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Comparison between Manual Lymph Drainage and Lymph stick on Circumference, Volume, Extracellular distribution ratio, Oxygen saturation, Body temperature and Satisfaction survey

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Abstract

Background/Objectives: This study investigated efficient interventional methods for reducing edema in women.

Methods/Statistical analysis: 20 healthy adult women were participated in this study and directed to wear high heels. Then, three interventions were applied to them; long sitting, manual lymph drainage (MLD), lymph stick. This study measured the circumference, volume, extracellular distribution ratio, oxygen saturation, body temperature and satisfaction survey. Comparisons between each intervention were analyzed through one-way ANOVA and intragroup comparisons were used by T-test.

Findings: The control group (long sitting) showed no significant difference in edema reduction. However, MLD and lymph stick showed significant differences (p<.05). In addition, there was no significant difference between the two interventions. According to the satisfaction survey, MLD and lymph stick showed a lot of positive answers on reducing edema, and lymph stick showed a lot of positive answers on overall satisfaction. In conclusion, we found the intervention that has a positive effect psychologically on the reduction of edema was lymph stick.

Improvements/Applications: Because this study was limited to gender, age and adult women, we expect that a variety of study will be conducted for many kinds of patients in future.

Keywords: Manual Lymph Drainage (MLD), lymph stick, vibration, swelling, high heel

1. Introduction

The heel is the higher, the more weight there is on ankles, dorsum of foot and hallux. Therefore, it increases muscle fatigue and causes foot and leg-related diseases, such as varicose veins, lower extremity edema, hallux valgus, callus and toe deformity [1].

Various non-drug management methods such as general massage, foot reflexology, foot bath, and spa therapy have been introduced to improve foot and leg symptoms such as lower extremity edema [2]. In addition to these methods, one of the applicable treatments is Manual Lymph Drainage (MLD). Lymph massage has the effect of increasing the movement and contractility of lymphatic vessels, promoting lymph flow and facilitating the excretion of waste products in tissues [3]. It has been mainly applied to postoperative edema, such as cancer, hemorrhoids, plastic surgery, and varicose vein surgery, sensitive skin care and the effects have been proved [4].

Vibration supports relieve fatigue in the skin and muscles, and works directly on the lymphatic system to remove lactic acid and other chemical wastes, therefore preventing pain and discomfort in joints and muscles [5]. A method of Whole body vibration is based on the mechanical massage effect of low frequency vibration that can accelerate the recovery process by stimulating muscle receptors in order to increase blood flow. Therefore, it has been proved that passive vibration can support recovery and healing of tissues, overcome fatigue, reduce recovery time and improve motor performance [6].

The previous study were 58 women with lymphedema after mastectomy and randomly controlled trials were conducted. The control group included 29 patients with standard treatment (skin care, exercise and compression measurements, bandages for 1 month and compression bandages). The experimental group included 29 patients with standard treatment and MLD. The treatment has been conducted daily for four weeks, and the patient's condition has been assessed one, three and six months after treatment. It has been reported that arm volume is decreased after

treatment and symptom improvement (severity of pain, swelling of endoplasmic reticulum, and degree of functional limitation) has been shown [7]. In another study, MLD has been introduced to improve upper extremity edema and hand function in patients with systemic sclerosis with edema. Then 40 white women with systemic sclerosis were randomly divided into MLD group and observation group through randomized controls. For the measurement method, it has been evaluated by dipping the hand into a slowly filled cylinder of water. In conclusion, the application of MLD has been reported to be effective in the treatment of edematous osmosis neuritis by reducing hand volume, edema and pain and improving hand function and quality of life [8].

However, Huang et al. has studied whether MLD can prevent or manage limb edema in women after breast cancer surgery. As a result, they could not find a significant difference in lymphedema between MLD group and the standard treatment group. The use of MLD has been reported to be not effective for treatment of prostate [9]. Nele has investigated the preventive effects of MLD for 160 patients who underwent breast cancer and unilateral axillary lymph node dissection. It has been conducted for 6 months and the experimental group has carried out the treatment program consisting of MLD, on the other hand, the control group has conducted the same program without MLD. As a result, MLD was not effective in reducing the incidence of cancer lymphedema in the short term [10].

