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ORIGINAL ARTICLE

Rehabilitation effect of manual lymphatic drainage on pain threshold and tolerance, tactile sensation, and strength

Efecto de rehabilitación del drenaje linfático manual en el umbral y tolerancia al dolor, sensación táctil y fuerza

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Abstract

Objective: *This study evaluates the acute therapeutic effect of manual lymphatic drainage (MLD).* **Method:** *Eighty-two individuals (164 upper limbs) participating in the study were divided into two groups: MLD and sham. Before and after treatment, measurements of pressure pain threshold (PPT), pain tolerance, muscle strength (using a hand dynamometer and pinchmeter), and two-point discrimination (2PD) with an esthesiometer were conducted.* **Results:** *Age, height, weight, body mass index, gender, and dominant extremity of the participants showed similar characteristics ($p > 0.05$). There was a difference hypothenar PPT ($p = 0.038$) and pain tolerance ($p = 0.009$), thenar PPT ($p = 0.021$) and pain tolerance ($p = 0.001$), mid-ulnar PPT ($p = 0.028$), biceps PPT ($p < 0.001$), pain tolerance ($p < 0.001$), and grip strength ($p = 0.030$) between the groups after the therapy. When comparison was made between the groups at baseline and after the treatment all were found to differ ($p < 0.05$).* **Conclusions:** *MLD reduced PPR, pain tolerance, hand grip, and pinch strength in young adults. However, in this population, the distance felt in 2PD evaluation with MLD decreased.*

Keywords: *Manual lymphatic drainage. Pain threshold. Pain tolerance. Tactile sense. Muscle strength.*

Resumen

Objetivo: *Este estudio evalúa el efecto terapéutico agudo del drenaje linfático manual (DLM).* **Método:** *Ochenta y dos individuos (164 miembros superiores) que participaron en el estudio se dividieron en dos grupos: DLM y DLM simulado. Antes/después del tratamiento, mediciones de umbral de dolor por presión (PPT) y tolerancia al dolor, mediciones de fuerza muscular con dinamómetro de mano y pinchómetro, y evaluación de discriminación de dos puntos (2PD) con un estesiómetro.* **Resultados:** *La edad, talla, peso, índice de masa corporal, sexo y extremidad dominante de los participantes mostraron características similares ($p > 0.05$). Hubo diferencia entre PPT hipotenar ($p = 0.038$) y tolerancia al dolor ($p = 0.009$), PPT tenar ($p = 0.021$) y tolerancia al dolor ($p = 0.001$), PPT mediocubital ($p = 0.028$), PPT de bíceps ($p < 0.001$) y tolerancia al dolor ($p < 0.001$), fuerza de agarre ($p = 0.030$) entre los grupos después de la terapia. Cuando se hizo la comparación entre los grupos al inicio y después del tratamiento, se encontró que todos diferían ($p < 0.05$).* **Conclusiones:** *El DLM redujo la PPT, la tolerancia al dolor, el agarre manual y la fuerza de pellizco en adultos jóvenes. Sin embargo, en esta población, la distancia sentida en la evaluación 2PD con DLM disminuyó.*

Palabras clave: *Drenaje linfático manual. Umbral del dolor. Tolerancia al dolor. Sentido táctil. Fuerza muscular.*

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Introduction

Manual lymphatic drainage (MLD), one of the components of complex decongestive physiotherapy, is a gentle massage technique with proven positive effects on lymphatic circulation. MLD can be applied to different parts of the body (e.g., arms, legs, neck, abdomen, and trunk), with a different technique for each region (stationary circle, scoop, pump, and rotary)[1]. It has disease-specific application principles, and its efficacy can be further increased by respiration[2]. MLD is effective in mobilizing lymph fluid, promoting lymphangiomotor activity and venous return, and supporting the immune system. With these effects, MLD has been proven to reduce edema in the extremities[3].

Although the efficacy of MLD is frequently investigated in patients with lymphedema/chronic venous insufficiency, it has been reported that this application has different effects on the body other than edema reduction in different patient populations and healthy individuals[4-6].

Various studies conducted with different populations have shown that soft touch activates different receptors on the skin through, not only increases stimulation in nerve endings but also activates inhibitory nerve endings, causes changes in tactile sensation, provides the activation of the parasympathetic system, increases muscle strength, results in changes in systolic and diastolic blood pressure, and reduces heart rate[7,8].

