

## Evaluation Method of Fomentation in Japan

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### Abstract

Our previous study demonstrated an increase in the serum adiponectin level and a decrease in soluble urokinase-type plasminogen activator receptor after the application of fomentation to femoral skeletal muscle in healthy people. In our *in vitro* studies, it was confirmed that thermal stimulation of human normal skeletal muscle cells gives a significant change in gene expression related to atherosclerotic cardiovascular disease. The local heat stimulation may have various influences on the skeletal muscles widely distributed throughout the body, there have been no studies on the evaluation of the influences of fomentation on metabolism or cell activity. Therefore, we reviewed the literature, focusing on the evaluation methods using physiological parameters in fomentation used in studies performed by researchers in nursing or clinical nurses, and studied the present status of the evaluation of fomentation using physiological parameters and the possibility of evaluation based on the metabolic function. Using the Web Japan Medical Abstract Society, we searched the database between 2004 and 2015 with either "fomentation" or "heat" as a key word and "original articles" as a condition. In the 74 reported articles evaluated in this study, the effects of fomentation were assessed based on the vital signs, skin surface temperature, skin blood flow, vascular distension rate, vascular circumference, cerebral blood flow, autonomic activity etc. However, there is no established method of effective fomentation and no consensus has been reached on the influences of local changes following fomentation. In addition, there have been no reports on the influences of fomentation on metabolism.

**Keywords:** Fomentation; Heat; Hot Compress; Thermal Stimulation; Prevention of ASCVD

### Abbreviations

HSP: Heat Shock Protein; ASCVD: Atherosclerotic Cardiovascular Disease

### Introduction

Fomentation is a method of hyperthermia, and an increase in the local blood flow following local thermal stimulation affects the entire body [1]. Fomentation as a nursing technique is used mainly for physical and psychological comfort. Its promoting effects on circulation mainly in the skin (blood flow, temperature) and autonomic nervous system, sleep onset, and intestinal peristalsis have been reported. Stimulation using fomentation induces cutaneous blood vessel dilation by inhibiting sympathetic nervous activity through the hypothalamus. In general, effects due to sympathetic activity inhibition are not local [2,3]. Assuming that the effects of fomentation are not local, there is a possibility that it also affects tissues throughout the entire body and the metabolic function. Some studies have shown the influences of local changes after fomentation on the entire body [4,5], or the expectation of the influences of local effects on blood flow and cell activity [6] and others have shown that heat has only local effects such as an increase in the skin temperature and does not affect the body temperature unless used for major blood vessels [7].

On the other hand, in hyperthermia, an effect via heat shock protein (HSP) is expected and induction of expression of the HSP 70 family has been reported to improve insulin resistance [8,9]. It has been reported that thermal stimulation of skeletal muscle may be a method to promote glucose metabolism by HSP activity [10]. In addition, it has been reported that hot water bathing showed a favorable effect on atherosclerotic and central haemodynamic parameters [11]. Also, thermal stimulation of skeletal muscle is known to encourage preventive effects against atherosclerotic cardiovascular disease (ASCVD) as exercise [12].

Our previous study [13] demonstrated an increase in the serum adiponectin level and a decrease in soluble urokinase-type plasminogen activator receptor after the application of thermal sheets to femoral skeletal muscle in healthy males and females. In nursing, the use of thermal sheets for various purposes has been reported as a compressing method with moderate continuous hyperthermic effects. The results of our previous study suggested the effects of thermal stimulation on ASCVD preventable factors. Furthermore, in our in vitro studies, it was confirmed that thermal stimulation of human normal skeletal muscle cells gives a significant change in gene expression related to ASCVD, and utilization of thermal stimulation effect was expected for prevention of ASCVD [14].

The local heat stimulation may have various influences on the skeletal muscles widely distributed throughout the body, there have been no studies on the evaluation of the influences of fomentation on metabolism or cell activity in nursing. Metabolism is a term used to refer to the sum of physiochemical reactions in the body or the sum of physiochemical reactions involving specific molecules. To investigate metabolic behavior, comprehensive measurements of the activities of transcripts of involved genes, enzymes, and metabolites are important [15].