In this study, we investigated the effect of edema reduction by analyzing quantitative indicators (circumferential change, extracellular distribution ratio, body temperature, oxygen saturation, volume) through long sitting, MLD and lymph stick. The targets were those who developed edema after wearing high heels.

2. Materials and Methods

2.1. *Subject*

We recruited 20 healthy female students from S University located in Asan city and selected 18 to 22year-old students. Then we fully explained about the research contents and purpose, experiment order, research stability, and human rights protection to the subjects. 20 subjects were tested three times over three weeks, and asked to wear high heel for 1 hour, through three interventions: long sitting, MLD and lymph stick. The intervention order has been randomized for each subject and they were participated in three experiments once a week. This study has been approved by Sun Moon University Institutional Review Board (SM-201904-016-1). The characteristics of the participants are shown in Table 1.

Table 1 : General characteristics of the subject

(N=20)

Division	Subject
Gender	Female
Age(year)	21.45±0.89
Height(cm)	163.20±4.62
Weight(kg)	56.00±7.70

2.2. *Experiment procedure*

This study has been divided into before wearing high heels, after wearing high heel for 1 hour and after mediation. All participants measured circumference, volume, extracellular distribution ratio, oxygen saturation, and body temperature three times before and after wearing high heels. They were asked to stand for one hour with legs wide open to the shoulder width on the standing table with wearing high heels. There were three methods of intervention: long sitting, MLD, and lymph stick. The above description is shown in Figure 1.