However, it is not known whether these effects are due to the MLD technique or the general therapeutic effectiveness of soft touches. Explaining the effects of MLD in every aspect can provide more effective management of the technique on diseases and pave the way for its use in different areas. Therefore, its effects on healthy individuals need to be known and defined. In this study, the effects of MLD technique and random soft touches on pain threshold, pain tolerance, muscle strength, and tactile sense were investigated.

Method

Patients and study protocol

Ninety-six healthy individuals participated in this 2-arm randomized controlled study. Fourteen individuals that used corticosteroid drugs within the past 2 months, and a further five that did not accept to participate in the study were excluded from the study. As a result, 82 (MLD group: 41, sham group: 41) volunteers were included in the study that November 2023.

The participants were randomly divided into two groups as the study and sham groups. The randomization procedure was performed using a coin toss. The participants were blinded to the group allocation. Ethical approval was obtained from the Non-Pharmaceutical and Medical Device Research Ethics Committee of blinded (decision number: blinded), and the study was conducted in accordance with the principles of the Declaration of Helsinki. Individuals were explained about the measurements and the reason for the study. Consent forms were obtained. It was explained to the participants that if they wanted to leave the study, they could leave the study at any time. The patients' demographic data were questioned. MLD application was made by lymphedema physiotherapist. The research was conducted in the physiotherapy course laboratory at Selcuk University.

This is prospective randomized controlled study and randomization was carried out by a different researcher Cansu Sahbaz Pirinççi (CSP), who did not apply the intervention, using a computer program. A researcher (EC) performed the assessments and treatments in this study. The participants were blinded to the group allocation.

Age, gender, height, weight, body mass index (BMI), and dominant extremity were recorded. MLD was applied to both extremities of the participants (a total of 164 upper extremities). Before and after MLD, the same physiotherapist performed pressure pain threshold (PPT) measurements, hand dynamometer (Jamar) and pinchmeter evaluations (Baseline), and tactile sensation evaluation with an esthesiometer.

Inclusion criteria

- Being aged 18-30 years
- Did not have any communication disorders.

Exclusion criteria

- Having any skin disease
- Having a history of neurological and/or orthopedic disease
- Having a significant scar or burn tissue in the upper extremity
- Having any condition that would prevent communication
- Steroid users.

Procedures

Manual Lymphatic Drainage (MLD)

MLD was limited to the upper extremities. During the MLD application, when the volunteers were in the supine hook position, blood hemodynamics and lower extremity motor function were increased through active bilateral shoulder rotation combined with breathing after first effleurage. Cervical lymph nodes were stimulated. The suction power in the thoracic duct was increased with breathing exercises. After the stimulation of central lymph nodes, the axillo-axillary collateral path was activated by stimulating the axillary lymph nodes in the contralateral region, and axillo-inguinal lymph nodes were activated by stimulating inguinal lymph nodes in the ipsilateral region. Then, upper extremity drainage was applied to the participants in this position. Following the drainage of the proximal part of the upper extremity, it was distally proceeded. The lymph fluid was drained by returning from the distal to the proximal and moved to axillary and inguinal lymph nodes through collateral pathways. The MLD session took an average of 30 min for each volunteer[9].

Sham Manual Lymphatic Drainage (MLD)

Similar to the MLD group, the physiotherapist applied random soft touches to similar areas. The touches were not in the order appropriate to any manual technique. Treatment duration and frequency for individuals in the sham MLD group were quite similar to their counterparts in the MLD group.

Outcome measures

Pressure Pain Threshold (PPT) and pain tolerance measurement

Quantitative PPT measurements were performed using a 1-cm^2 surface algometer (Baseline, USA), which was found to be valid and reliable by previous studies[10]. This algometer consists of a metal piston attached to a dial that can measure pressure in kilograms (kg) and pounds (Lb). The algometer was positioned vertically and placed on the thenar, hypothenar, mid-ulnar, and biceps regions using the marked points. Measurements were repeated 3 times with a rest period of 10 s. The average of these three measurements was used for analysis. Pain tolerance was measured once at the same points. The highest tolerable pressure was used in the measurement and it was recorded.

