

ORIGINAL PAPER

Thermal Therapy: A Viable Adjunct in the Treatment of Heart Failure?

Despite major advances in pharmacologic, medical devices, and surgical treatment of heart failure, mortality and morbidity remain significantly high. The search for effective and safe modalities continues. One approach that has attracted attention is thermal or heat therapy, which utilizes relatively small increases in core body temperature intermittently for therapeutic purposes.^{1,2} This form of hyperthermia can be achieved by the exposure of all or part of the patient's body to higher-temperature environments for a short period of time or by other means to raise the core body temperature by approximately 1°C. This approach resembles the use of traditional Finnish saunas baths, which have been practiced for thousands of years,³ and other traditional approaches such as use of Turkish baths and Japanese hot springs. During the last decade, several controlled clinical studies have been conducted using heat as a therapeutic modality for cardiovascular diseases such as hypertension, coronary artery disease (CAD), and congestive heart failure.⁴ The findings in these clinical studies are congruent with epidemiologic statistics showing that morbidity and mortality from cardiovascular etiologies are lower in hot environmental temperatures in various geographic regions.⁵⁻⁸

Thermal Therapy

The use of thermal exposure causing periodic increases to the core body temperature and inducing therapeutic effect will be referred as thermal therapy throughout this text. A variety of

The aim of this work was to review and provide a summary of published literature on the clinical impact of thermal therapy (ie, warm water immersion, traditional sauna bathing, and dry infrared sauna) in patients with heart failure. Medline and Embase database literature searches were conducted, and studies that included measurement of heart failure-related clinical parameters were reviewed. Thermal therapy was found to have a positive impact on key heart failure-related parameters across multiple studies. Significant improvements were noted across a wide scope of heart failure-related parameters in the areas of (1) endothelial function, (2) hemodynamics, (3) cardiac geometry, (4) neurohormonal markers, and (5) quality of life. Of special note, thermal therapy also conveyed a strong antiarrhythmic effect in heart failure patients. The clinical evidence highlights repeatable and compelling data showing that thermal therapy may provide an important and viable adjunct in the treatment of heart failure. Congest Heart Fail. 2008;14:180-186. ©2008 Le Jacq

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thermal therapy methods, including traditional sauna, have been studied in patients with heart failure.

Warm Water Immersion/Hydrotherapy Method. One such method consists of warm water immersion of the patient's body in a semirecumbent position at a water temperature of 41°C.⁹ Another water-based method was reported by a German research group that investigated home-based hydrotherapy in patients with New York Heart Association (NYHA) class II or III

heart failure.¹⁰ In this form of hydrotherapy, patients receive warm peripheral baths to a maximum of 40°C followed by the application of cold baths with a temperature of <18°C; this process is repeated 3 times a day for 6 weeks. These studies resulted in clinically measurable improvements in heart failure and excellent patient compliance.¹⁰ However, the main disadvantage is the impact of hydrostatic pressure during water immersion, which can lead to significant increases in right-sided intracardiac

Table. Summary of the Findings of Published Studies on Clinical Impact of Thermal Therapy in Heart Failure Patients

PARAMETERS STUDIED	NO. OF PATIENTS	NYHA CLASS	THERMAL THERAPY METHOD	PARAMETER CHANGE (UNITS)	PARAMETER CHANGE (%)	REFERENCE
Vascular resistance	20	II–III	2 Weeks' dry sauna	↓ SVR from 2267±640 to 1910±451 dynes·s ⁻¹ ·m ⁵	↓ 15.7	2
	32	II–IV	Single dry sauna	↓ SVR from 1795±468 to 1205±320 dynes·s ⁻¹ ·m ⁵ during sauna bath	↓ 32.9	11
	26	II–IV	Single warm water immersion	↓ SVR from 1842±592 to 1077±296 dynes·s ⁻¹ ·m ⁵ during thermal therapy	↓ 41.5	11
	32	II–IV	Single dry sauna	↓ PVR from 238±74 to 213±62 dynes·s ⁻¹ ·m ⁵	↓ 10.5	11
Ejection fraction	20	II–III	2 Weeks' dry sauna	↑ FMD from 4.4±2.5 to 5.7±2.5 %	↑ 29.5	2
	28	II–IV	Single dry sauna	↑ From 24.1%±8.2% to 28.5%±8.6%	↑ 18.3	11
	20	II–IV	Single warm water immersion	↑ From 23.8%±9.5% to 29.2%±10.6%	↑ 22.7	11
	53	III–IV	4 Weeks' warm water immersion and/or sauna bath	↑ From 24%±7% to 31%±9%	↑ 29.2	14
Cardiac index	32	II–IV	Single dry sauna	↑ From 2.7±0.5 to 4.0±0.7 L/min/m ²	↑ 48.1	11
	26	II–IV	Single warm water immersion	↑ From 2.8±0.5 to 4.2±0.7 L/min/m ²	↑ 50	11
Stroke index	32	II–IV	Single dry sauna	↑ From 36±7 to 41±7 mL/min/m ²	↑ 13.9	11
	26	II–IV	Single warm water immersion	↑ From 37±7 to 43±7 mL/min/m ²	↑ 16.2	11
Diastolic blood pressure	32	II–IV	Single sauna bath	↓ Diastolic blood pressure	–	9
	26	II–IV	Single warm water immersion	↓ From 79±12 to 68±10 mm Hg after bath	↓ 13.9	11
	32	II–IV	Single dry sauna	↓ From 78±10 to 67±11 mm Hg after bath	↓ 14.1	11
Systolic blood pressure	20	II–III	2 Weeks' dry sauna	↓ From 107±22 to 97±17 mm Hg	↓ 9.3	2
	15	II–III	4 Weeks' dry sauna	↓ From 101±13 to 98±14 mm Hg	↓ 3.0	47
Intracardiac pressures	34	II–IV	Single dry sauna or warm water immersion	↓ PAP, PCWP, RAP	–	11