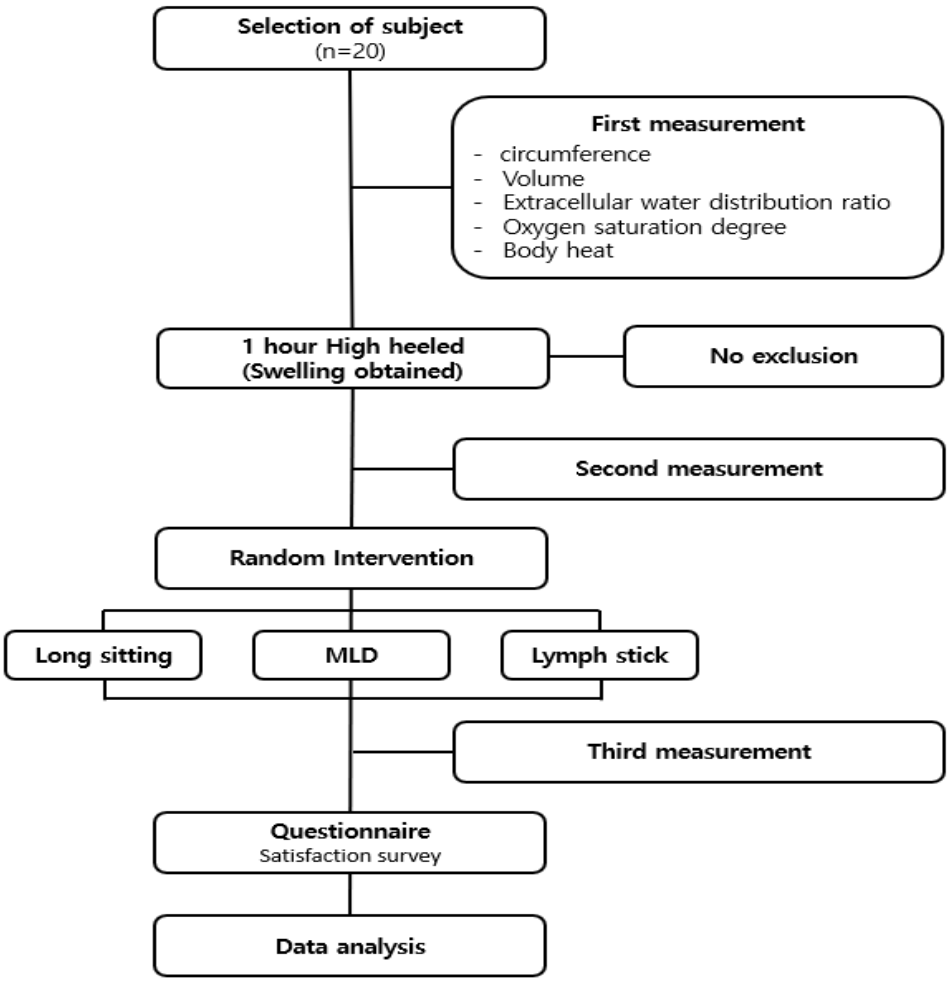


Figure 1. Experiment protocol flow chart

2.3. *Intervention methods*

2.3.1. Long sitting

20 subjects were asked to wear high hill for 1 hour to alleviate lower extremity edema. As a rest method, subjects have been tested for 10 minutes in a long sitting position on the treatment bed.

2.3.2. MLD

MLD has been conducted on 20 subjects as an intervening method to alleviate lower extremity edema caused by wearing high heels for 1 hour. It has been conducted under the guidance of a physical therapist who had more than three years of clinical experience. The subjects have been placed in a supine position on the treatment bed, then it was applied to their both legs. A total of 10 minutes has been applied.

2.3.3. Lymph stick

As an intervening method to alleviate lower extremity edema caused by wearing high heels for 1 hour, vibrating lymph massage device designed for systemic lymph massage has been used for 20 subjects (Limfa stick, SP care, Korea). The first stage of lymph stick was used to stimulate lower extremity muscle by 1500RPM vibration and 8cm spaced ball and 43˚C warm stimulation. Especially the stimulation area was precisely stimulated by the vibration of the handle of the lymph stick, and the skin was not irritated. Vibration lymph massage was conducted by students in the department of physiotherapy and applied to the same area as MLD. The subjects have been lying on the bed and it was applied to their left and right legs. A total of 10 minutes has been conducted [Figure 2].

Figure 2. lymph stick

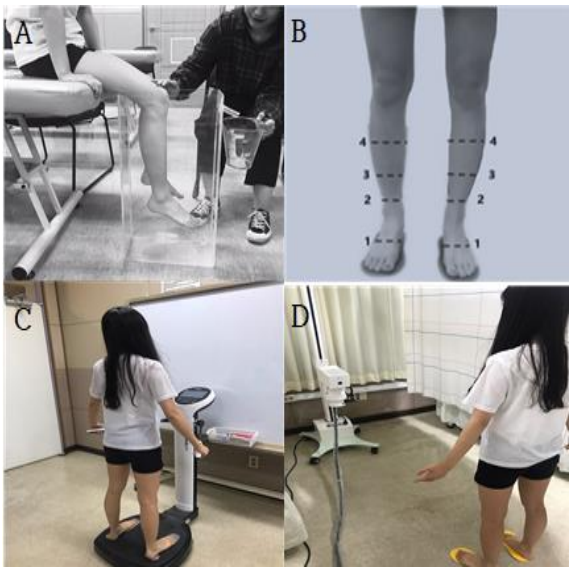


Figure 3. Measurement methods
A: Volumeter B: Measured part C: Extracellular distribution ratio D: body heat