Evaluation of hand and finger grip strength

The Jamar dynamometer recommended by the American Association of Hand Therapists was used to measure hand grip strength. A pinchmeter (Baseline) was used to measure finger grip strength. Hand grip and finger grip strength was measured using the recommended standard position, with the patients sitting, with their shoulders in adduction, elbows in 90° flexion and mid-rotation, and wrists in neutral position. Three measurements were made at 1-min intervals, and the average values were recorded[11,12].

Two-point discrimination (2PD)

This evaluation was performed using an esthesiometer (Instrument Company, Lafayette, IN, USA), with the participants in the sitting position with their eyes closed. Evaluation was made from the biceps medial to the elbow[13]. Starting from the range where two points could be easily distinguished, the distance between the two points was reduced in 1-mm increments until the two points were felt as one point. Then, starting with two-point stimulation at the minimum interval that was felt as a single point, the distance between the two points was increased in 1-mm intervals until the distance between the two points was felt separately as two points again. The contact time of the two-point stimulation was adjusted to be approximately 1-2 s, and approximately 3-5 s was waited between each stimulation. The shortest distance felt between two points provided the static 2PD value.

Statistical analysis

G*Power software package (G*Power, Version 3.0.10, Franz Faul, Universität Kiel, Germany) was used to calculate the sample size. Ten participants from each group were randomly recruited for the pilot study. The effect size corresponding to this value was 0.632. It was calculated that to achieve 80% power with α = 0.05 type I error, 41 patients were required for each group. Frequency tables and descriptive statistics were used to interpret the findings. The conformity of the variables to the normal distribution was examined using visual (histogram and probability graphs) and analytical (Shapiro-Wilk test) methods.

