprou, 2011). There are high intra-class correlation coefficient (ICC) values of the MicroFET measurements of 0.807–0.971 and ICC >0.970, respectively (Bohannon, 1998; Schaubert and Bohannon, 2005). Data for each leg of each participant were compared to normative values (Andrews et al, 1996).

Functional exercise capacity

The secondary outcome parameter of the study was functional exercise capacity measured with the 6-minute walk test (6MWT; Butland et al, 1982). This standardised test is performed on a 30-metre (m) course where every 5 m are marked. The test was performed by JvE. The patient was instructed to cross a maximum distance in 6 minutes, with the possibility to stop or rest if necessary (Butland et al, 1982). During the test, the participant was encouraged to walk as far as possible (Bohannon, 1998; Enright and Sherrill, 1998). The result is the walking distance in metres after 6 minutes (with 5 m exactness). The test-retest reliability of this test is high (ICC 0.94) in older adults (Harada et al, 1999). The walking distance of each participant was compared to normative values of healthy people (Enright and Sherrill, 1998).

Analyses

All data were analysed with the statistical package for social sciences (SPSS) version 20.0. Tests for normality were performed on the data with the Shapiro-Wilk test. All data were normally distributed. Data were presented as quantitative data and expressed as the mean ± standard deviation (SD). Demographic and anthropometric data were expressed using descriptive statistics. Independent sample t-tests were used to compare women with lipoedema and women with obesity in terms of muscle strength and functional exercise capacity. This test was also used to compare measured values to normative values. An alpha of 0.05 was considered statistically significant.

Results

Study population

Mean demographic and anthropometric data are described in *Table 2*. All participants performed a MicroFET measurement and a 6MWT without any complications or adverse events.

Box 1. Clinical diagnostic criteria for lipoedema (Wold et al, 1951).

- Occurrence almost exclusively in women
- Of a bilateral and symmetrical nature, with minimal involvement of the feet, resulting in an 'inverse shouldering' or 'bracelet effect'
- Minimal pitting oedema sometimes present
- Pain, tenderness and easy bruising
- Persistent enlargement despite weight-loss or elevation of the extremities.

Muscle strength

There was a statically significant difference in the muscle strength between the lipoedema and obesity groups for the right (p<0.01) and left legs (p<0.01; *Table 3*). The group with lipoedema scored much lower than did the group with obesity.

Functional exercise capacity

There was no statistically significant difference between the groups (p=0.296) in terms of the mean scores for the 6MWT and the results of the independent samples t-test (*Table 3*). The group with lipoedema had a non-significant, but clinically relevant, lower exercise-endurance capacity. Compared to normative values of healthy people, no statistically significant difference (p=0.071) was found between the groups when the distance covered was expressed as a percentage of that predicted.

Discussion

The diagnosis of lipoedema is challenging in the absence of robust criteria. Subjective and clinical criteria have been frequently used by lack of objective parameters. This study sought to investigate further objective physical endpoints that may be helpful in delineating lipoedema from obesity, in order to initiate appropriate therapy at the earliest possible point in treatment.

Our trial revealed a statistically significant difference in muscle strength between women with lipoedema and those with obesity. A difference is also seen in the percentage of the predicted score, where participants with lipoedema had decreased quadriceps muscle strength by up to 30%, whereas patients with obesity had 103.6% of the predicted strength. The secondary aim was to investigate the difference in functional exercise capacity between women with lipoedema and women with obesity. A small, not statistically

Box 2. Exclusion criteria for lipoedema. A typical case of lipoedema can be excluded with a least one negative criterion (Forner-Cordero et al, 2009; Reich-Schupke et al, 2013).

- Lack of disproportion between upper and lower legs
- Asymmetry of both legs/arms
- Subcuticular thickness <12mm (6–8cm above the malleolus)
- Manifestation in late adulthood
- Waist-height ratio: <40 years: >0.5 pathological; 40–50 years: 0.5–0.6 pathological; >50 years: >0.6 pathological
- Absence of step formation in the ankle region
- Absence of pressure-induced tissue pain
- Absence of tendency to develop haematomas

significant, difference in favour of the obesity group was seen in functional exercise capacity between women with lipoedema and obesity, with lower values obtained for the lipoedema group.

These results are relevant, as muscle strength has not been formally investigated previously in patients with lipoedema. In its early stages of development, lipoedema can cause discomfort without any obvious enlargement of the extremities during physical examination (Damstra and Lamprou, 2011). It is still unknown if the decrease in muscle power in patients with lipoedema is part of the condition, or if decreasing activity levels leads to lower muscle power. Information about muscle strength related to normative values in patients with lipoedema may provide more clarity to the severity of the disease during physical examination in the early stages of lipoedema, as well as possible input for physical therapy for improving muscle strength.

There was a small difference in functional exercise capacity between the two groups. Compared to normative values, the group with lipoedema scored 92% of predicted, compared to 102% of predicted for the group with obesity. Although the differences are small, this result may be explained by the sources of variability set by the American Thoracic Society (ATS; ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002). The ATS named muscle-wasting as one of the reducing factors in performing the 6MWT (ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002). As patients with lipoedema suffer from muscle weakness, this factor also may be a limiting factor in performing the 6MWT.

Because this was a pilot study, the groups consisted of relatively small sample sizes. The MicroFET was used to examine muscle strength. Pain can be a mitigating factor in performing the MicroFET test, which may limit the accuracy of results. We must take this limitation into account, as there is a possibility that patients will not perform to their maximum level because they are experiencing pain while performing the test. MicroFET is less expensive and more efficient than isokinetic dynamometry for providing quantitative measurements of the isometric force of muscle actions. In the Dutch Expertise Centre for Lympho-vascular Medicine, MicroFET is used because it is a practical and valuable measurement that can be easily used by several physical therapists.