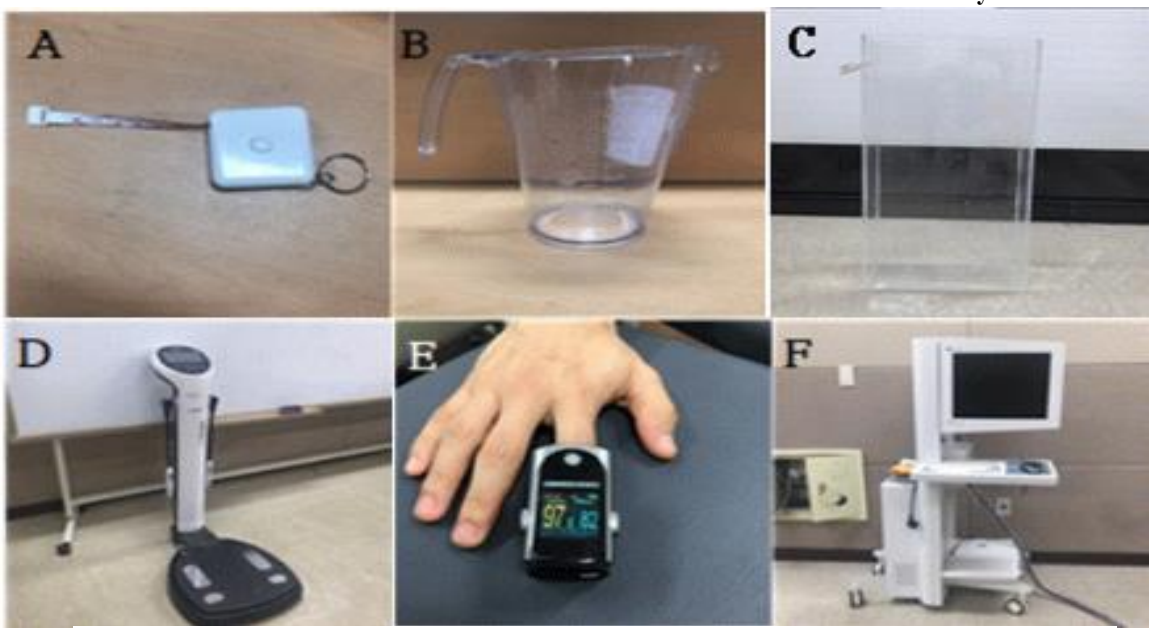


Figure 4. Measurement tools
A: Tape measure B: Beaker C: Volumeter D: Inbody
E: Fingertip pulse oximeter F: Digital infrared thermometer

2.4. *Measurement methods and tools*

2.4.1. Parts and methods of measuring the leg circumference

We measured the subjects using tape and four areas were measured; metatarsal, ankle, 5cm above the ankle and the thickest part of the calf [Figure 3, Figure 4]. To investigate the incidence of edema, we compared the difference in circumference before and after the intervention and used average value in order to reduce the error of the measurement after a total of three measurements.

2.4.2 Measurement of volume

To measure the volume, we filled the cylinder with 28,000 ml of water, allowing the subjects to sit and place their legs in the cylinder of tibia tuberosity [Figure 3, Figure 4]. Later, we filled the water of the beaker to measure the volume and reduced the error range by measuring it in a total 2 times.

2.4.3. Measurement of edema

Edema is measured by a body composition analyzer (Inbody720 Biospace Co, Korea) as follows [Figure 3, Figure 4]. Align both feet of the subjects to the electrode and open with both arms about 15 degrees apart.

2.4.4. Oxygen Saturation

Oxygen saturation is measured by Fingertip Pulse Oximeter (choice MMed) in the following way [Figure 4]. It is measured after wearing on one index finger. Increased oxygen saturation means increased blood circulation. Blood circulation disorder is found to be the cause of edema, therefore we could find increase and decrease of the blood

circulation.

2.4.5. Infrared thermography

We used infrared thermography to measure whole body infrared thermography for once. The subjects were asked to wear shorts, and the front and rear of the lower body were photo-taken, and the temperature of the front and rear of the lower body was measured after the shooting. Statistical values were used to measure the temperature of the popliteal area [Figure 3, Figure 4].

2.4.6 A survey on satisfaction

We conducted satisfaction survey for the participants who participated in the experiment. The articles were consisted of application time for each intervention, reduction of edema, and overall satisfaction. A five-point question Likert scale was applied from a number from 1 to 5 to check if the application time is adequate, how much the subjects felt reduction in edema and how much they were satisfied overall.

2.5. *Data analysis*

Statistical analysis of the collected data was conducted by SPSS 22.0 version program. Descriptive statistics were used to evaluate general characteristics. All variables have been found in the group produced mean (M) and standard deviation (SD). We used paired-T to verify the occurrence and reduction of edema. In addition, we used One-way ANOVA to verify the effects of each exercise type program by group and conducted Bonferroni's post-hoc test when significance was recognized. All statistical significance levels were set at $p<.05$ for statistical analysis.