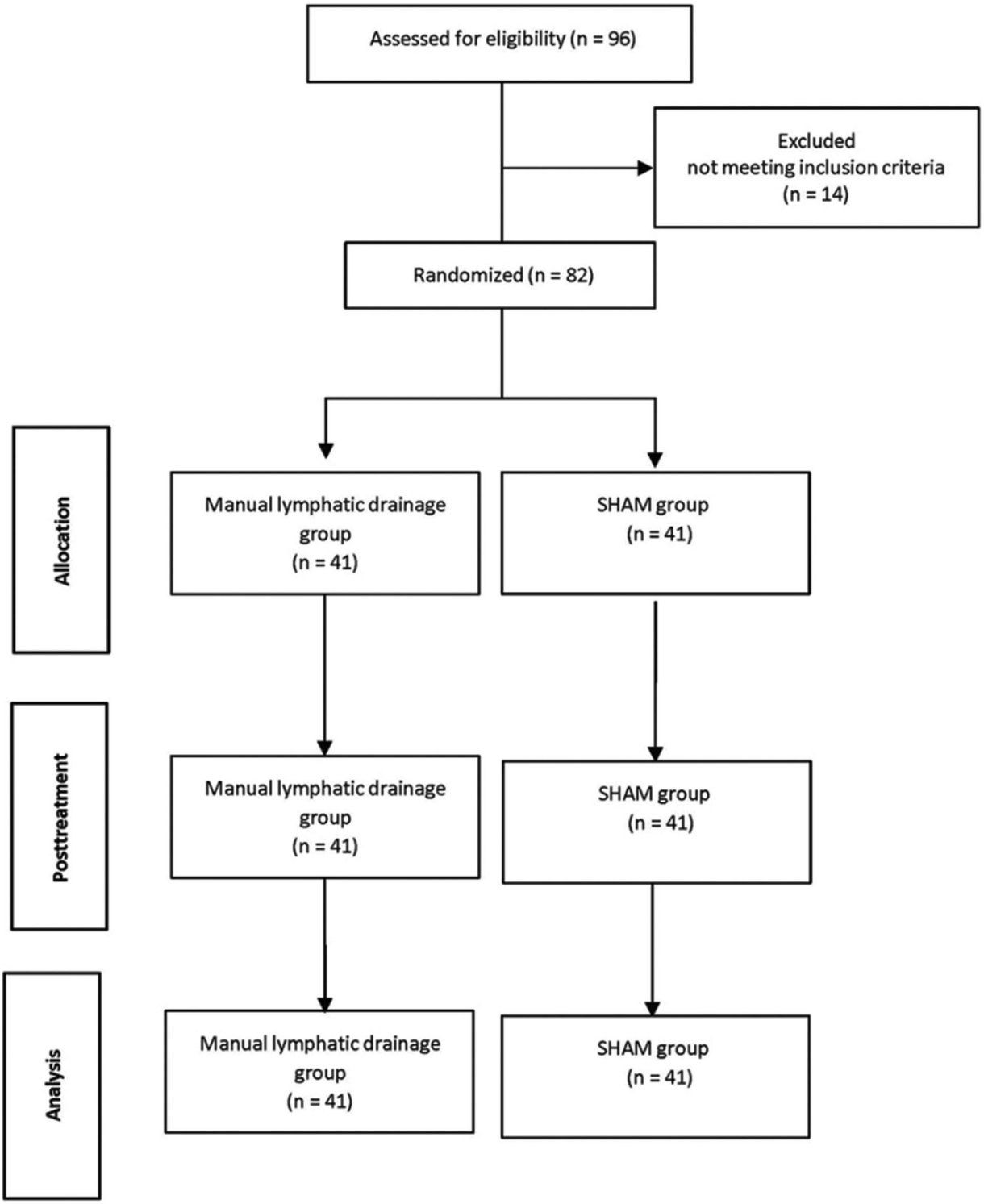

Figure 1. *CONSORT flow diagram.*

Related-samples t-test (Wilcoxon test) was used to evaluate the parameters that did not show a normal distribution and the paired-samples t-test was used to evaluate the parameters with a normal distribution within the groups. In the intergroup evaluations, Mann-Whitney U-test was used for the data that did not show normal distribution. The effect size (d) was calculated by Cohen's guidelines. In all statistics,

Table 1. Demographic data of the participants

Variables	MLD Group (n = 41)		Sham group (n = 41)		x^2, z	p
	X ± SD	n (min-max)	X ± SD (n = 41)	n (min-max)		
Age (years)	20.07 ± 1.52	20 (18-24)	19.97 ± 1.90	19 (18-25)	–0.919	0.358
Height (cm)	166.61 ± 8.05	165 (153-186)	169.73 ± 7.87	168 (158-186)	–1.779	0.075
Weight (kg)	64.27 ± 12.11	62 (42-95)	63.43 ± 13.69	65 (45-89)	–0.605	0.545
BMI (kg/m^2)	23.02 ± 3.12	22.67 (17.94-31.02)	21.78 ± 3.15	21.95 (18-28.41)	–1.648	0.099
	n	%	n	%		
Gender						
Male	14	34.1	20	48.8	1.809	0.179
Female	27	65.9	21	51.2		
Dominant extremity						
Right	33	80.5	28	68.3	1.6	0.206
Left	8	19.5	13	31.7		

cm: centimeter; kg: kilogram; m: meter; X: mean; SD: standard deviation; n: number of participants; min: minimum; max: maximum; %: percentage; BMI: body mass index.

p significance value was accepted as $p < 0.05$. Statistical analyses were performed using IBM SPSS Statistics version 24.0 package 61 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.).

Results

A total of 82 (MLD group: 41, Sham group: 41) people participated in the study. No side effects were observed in participant during and after application. There was no loss during the study (Fig. 1). Age, height, weight, BMI, gender, and dominant extremity of the participants showed similar characteristics ($p > 0.05$). Changes of the participant's demographic data are shown in table 1.

In the comparison between the groups, all the parameters were similar before the therapy ($p > 0.05$). There was a difference hypothenar PPT ($p = 0.038$) and pain tolerance ($p = 0.009$), thenar PPT ($p = 0.021$) and pain tolerance ($p = 0.001$), mid-ulnar PPT ($p = 0.028$), biceps PPT ($p < 0.001$), and pain tolerance ($p < 0.001$) between the groups after the therapy. In the MLD group, all parameters changed after the treatment ($p < 0.05$). In SHAM group, hypothenar PPT ($p = 0.008$), mid-ulnar pain tolerance ($p = 0.007$), and biceps pain tolerance ($p = 0.005$) changed after the treatment. Changes in PPT and pain tolerance are shown in table 2.

In the comparison between the groups, all the parameters were similar before the treatment ($p > 0.05$). There was a difference grip strength ($p = 0.030$) between the groups after the treatment. In the MLD group, all parameters changed after the treatment ($p < 0.05$). In SHAM group, grip strength ($p = 0.008$ changed after the treatment. Changes in muscle strength and 2PD are shown in table 3.