Therefore, we reviewed the literature, focusing on the evaluation methods using physiological parameters in fomentation used in studies performed by researchers in nursing or clinical nurses, and studied the present status of the evaluation of fomentation using physiological parameters and the possibility of evaluation based on the metabolic function. This review is necessary to examine ways to use the thermal method and to use it for the prevention of ASCVD.

## Materials and Methods

### Literature search methods

Using the Web Japan Medical Abstract Society Ver.5, we searched the database between 2004 and 2015 with either “fomentation” or “heat” as a key word and “original articles” as a condition, and retrieved 174 articles using “hot compress” as a key word and 2,313 using “heat” as a key word. These articles were narrowed down based on the conditions described below. As a result, 308 original articles by nurses were retrieved. Of the 308 articles, 74 were selected by the reasons mentioned below and evaluated in this study.

### Authors of studies

Since the purpose of this study was to clarify the physiological evaluation of fomentation in nursing, study articles in which the first author was a nurse were included. Whether or not the researcher was a nurse was determined based on the author’s affiliation and the name of the journal containing the article.

### Subjects of studies

Articles with adults as the subjects were included. To assess the possibility of evaluation based on the metabolic function, children were excluded. In addition, the pregnancy, delivery, and puerperal periods were excluded because of differences in the metabolic function between these periods and the non-pregnancy period.

### Study methods

Only interventional studies in which the effects of fomentation were physiologically evaluated were included in this study. Interventional studies were defined as studies such as experimental, quasi-experimental, and preparatory experimental studies in which data

were collected following certain procedures, and 2 or more subjects were analyzed. To clarify the methods of evaluating the influences of local heat stimulation on the entire body, previous studies in which skin application type fomentation (heat-generating sheets, hot packs, and hot towels) were used, and physical (physiological) evaluation was performed were included. Bed bath, bath, and sauna, which are not local heat stimulation methods, heated drug administration, and moxibustion were excluded. Studies in which fomentation were used in combination with other types of care were included, except for studies in which their purpose was the evaluation of other types of care, not fomentation.

### Analysis

References selected using the above methods were analyzed from the following aspects.

#### Intervention methods when the effects of fomentation used in the nursing field are physiologically evaluated

The trend of physiological evaluation of fomentation is clarified based on the study design, subjects, intervention methods, and purpose.

#### Influences of fomentation used in the nursing field on the body

Based on the method of using fomentation, their influences on the body are evaluated, and the necessity of evaluation in terms of the metabolic function is classified.

### Results and Discussion

#### Physiological evaluation of fomentation in nursing

In the 74 reported articles evaluated in this study, the effects of fomentation were assessed based on the vital signs, skin surface temperature, skin blood flow, vascular distension rate, vascular circumference, cerebral blood flow, range of joint motion, autonomic activity, intestinal sounds, defecation, oral temperature, oral moisture content, degree of edema, and symptoms. The influences of fomentation on metabolism were not reported, but those on the skin blood flow and body temperature were confirmed [4,5,16,17]. In addition, improvement in blood flow using thermal sheets was reported to also increase muscular blood flow [18]. Thus, there is a possibility that these influences on blood circulation in tissues induce functional changes in the tissues and affect metabolism via HSPs.

However, there is no established method of effective fomentation [3,19] and no consensus has been reached on the influences of local changes following fomentation on the entire body. In addition, there have been no reports on the influences of fomentation on metabolism. Further studies are necessary to clarify the influences of fomentation on the body using new parameters such as metabolic functions.

Studies on fomentation involve complicated elements such as hot compress materials, time of use, application sites, techniques, and its combination with other support methods. Therefore, comparison of the results of fomentation among studies is also difficult.

#### Fomentation in nursing with physiological influences

In the 74 original articles evaluated in this study, the purpose of the intervention was to help improvement of defecation, relieve pain, achieve sleep and relaxation, reduce stiff shoulder and contracture, or facilitate intravenous catheterization. Concerning hot compress appliances, hot towels and heat-generating sheets were the most frequently reported, and hot packs, hot-water bottles, and instruments made by researchers themselves were also used.