3. Results

3.1. *Comparison of Reduction Effect of Lower Extremity with Mediation*

3.1.1. Change in circumference

The circumference of each area was compared to see how much edema has been reduced after wearing high heels for 1 hour through long sitting, MLD and lymph stick. Edema relief through long sitting did not show any significant difference in edema relief in all areas of right and left through MLD and lymph stick. Edema relief through MLD and lymph stick also showed no significant difference in all areas of right and left [Table 2], [Figure 5].

3.1.2 Change of edema

Then reduction of edema has been compared after wearing high heels for 1 hour through long sitting, MLD and lymph stick. Edema relief by long sitting showed significant difference between right and left in edema relief by MLD ($p<.05$). Comparing the average of long sitting and MLD, the edema-relieving was more effective through MLD. Edema relief through lymph stick had no significant difference between right and left in edema relief through long sitting and MLD [Table 2], [Figure 5].

3.1.3 Changes in extracellular distribution ratio

After wearing high heels for 1 hour, we measured how edema has been relieved by long sitting, MLD and lymph stick. Edema with long sitting showed a significant difference in edema relief through MLD and lymph stick ($p<.05$). Compared with the after 1hour to after intervention difference of long sitting, MLD, lymph stick, edema with MLD and lymph stick are shown to be more effective than long sitting. And there was no significant difference between edema relief through MLD and lymph stick [Table 3], [Figure 5].

3.1.4. Oxygen Saturation

This study measured the blood circulation effect of each intervention on the lower limb edema caused by high heels through oxygen saturation. And there was no significant difference when compared each intervention [Table 3], [Figure 5].

3.1.5. Body temperature

The statistical values for body heat are as follows. When the body temperature was compared with baseline and after 1 hour, the body temperature has been decreased but after intervention, the body temperature has been increased on average. In particular, temperature rise was significantly different in the right leg in the long sitting and lymph stick groups ($p<.05$) [Table 2], [Figure 5].

3.1.6. A survey on satisfaction

As the experiment has been continued, we conducted a satisfaction survey. The questionnaires were largely consisted of application time of intervention, reduction of edema and overall satisfaction. The statistics are as follows. There were no significant differences in terms of time but a significant differences in long sitting, MLD, and lymph stick in terms of edema reduction ($p<.05$). Overall satisfaction with the intervention was significantly different between the long sitting and lymph stick groups ($p<.05$) [Table 3].

Table 2: The difference of between intervention according to measured circumference, volume, body temperature by each group