When comparison was made between the groups at baseline and after the treatment all were found to differ (Table 4).

Discussion

On completion of the study, we conducted with healthy young adults, we found that MLD caused a decrease in PPT and pain tolerance, reduced grip and pinch strength, and increased their tactile sensation in 2PD.

MLD is part of complex decongestive therapy, which is considered as the gold standard in the treatment of lymphedema[14]. In the past decade, the efficacy of MLD on edema and pain has been investigated in different patient groups. In a study including MLD in exercise therapy for complex regional pain syndrome, Uher et al. reported that MLD improved pain, edema, and range of motion, but the results were similar to the exercise-only group[15]. Similarly, Kim (2014) found that MLD had a curative effect on pain, but this was not statistically significant. The author also noted that PPT significantly increased after MLD treatment[8]. There are also studies showing that the increase in PPT and pain tolerance has clinical significance[16].

The effect of MLD on pain can be explained by different theories: MLD nociceptive receptors can increase parasympathetic responses by reducing

Table 2. Changes in PPT and pain tolerance

Variables	Variables	MLD Group (n = 82)		Sham group (n = 82)		z	p	d
		Mean ± SD	Median (min-max)	Mean ± SD	Median (min-max)			
Hypothenar	BT-PPT	6.54 ± 2.28	6 (3-14)	6.06 ± 2.49	6 (3-12)	−1.828	0.068	
	AT-PPT	5.60 ± 2.27	5 (2-13)	6.40 ± 2.48	6 (3-12)	−2.075	0.038	0.336
	t, z		−3.301		−2.668			
	p		0.001		0.008			
	d		0.413		0.136			
	BT-pain tolerance	10.82 ± 5.13	10 (3-30)	10.34 ± 4.82	9.75 (5-30)	−0.670	0.503	
	AT-pain tolerance	8.62 ± 3.37	8 (2-17)	10.73 ± 5.22	10 (3-30)	−2.621	0.009	0.480
	t, z		−4.496		−1.178			
	p		< 0.001		0.239			
	d		0.057		0.077			
Thenar	BT-PPT	6.54 ± 2.72	6 (2-15)	6.13 ± 2.12	6 (2-14)	−0.678	0.498	
	AT-PPT	6.52 ± 7.22	5 (2-55)	6.16 ± 2.11	6 (2-14)	−2.300	0.021	0.067
	t, z		−3.174		−1.633			
	p		0.002		0.102			
	d		0.003		0.014			
	BT-Pain tolerance	9.43 ± 3.95	8.75 (4-25)	9.18 ± 3.37	8.75 (4-20)	−0.187	0.852	
	AT-Pain tolerance	7.29 ± 2.74	7 (2-16)	9.07 ± 3.40	8.5 (4-20)	−3.383	0.001	0.576
	t, z		−4.885		−1.807			
	p		< 0.001		0.071			
	d		0.629		0.032			
Mid-Ulnar	BT-PPT	5.77 ± 2.18	5 (1-13)	5.54 ± 1.92	5 (1-12)	−0.577	0.564	
	AT-PPT	5 ± 1.80	5 (2-13)	5.44 ± 1.93	5 (1-12)	−2.193	0.028	0.235
	t, z		−2.795		−1.841			
	p		0.005		0.066			
	d		0.385		0.051			
	BT-Pain tolerance	8.68 ± 3.04	8 (4-16)	8.21 ± 2.85	8 (4-15)	−1.049	0.294	
	AT-Pain tolerance	7.55 ± 2.72	7 (2-15)	7.90 ± 2.67	8 (4-15)	−0.791	0.429	0.129
	t, z		−3.620		−2.692			
	p		< 0.001		0.007			
	d		0.391		0.112			
Biceps	BT-PPT	5.22 ± 1.66	5 (2-10)	5.49 ± 1.77	5 (2-12)	−0.89	0.373	
	AT-PPT	4.36 ± 1.62	4 (1-9)	5.30 ± 1.86	5 (2-12)	−3.751	< 0.001	0.538
	t, z		−4.178		−1.897			
	p		< 0.001		0.058			
	d		2.626		0.104			