The temperature for fomentation was constant (38 - 40°C) using heat-generating sheets but varied (37 - 60°C) using other appliances excluding hot-water bottles (constant surface temperature). The local skin temperature after fomentation was reported in 19 subjects, being 33 - 43.1°C 2 - 120 minutes after the application of various appliances to various areas (Table 2). The local skin temperature was 36.4 - 43.1°C in studies in which hot towels, as a frequently used method, were applied to the neck, back, low back, and abdomen and 38.78 - 42.9°C in studies in which heat-generating sheets were applied to the same areas. These results suggest that heat-generating sheets are less affected by a decrease in the temperature of the applied material, and can maintain the skin temperature at a constant level.

The application time was within several tens of minutes for most subjects. Using heat-generating sheets, application for 5 - 8 hours for several days-4 weeks was also observed. Fomentation even for several tens of minutes was reported to affect the body. An advantage of the long-term application of heat-generating sheets is maintenance of the temperature for many hours. A previous study [20] in which the effects of hot towels (60°C, 10 minutes) and heat-generating sheets (40°C, 5 hours) were evaluated for 4 weeks, showed a decrease in the number of days using a laxative in the group using hot towels and improvement in the symptoms of constipation in the group using heat-generating sheets. Although factors associated with these results were not clarified, the effectiveness of the marked change in temperature using hot towels (60°C) and moderate warmth using heat-generating sheets (40°C) was suggested. Whether or not prolonged stimulation (5 hours) in addition to these effects was necessary was unclear in this study, and this should be determined in the future.

Among interventional studies using fomentation in the nursing field in which physiological evaluation was performed, no studies evaluated effects using metabolic parameters. Fomentation has effects by stimulating various areas with heat. These local areas consist of various tissues such as skeletal muscle tissue, fat tissue, subcutaneous tissue, and blood vessels. Since fomentation in nursing has been shown to affect the skin blood flow and temperature, it may affect not only the blood flow in tissues but also cell activity in the tissues and the metabolic function.

In particular, heat-generating sheets frequently used in interventions allow warming of the same areas for many hours. To increase the skin temperature, i.e. cutaneous blood flow, continuation of the use of heat compresses with regular replacement is considered to be desirable [21]. In addition, a previous study showed that prolonged thermal loading using heat-generating sheets increases the blood flow in not only the skin but also trapezius muscle [18,22]. The increased muscle blood flow after 30-minute warming with heat-generating sheets was reported to be maintained even 20 minutes after their removal [23]. It was reported that the skin blood flow in the heat-generating sheet application area (low back) reached a plateau after 45 minutes, but there were no changes in the tympanic temperature, blood flow, or heart rate [5].

One of the purposes of heat compress application is to modify cell activity [6]. Thus, it is necessary to evaluate the effects of heat compresses using parameters of the metabolic function. However, for evaluation of the metabolic function, samples should be obtained, and measurement is not straightforward. Therefore, overall analysis is necessary to determine factors and methods that are appropriate to evaluate the effects of heat compress application. There may be factors that can be measured using residual blood at the time of regular blood collection without imposing an extra burden on subjects. When evaluation methods using metabolic parameters are established, it may become possible to evaluate the systemic influences of heat compress application and the influences of this method to treat chronic inflammation, which may lead to the evaluation of effective interventional methods.

Purpose of intervention	Equipment	Warmed Part	Temperature (°C)*	Period	Bibliography	
Assistance related to urination	Thermal sheet	Lumbar Region or Lower Abdomen	38 to 40	5 to 8 hours a day, 3 days	24, 25	
Assistance related to urination and defecation	Thermal sheet	Lower Abdomen	38 to 40	5 hours a day, 5 days	26	
Assistance on defecation	Warm towel	Lower Back	40 to 43	10 minutes	27	
			43 to 45	15 minutes	29	
			Unknown	10 minutes	30	
			Unknown	20 minutes	31	
		Abdomen or Lumbar Region	Unknown	20 minutes	32	
		Lumbar Region	60	90 minutes	16	
		Abdomen	37 to 39	10 minutes, 4 days	33	
		Lower Back	39.58	10 minutes	34	
	Lower Abdomen	38.25				
	Thermal Sheet	Lower Abdomen	38 To 40	5 to 8 hours a day, 7 days	35	
			40	8 hours a day, 7 days	37	
			40	8.5 ± 1.8 hours a day, 7 days	38	
			60	10 minutes a day, 4 weeks	20	
		Lumbar Region	40	5 hours a day, 4 weeks	40	
		Hot Pack	Lumbar Region	45	30 minutes	40
				50	30 minutes	41
		Foot Bath	Foot	40		
Infusion Pack	Lower Back	Unknown	10 minutes	42		
Hot Pillow	Lower Back	40 to 44	10 minutes	43		
Unknown	Abdomen	Unknown	Once a day, two months	44		
Pain relief	Warm Towel	Wrist to Both Elbow Joints	43 to 44	10 minutes	45	
	Thermal Sheet	Knee Joint	38 to 40	Over 5 hours a day, 7 days	46	
	Hot Pack	Posterior Neck	36 to 37	30 minutes	21	
		Lumbar Region	Unknown	10 minutes	47	
	Hot Water Bottle (Gel)	Shoulder Joint	45	120 minutes	48	
	Ginger Compress	Knee Joint	40 to 50	20 minutes	49	