Time	Lt.	F	Rt.	F

			A	B	C		A	B	C	
Circumference	Metatarsal area, base	After 1h	22.06±1.00	21.71±0.98	21.49±0.84		21.96±1.07	21.63±0.92	21.43±0.92	
		After intervention	21.62±1.03	21.24±0.90	21.26±0.84		21.71±1.04	21.73±1.88	21.22±0.89	
		t	4.077***	1.949	2.680*		1.021	-0.276	4.583***	
		difference	-0.44±0.48	-0.47±0.42	-0.23±0.38	1.869	-0.26±0.47	0.10±1.62	-0.21±0.20	0.775
	Ankle joint area	After 1h	20.72±1.27	20.57±1.23	20.73±1.27		20.73±1.24	20.62±1.41	20.59±1.22	
		After intervention	20.68±1.35	20.32±1.39	20.50±1.28		20.63±1.45	20.30±1.33	20.27±1.25	
		t	2.242*	4.046***	3.043**		1.696	1.720	4.213***	
		difference	-0.15±0.29	-0.36±0.40	-0.23±0.33	2.017	-0.11±0.29	-0.34±0.26	-0.32±0.34	3.583*
	5cm above Ankle joint	After 1h	23.74±1.65	23.52±1.78	23.11±1.83		23.78±1.78	23.40±1.79	23.24±1.81	
		After intervention	23.27±1.52	22.89±1.83	22.76±1.76		23.21±1.48	22.76±1.67	22.93±1.72	
		t	3.323**	5.285***	4.071***		4.041***	6.011***	4.425***	
		difference	-0.47±0.63	-0.64±0.52	-0.35±0.38	1.558	-0.57±0.63	-0.64±0.48	-0.32±0.32	2.418
	Perone us area	After 1h	36.67±2.62	36.60±2.74	36.18±2.56		36.52±2.73	36.48±2.76	36.30±2.48	
		After intervention	36.29±2.72	36.03±2.86	35.73±2.61		36.23±2.86	35.99±2.79	35.69±2.45	
		t	3.106**	4.739***	5.086***		2.939**	5.211***	6.938***	
		difference	-0.38±0.54	-0.58±0.55	-0.44±0.39	0.875	-0.30±0.45	-0.50±0.42	-0.61±0.39	2.775
Volume		After 1h	731.00±247.55	639.50±348.83	633.00±298.23		776.00±245.43	677.00±361.00	684.50±306.35	
		After intervention	720.50±215.20	568.00±336.71	585.00±295.43		740.00±204.48	580.00±350.53	605.50±309.92	
		t	0.648	5.499*	5.620***		2.127*	6.247***	6.098***	
		difference	-10.50±72.50	-71.50±58.15	-48.00±38.20	5.624*	-36.00±75.70	-97.00±69.44	-79.00±57.94	4.237*
Body temperature		After 1h	32.05±0.69	32.24±1.15	33.00±1.06		31.83±0.75	32.17±1.00	32.90±1.28	
		After	32.30±0.	33.20±1.	34.01±1.0		32.12±0.	32.99±0	33.89±0	

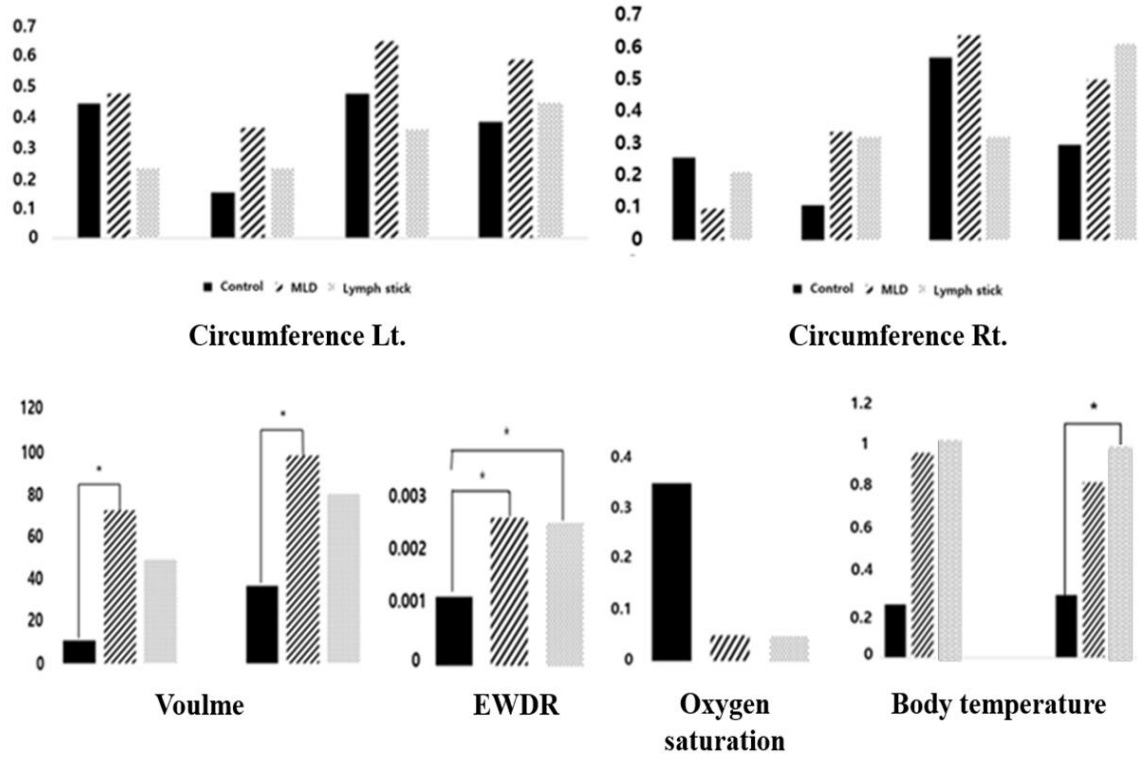
	intervention	68	15	6		66	.95	.98	
	t	-2.067	-3.11***	-8.936***		1,722	-4.282***	-6.890***	
	difference	0.25±0.55	0.77±0.78	1.02±0.51	7.797	0.29±0.74	0.82±0.85	0.99±0.64	4.757*