(Continues)

Table 2. Changes in PPT and pain tolerance *(continued)*

Variables	Variables	MLD Group (n = 82)		Sham group (n = 82)		z	p	d
		Mean ± SD	Median (min-max)	Mean ± SD	Median (min-max)			
	BT-Pain tolerance	7.82 ± 2.79	7.75 (3-15)	8.06 ± 2.74	8 (3.5-15)	–0.556	0.578	
	AT-Pain tolerance	5.89 ± 2.46	5 (2-13)	7.71 ± 2.80	8 (3.5-15)	–4.201	< 0.001	3.341
	t, z		–5.282		–2.823			
	p		< 0.001		0.005			
	d		0.733		0.126			

BT: before treatment; AT: after treatment; PPT: pressure pain threshold; MLD: manual lymph drainage; X: mean; SD: standard deviation; n: number of extremities; min: minimum; max: maximum; p < 0.05.

Table 3. Changes in muscle strength and two-point discrimination

Variables	MLD Group (n = 82)		Sham Group (n = 82)		z	p	d
	Mean ± SD	Median (min-max)	Mean ± SD	Median (min-max)			
BT-Grip strength	29.20 ± 9.68	26.6 (16.3-58.3)	28.36 ± 9.70	26.45 (11-55)	–0.406	0.685	
AT-Grip strength	25.70 ± 9.31	21.6 (10-46)	28.06 ± 9.55	25.80 (11-55)	–2.169	0.030	0.250
t, z		–6.738		–2.668			
P		< 0.001		0.008			
D		0.368		0.031			
BT-Pinch Strength	4.34 ± 1.71	4.1 (1.6-9.6)	4.19 ± 1.70	4 (1.6-9)	–0.628	0.530	
AT-Pinch Strength	3.84 ± 1.47	3.55 (1.5-7.6)	4.04 ± 1.73	3.6 (1.6-9)	–0.313	0.754	0.124
t, z		–3.375		–1.728			
P		0.001		0.084			
D		0.340		0.087			
BT-Two-point discrimination	13.97 ± 2.10	15 (1-15)	13.59 ± 2.35	14 (1-15)	–1.452	0.146	
AT-Two-point discrimination	13.54 ± 1.84	14 (8-18)	13.85 ± 1.37	14 (9-15)	–0.703	0.482	0.191
t, z		–2.563		–0.885			
P		0.010		0.376			
D		0.217		0.135			

BT: before treatment; AT: after treatment; MLD: manual lymph drainage; X: mean; SD: standard deviation; n: number of extremities; min: minimum; max: maximum; p < 0.05.

sympathetic nervous system activation through rhythmic stimulation. According to the gate control theory of pain, MLD can reduce the activity of A delta and C fibers through the soft touches that it contains or it can regulate pain intensity by helping increase neurotransmitter release[8,17,18].

Contrary to the literature, in the present study, we found that MLD caused a significant decrease in PPT and pain tolerance. This may be due to the criteria that we used in sample selection. We only included individuals with a pain level of < 1 according to the Visual Analog Scale, which may actually be evidence that the pain-reducing mechanisms of these individuals were deactivated. We consider that this mechanism of action of MLD on pain has not yet been explained.

The results we obtained from the 2PD evaluation indicate that MLD may have increased sensitivity in fibers carrying pressure sensation. Static 2PD assessment tests the slowly adapting type I afferent Aβ fiber system in the skin and is received by Merkel receptors.

Table 4. Comparison of differences between groups at baseline and after treatment