Lipoedema is a chronic condition that presents the possibility of aggravation during life. The incurable nature and severity of the condition depend to a large extent on comorbidities, such as obesity, functional impairment and psychological and/or psychiatric disorders (Wenczl and Daroczy, 2008). The goal of lipoedema management is to improve subjective symptoms and prevent the progression of lipoedema (Reich-Schupke et al, 2013).

The World Health Organization (WHO) has designed a framework to describe human functioning in a systematic and valid approach: the *International Classification of Functioning, Disability and Health* (ICF) (WHO, 2001). The ICF is a multipurpose classification for the description of health and health-related statuses and defines participation as 'involvement in life situations', using extra clinicmetrical criteria to measure the effect of a chronic condition (WHO, 2001). Because of the wide range of issues experienced by patients with lipoedema, the ICF could be a useful method to describe the holistic condition of patients, broader than lipoedema-specific criteria (Wold et al, 1951).

The Chronic Care Model (CCM) identifies the essential elements for delivery of high-quality chronic disease care (Coleman et al, 2009):
- Community support
- Health system support
- Self-management support
- Delivery-system design
- Decision-making support
- Clinical information systems.

Effective self-management support means more than telling patients what to do. It means acknowledging the patient's central role in their care, one that fosters a sense of responsibility for their own health. Using a collaborative approach, providers and patients work together to define problems, set priorities, establish goals, create treatment plans and solve problems along the way (Von Korff et al, 1997).

All patients with chronic illness make decisions and engage in behaviours that affect their health (self-management). Disease control and outcomes depend to a significant degree on the effectiveness of self-management. Because lipoedema is a chronic disease, the CCM can be possibly used to effectively treat patients with lipoedema.

Decreased physical activity negatively influences the course of lipoedema, correlating with increased complaints about symptoms, weight gain, and progressive fatigue and muscle weakness. To develop a good health status, it is important to increase muscle strength, to re-condition and finally to re-activate the patient to a minimum level of daily activities necessary to maintain a healthy life and an improved QOL (Damstra and Lamprou, 2011). However, poor adherence to exercise and physical activity may limit long-term effectiveness, and many patients are uncertain about the amount

Table 2. Demographic data of the study population.

Variable	*Total group (n=44)*	*Lipoedema group (n=22)*	*Obesity group (n=22)*
Age (years), mean (SD)	43.8 (±12.4)	39.23 (±13.0)	48.45 (±9.9)
BMI (kg/m^2), mean (SD)	34.33 (±6.5)	33.59 (±8.3)	35.06 (±4.3)

SD = standard deviation; BMI = body mass index.

of physical activity they can undertake (Jordan et al, 2010). Some patients believe that activity will lead to increased muscle mass in the legs, further exacerbating the disproportion between their upper and lower body, and others are not able to perform more physical activities (Meier-Vollrath et al, 2005).

Physical activity should be encouraged for patients with lipoedema. Exercise also activates venous and lymphatic pump function in the lower-limb muscles, reducing oedema formation in the tissue and reducing the risk of co-morbid obesity (Reich-Schupke et al, 2013). When it is difficult to continue an exercise programme, 'graded activity' can be helpful (Jordan et al, 2010). Graded activity is a structured treatment form, based on cognitive and behavioural learning theories. It consists of gradually building activities according to a time schedule, so that the patient can learn to build and maintain a prescribed activity level independently (Jordan et al, 2010). In the Dutch Expertise Centre for Lymphovascular Medicine, we see that women who consistently wear compression stockings, exercise and maintain a normal weight typically have distinctly better prognoses and milder conditions than those who, in addition to existing lipoedema, are obese and inactive (Reich-Schupke et al, 2013).

Table 3. Mean scores and comparison of the MicroFET measurements and the 6-minute walking test for the lipoedema and obesity groups.

Variable	*Group with lipoedema (n=22)*	*Group with obesity (n=22)*	*p-value*
Muscle strength quadriceps right (N), mean (SD)	269.7 (±67.8)	400.3 (±69.1)	<0.01
Muscle strength quadriceps right as % of normative value, mean (SD)	67.7 (±19.1)	100.0 (±20.4)	<0.01
Muscle strength quadriceps left (N), mean (SD)	259.9 (±77.3)	401.5 (±75.9)	<0.01
Muscle strength quadriceps left as % of normative value, mean (SD)	67.0 (±22.9)	103.6 (±20.9)	<0.01
6MWT (metres), mean (SD)	494.1 (±116.0)	523.9 (±62.9)	0.296
6MWT as % of normative value, mean (SD)	92.1 (±23.6)	102.4 (±11.0)	0.071

N = Newtons; SD = standard deviation; 6MWT = 6-minute walk test; normative values — strength, MicroFET (Andrews et al, 1996); normative values 6MWT test (Enright and Sherrill, 1998).

Conclusions

Patients clinically diagnosed with lipoedema need further clinimetrics in the functional domains (muscle strength, activities in daily living and condition) to obtain objective criteria, which can be used as a discriminatory parameter with obesity and an entrance for a therapeutic intervention. On the other hand, adding MicroFET and 6MWT seems to be a good addition to the standard clinical examination to develop a more dedicated therapeutic approach with exercise training.

To our knowledge, this is the first study to investigate muscle strength and functional exercise capacity in patients with lipoedema. Consequently, the results of this study should be interpreted taking these limitations into account. Further research is needed to determine whether decreased muscle strength in patients with lipoedema compared to normative values can be used as a supplementary criterion in diagnosing lipoedema, and as a therapeutic parameter for measuring the success of treatment.

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