∗p<.05, mean ± standard deviation, After 1 h: 1 hour after wearing high heel shoes, After intervention: Intervention with 1 hour after wearing high heel shoes, A: control group(long sitting), B: manual lymph drainage (MLD) group, C: Lymph stick group

Table 3: The difference of between intervention according to measured extracellular water distribution ratio, oxygen saturation, satisfaction by each group

		A	B	C	F
extracellular water distribution ratio	After 1 h	0.384±0.045	0.383±0.004	0.386±0.005	
	After intervention	0.383±0.005	0.381±0.004	0.383±0.005	
	t	5.080***	11.994***	7.611***	
	difference	-0.001±0.001	-0.003±0.001	-0.003±0.001	8.976*
Oxygen saturation	After 1 h	97.80±0.62	98.05±0.22	98.35±0.59	
	After intervention	97.45±0.76	98.00±0.00	98.30±0.73	
	t	1.677	1.000	0.326	
	difference	-0.35±0.93	-0.05±0.22	-0.05±0.69	1.602
Satisfaction	Intervention with arbitration time	3.45±1.10	3.65±0.75	4.05±0.76	2.394
	Overall satisfaction	3.05±1.23	3.70±0.73	4.20±0.89	6.974**
	Decrese in sensual edema	2.80±1.32	3.65±0.81	4.10±0.85	8.343***

∗p<.05, ∗∗p<.01, ∗∗∗p<.001
A: control group (long sitting), B: manual lymph drainage (MLD) group, C: Lymph stick group.



EWDR: Extracellular water distribution ratio

Figure 5. Comparison between three groups

4. Discussion

The purpose of this study is to investigate the effect of long sitting, MLD and lymph stick on reducing edema in people who have edema. Under the same conditions, differences have been found before and after leg circumference, volume, oxygen saturation, extracellular distribution ratio, and body heat.

When compared MLD and long sitting, there was a significant difference in volume and extracellular distribution ratio in MLD. Szolnoky has reported that MLD-mediated methods significantly reduced edema and proposed that MLD may serve to improve lymphatic circulation and reduce postoperative edema and pain [11]. And Shao and Zhong conducted four randomized controlled trials of 234 patients with breast cancer-related lymphomas. As a result, MLD had a significant difference in reducing edema [12]. The studies on MLD and extracellular distribution ratio, Robert and Neil applied MLD as a single session and found that MLD has a significant clinical effect on extracellular distribution ratio. It has also been reported to soften tissues in all major lymph areas [13]. MLD increases lymphatic vessel contraction and lymph circulation in the area of application. Moseley has reported that the use of MLD in medical practitioners could help improve symptoms. Participants were divided into MLD and intermittent pneumatic compression groups, who reported a decrease in leg fatigue and stiffness in the MLD group, but not in the intermittent pneumatic compression group [14]. In another study, Lee randomly assigned 45 subjects to MLD, ultrasound, and control groups by 15 subjects. The results of this study showed significant changes in MLD, ultrasonography, and control group. However, there was no significant difference between groups and MLD and a rapid recovery [15]. MLD has been known to be an effective mediator for reducing lymphedema. The above studies are the same as the results in that MLD showed significant difference in volume and extracellular distribution ratio.