Variables	MLD group (n = 82)		Sham group (n = 82)		z	p	d
	Mean ± SD	Median (Min-Max)	Mean ± SD	Median (Min-Max)			
Hypotenar PPT	−0.93 ± 2.67	−1 (−9-6.5)	0.34 ± 1.11	0 (0-5.5)	−5.161	< 0.001	0.621
Hypotenar pain tolerance	−2.20 ± 4.51	−2 (−20-7)	0.39 ± 2.89	0 (−2-25)	−5.858	< 0.001	0.683
Thenar PPT	−0.02 ± 7.50	−1 (−10-49)	0.03 ± 0.16	0 (0-1)	−4.09	< 0.001	0.009
Thenar pain tolerance	−2.14 ± 3.91	−2 (−19-4)	−0.10 ± 0.54	0 (−3-1)	−4.893	< 0.001	0.730
Mid-ulnar PPT	−0.77 ± 2.21	−1 (−7-4)	−0.09 ± 0.51	0 (−4-0)	−2.551	0.011	0.423
Mid-ulnar pain tolerance	−1.13 ± 2.57	−1 (−9-4)	−0.31 ± 0.97	0 (−4-0)	−2.561	0.010	0.422
Biceps PPT	–	−1 (−6-4)	−0.18 ± 0.91	0 (−5-1.5)	−4.188	< 0.001	0.474
Biceps pain tolerance	−1.93 ± 2.72	−2 (−9-5)	−0.34 ± 1.03	0 (−5-0)	−5.631	< 0.001	0.773
Grip strength	−3.50 ± 4.13	−2.65 (−17-8)	−0.30 ± 0.99	0 (−6-0)	−7.771	< 0.001	1,06
Pinch strength	−0.49 ± 1.31	−0.3 (−5-2.9)	−0.15 ± 0.79	0 (−3.5-2)	−3.24	0.001	0.314
Two-point discrimination	−0.42 ± 2.67	0 (−7-13)	0.26 ± 1.64	0 (−2-8)	−2.797	0.005	0.306

PPT: pressure pain threshold; MLD: manual lymph drainage; X: mean; SD: standard deviation; n: number of extremities; min: minimum; max: maximum; p < 0.05.

While only myelinated thick afferents were previously considered to be tactile sensory receptors, recent studies have shown that C fibers also contribute to tactile sensation. These are unmyelinated low-threshold C afferents that respond strongly to the pleasant sensation caused by a light and soft touch[19]. C afferents carrying delayed pain[20] may make the skin sensitive to touch by acting as tactile receptors for pleasant touches in the absence of pain. Thus, increased tactile sensitivity may heighten the "pressure"[21] factor based on the working mechanism of the algometer. We consider that in painless and healthy tissue that becomes sensitive to pressure, this may cause a decrease in PPT and pain tolerance.

MLD generally provides an increase in muscle strength when used in cases that develop lymphedema after cancer. An increase in muscle strength with increased function as a result of reduced edema is an expected result[11]. It has been reported that MLD supports the regeneration of muscle strength in the post-exercise period in athletes engaged in Far Eastern sports, MLD has been suggested to be one of the important elements of therapeutic methods to reduce the risk of injury[22]. However, these studies reporting improvement in muscle strength performed evaluations in the regeneration period. In studies investigating classical massage applications, massage is not recommended before performance because it may reduce performance in activities, such as sprinting and vertical jumping, that require muscle strength[23]. Massage, whether superficial or deep, affects neuromotor and neuromuscular components and changes the internal tension of structures[24]. In our study, grip and pinch strength significantly decreased after MLD, which may be due to the reaction of muscles to changes in internal tension or the increase in muscle relaxation as a result of heightened parasympathetic responses with the suppression of the sympathetic system[8]. Increased parasympathetic activity may have caused a decrease in readiness for action.

Conclusion

MLD applied to healthy individuals causes a decrease in muscle strength. However, it enhances tactile sensation and results in increased sensitivity in 2PD. It reduces PPT and pain tolerance. In this case, MLD can be thought that the activity in pain and sensory receptors increases. The decrease in muscle strength emphasizes the reducing effect of MLD on the internal tension of the muscle. Based on these findings, the clinical usage areas of MLD can be rearranged.

Limitations

Due to the similar ages of the participants, we only evaluated a certain age group. The use of this method in different populations may show age-related variations

in terms of efficacy. In addition, laboratory studies should be included in the future to make the results more objective.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical considerations

Protection of humans and animals. The authors declare that the procedures followed complied with the ethical standards of the responsible human experimentation committee and adhered to the World Medical Association and the Declaration of Helsinki. The procedures were approved by the institutional Ethics Committee.

Confidentiality, informed consent, and ethical approval. The authors have obtained approval from the Ethics Committee for the analysis of routinely obtained and anonymized clinical data, so informed consent was not necessary. Relevant guidelines were followed.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

Ethical approval

The study was approved by the Non-Pharmaceutical and Medical Device Research Ethics Committee of Konya Chamber of Commerce Karatay University (decision number: 2022/009)

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