Assist in venipuncture	Warm Towel	Finger to Wrist Joint	38, 41, 44	15 minutes	50
		Inside Forearm	45	3 minutes	51
	Warm Towel	Forearm	Unknown	10 minutes	52
	Buckwheat Pillow				
	Warm Towel	5 cm above the elbow from the fingertip	50	15 minutes	53
	Gel Heat Retention Tool				
Hot Pack	Inside Forearm	40 ± 2	15 minutes	54	
	Dorsal Forearm				
Assistance for stiff shoulders	Thermal sheet	Scapular Region	40	30 minutes	23
			38 to 40	30 minutes	22
	Hot pack	Shoulder (Right and Left)	42 to 45	10 minutes	55
Improve contracture	Warm towel	Posterior Neck	Unknown	30 minutes	56
Improve edema	Red bean bag	Sole	Unknown	20 minutes	57
Relaxation	Warm towel	Lower Back	43	5 minutes	58
	Hot pack	Eye	47.5 ± 1.5	13 minutes	59
	Hot pack	Lower Back	40 to 42	20 minutes	60
	Foot bath	Foot	40 to 41	20 minutes	
Relaxation and sleep aid	Warm towel	Right Foot	Unknown	15 minutes	61
Assistance to sleep	Warm towel	Posterior Neck	40 To 45	10 minutes	62
			Unknown	10 minutes, 3 days	63
	Hot pack	Lower Thigh	38.5 To 43	50 minutes	64
Evaluation of pleasantness and effect on autonomic nerve	Warm towel	Lower Back	60	10 minutes	65
		Neck to Lumbar Region	78	15 minutes	19
	Warm towel	Posterior Neck	60	10 minutes	3
	Thermal sheet		40		
	Thermal sheet	Posterior Neck	38 to 40	10 minutes	66
Assistance for menstruation associated symptoms	Thermal sheet	Lower Abdomen	38 to 40	5 hours or more per day, about 5 days	67
				More than 5 hours a day, 4 days to 7 days	68
	Thermal sheet	Lumbar Region	40	Average of 8.9 ± 1.3 hours a day, average of 5.7 days ± 1.4 days	69
Assistance for fatigue	Warm towel	Back	Unknown	15 minutes	70
Assistance to drying in the mouth	Hot pack	Salivary Gland Circumference	50	10 minutes	71
	Disposable heating pad	Parotid Gland, Whole Mandible, Occipital Region	50	60 minutes	72
Assistance for abdominal fullness	Warm towel (aroma)	Abdomen	Unknown	14 minutes	73
Assistance for coldness	Warm towel	Posterior Neck	43.9 ± 1.6	15 minutes	75
	Thermal sheet	Lumbar Region	38 to 40	120 minutes	76
Evaluation of influence on biological reaction	Warm towel	Posterior Neck	43 ± 2.0	10 minutes	77
			43.8 ± 1.57	10 minutes	4
			44.5 ± 1.58	10 minutes	78
			Unknown	10 minutes	2
	Warm towel	Foot	About 40	15 minutes	17
	Foot bath		40		
	Thermal sheet	Scapular Region	Unknown	30 minutes	18
		Lower Back	38 to 40	60 minutes	5
		Lower Abdomen or Lower Back	40	120 minutes	79
	Hot pack	Sole, Anterior Surface of Lower Thigh	36 to 40	40 minutes	80
	Hot pack (Physiological saline)	Dialysis Puncture Site	Unknown	10 minutes	81
	Far-infrared sheet	Foot	40 to 43	60 minutes	82
	Red bean bag	Unknown	42.6 to 42.9	30 minutes	83
	Warm towel				
Hot water bottle	Sole	30, 55, 80	120 minutes	1	

\* Unknown was used for those which are not described as to what extent the temperature drops at the time of application.