Vibration helps relieve skin and muscle fatigue and also directly affects the lymphatic system [5]. Lymph stick in this study has led to changes in extracellular distribution ratio and body heat. Shit and Majee has studied about vibration and body heat, 11 subjects who received a 50 Hz vibration for 15 minutes showed significantly higher skin temperature rise in the vibrated forearm than the forearm of control groups [16]. Nisha said that increased blood flow in healthy people is associated with increased skin temperature [17]. It is believed that the vibration technique effectively leads to changes in body heat. In addition, a study of Cornish involving extracellular distribution ratio confirmed that the total limb dose and techniques of extracellular fluid is accurate in the detection of lymphedema. [18] Deursen has attempted to evaluate the effect of edema in the group sitting in the experimental chair of the RCPM and the fixed seat fan. 10 patients with low back pain kept sitting down for 3 hours. Leg volume was measured four times at 1hour intervals. The results showed that a significant difference in lower body edema of dynamic stimulation chairs [19]. In conclusion, research showed that vibration therapy is effective in reducing edema. In this study, MLD did not show any significant difference in body heat. Adelaida et al. has conducted an experiment to investigate the effects of MLD to prevent edema after breast cancer surgery. We evaluated extracellular distribution ratio,

temperature, and functional evaluation of the shoulder. After MLD, there was a significant difference in extracellular distribution and functional evaluation, however no significant difference in temperature [20]. The above studies are the same as the results of lymph stick which showed a significant difference in body heat.

In this study, there were significant differences in volume, extracellular distribution ratio and body heat in long sitting, MLD and lymph stick. To be more specific, when comparing long sitting and MLD, there was a significant difference in the volume of the left and right legs. There were significant differences between the three groups in the right ankle area in the circumference, but no significant differences were found when comparing each group one by one. This differs between groups, but there is no clear difference as to which group is better. And there were significant differences in extracellular distribution ratio between long sitting, MLD and lymph stick.

On the other hand, there was a significant difference between long sitting and lymph stick in the right leg. But there was no significant difference between MLD and lymph stick. In the satisfaction survey, the articles were consisted of time satisfaction, total satisfaction, and reducing edema. Likert scale was used in the satisfaction survey. Harry and Boone said that the Likert scale is used as a series of five answers [21]. Kim is widely used because the advantages of the Likert scale and contents are simple. In general, it may be adopted under a wide variety of situations and conditions. In addition, it can be used to measure various affective psychological characteristics and attitudes through appropriate modifications [22]. There was no significant difference among the groups on the article of the time satisfaction category. In terms of overall satisfaction, Lymph stick showed higher satisfaction than long sitting. There was no significant difference between MLD and lymph stick. In conclusion, MLD and lymph stick showed higher satisfaction than long sitting in reducing edema.

This study has few limitations. First, all the participants in the study were healthy subjects without edema-related diseases. Second, the subjects were university students, therefore we could not study about various age groups. Third, the gender of the subjects was not composed of all genders but only women. Lastly, when the mediation time was applied to 10 minutes, the subjects felt insufficient. It is considered that future studies should make more accurate measurements through volume measurement, extend the intervention time and vary the age and gender.

5. Conclusion

In this study, we investigated on the effects of long sitting, MLD and lymph stick for reducing leg edema and measured the circumference, volume, extracellular distribution ratio, oxygen saturation, and body temperature to compare edema reduction.

First, there was no significant difference in each mediation when measuring circumference. Second, MLD is decreased more effectively than long sitting when measured the volume. Third, MLD and lymph stick have been decreased more effectively than long sitting when extracellular distribution ratio was measured. Fourth, there was no significant difference in oxygen saturation for each intervention. Fifth, the body temperature was higher in the lymph stick than the long sitting and did not differ from the MLD.

There were no clear conclusion that certain intervention is better. To find out a little more, we conducted the satisfaction survey. In the satisfaction survey, there was no difference in the time satisfaction category for each intervention.

In terms of overall satisfaction, Lymph stick showed more satisfactory effects than long sitting. MLD and lymph stick showed higher satisfaction rate in the reduction of edema.

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