Table 1: Method of intervention of the reported physiological evaluation of the thermal effect.

Equipment	Warmed Part	Temperature (°C)*	Local skin temperature before application (°C)	Local skin temperature during application (°C)	Bibliography
Warm Towel	Lower Abdomen	39.58	About 38.8	About 36.4 (5 minutes later), about 35.4 (25 minutes later)	34
Warm Towel	Lower Back	38.25	About 38.5	About 36.6 (5 minutes later), about 36 (25 minutes later)	
Warm Towel	Lumbar Region	60	34.7 to 36.4	38.9 (20 minutes later)	16
Warm Towel	Abdomen	Unknown	34	40.4 (7 minutes later), 41 (14 minutes later)	74
Warm Towel	Abdomen or Lower Back	Unknown	Abdomen 34.5, lower back 32.5	Abdomen+4.7, lower back+5.7	32
Warm Towel	Right Foot	Unknown	33.25 ± 0.24	34.14 ± 0.23	61
Warm Towel	Lower Back	60	Unknown	Maximum 43.1	65
Warm Towel	Lower Back	43	Unknown	About +3	58
Warm Towel	Lower Back	43	Unknown	About +3.5	
Warm Towel	Foot	Unknown	32.1 ± 1.2	2.9 ± 1.1 (rise)	17
FootBath			31.7 ± 1.2	3.4 ± 1.4 (rise)	
Warm Towel	Posterior Neck	60	About 35	38.3 (2 minutes later)	3
Thermal Sheet	Posterior Neck	40	About 35	38 (5 minutes later)	
Thermal Sheet	Lower Abdomen	38 to 40	About 34	38 to 40 (0.5 hour later to 5.5 hours later)	67
Thermal Sheet	Scapular Region	Unknown	33.2 ± 0.9	40.3 ± 1.0	18
Thermal Sheet	Lower Back	38 to 40	34.5	39 (45 minutes later)	5
Thermal Sheet	Scapular Region (Trapezius Muscle)	40	33.2 ± 0.5	42.9 ± 2.7 (30 minutes later)	23
Thermal Sheet	Scapular Region	38 to 40	33.2	Maximum 42.9	22
Hot Pack	Inside Forearm	40 ± 2	About 32	About 40 (5 minutes later), about 40 (10 minutes later), about 39.5 (15 minutes)	54
	Dorsal Forearm		About 32	5 minutes about 38.5, 10 minutes about 39, 15 minutes about 39	
Hot Pack	Eye	47.5 ± 1.5	Unknown	41.2 ± 0.78	59
Hot Pack	Lower Back	40 to 42	33.94 ± 2.16	34.53 ± 2.19 (20 minutes later)	60
FootBath	Foot	40 to 41	32.94 ± 2.91	31.97 ± 0.71 (20 minutes later)	
Red Bean Bag	Sole to Dorsum of the foot	Unknown	Unknown	42 (10 minutes later), about 40 to 41 (20 minutes later)	57
Far-Infrared Sheet	Foot (Right and Left)	40 to 43	Right 28.37 ± 3.25, left 29.49 ± 2.86	Right 33.04 ± 2.45, left 33.24 ± 2.32	82

\*Unknown was used for those which are not described as to what extent the temperature drops at the time of application.

Table 2: Temperature loading local temperature.

## Conclusion

Conclusion should reflect and elucidate how the results correspond to the study presented and provide a concise explanation of the allegation of the findings.

Fomentation is used in various ways. However among interventional studies using fomentation in the nursing field in which physiological evaluation was performed, no studies evaluated effects using metabolic parameters. Further studies are necessary to clarify the influences of fomentation on the body using new parameters such as metabolic functions. In the future, new applications can be expected by adding evaluation by the metabolic function to the influence of fomentation in nursing. Furthermore, we believe that the evidence of care will also be strengthened.

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## Conflict of Interest

There is no financial interest or any conflict of interest exists.

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**Volume 2 Issue 3 November 2018**

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