table continues on next page

excretion of NO metabolites (nitrate and nitrite) following thermal therapy, suggesting increased NO activity as a result of thermal therapy.¹⁶

Cardiac Function. Cardiac function was assessed in several studies by measuring EF, cardiac index, and stroke index. In a trial using a single dry sauna treatment, it was shown that cardiac index and stroke index increased by 48.1% and 13.9%, respectively, in NYHA class II through IV patients during treatment.¹¹ In addition, EF was increased from 24.1%

to 28.5% during thermal therapy in this study. Subsequent studies utilizing repeated thermal therapy treatments (1–2 times/d, 5 times/wk for 4 weeks) resulted in increasing the EF of NYHA class III and IV patients from 24% to 31%.¹⁴ These patients also averaged a >1-class improvement in the NYHA scale after 4 weeks of repeated thermal therapy treatment.

Cardiac Geometry (Size and Shape).

Heart failure can result in dilation of the cardiac chambers and hypertrophy of the myocardium.²¹ The level of the

resultant cardiomegaly is an indicator of the severity of the disease. Thermal therapy was found to positively influence cardiac geometry. Cardiothoracic ratio (CTR) was shown to decrease after repeated applications of thermal therapy.^{2,13,14,22} Two weeks of dry thermal therapy resulted in decreased CTR from 60% to 57% in patients with both dilated and ischemic cardiomyopathy.²² In another study, 4 weeks of thermal therapy resulted in a reduction of CTR from 61% to 55% in NYHA class III and IV patients.¹⁴ The echocardiography parameter left

Table. Summary of the Findings of Published Studies on Clinical Impact of Thermal Therapy in Heart Failure Patients (continued)

PARAMETERS STUDIED	NO. OF PATIENTS	NYHA CLASS	THERMAL THERAPY METHOD	PARAMETER CHANGE (UNITS)	PARAMETER CHANGE (%)	REFERENCE
Arrhythmia	34	II–IV	Single dry sauna or warm water immersion	Noted ↓ coupled or multiform extrasystoles	–	11
	26	II–III	2 Weeks' dry sauna	↓ PVC from 2993±905 to 1476±592 PCVs/24h	↓ 50.7	22
	20	II–III	2 Weeks' dry sauna	↓ PVC from 3161±104 to 848±415 PCVs/24h ↑ HRV	↓ 73.2	13
Cardiac geometry	28	II–IV	Single dry sauna	↓ LV and LA dimensions	–	11
	20	II–IV	Single warm water immersion	↓ LV and LA dimensions	–	11
	20	II–III	2 Weeks' dry sauna	↓ CTR from 58.2%±7.1% to 55.9%±7.9% ↓ LVEDD from 59±8 to 57±9 mm	↓ 4 ↓ 3.4	2
	20	II–III	2 Weeks' dry sauna	↓ CTR from 59%±1 to 56%±2%	↓ 5	13
	26	II–III	2 Weeks' dry sauna	↓ CTR from 60%±2% to 57%	↓ 5	22
	56	III–IV	4 Weeks' warm water immersion and/or sauna bath	↓ CTR from 61%±5% to 55%±4% ↓ LVEDD from 66±5 to 62±5 mm	↓ 9.8 ↓ 6.1	14
Mitral regurgitation	34	II–IV	Single dry sauna or warm water immersion	Decreased in 20 cases out of 26 with mitral regurgitation at baseline	–	11
Sign and symptoms	56	III–IV	4 Weeks' warm water immersion and/or sauna bath	↓ 1.2 NYHA class	–	14
	15	II–III	6 Weeks' peripheral warm water baths and cold applications	Improved positive mood, physical capacity, relaxation, socialization, and depression	–	10
	20	II–III	2 Weeks' dry sauna	Clinical symptoms: dyspnea, fatigue, edema, sleeplessness, appetite loss, and constipation—improved in 17/20 patients	—	13
BNP	20	II–III	2 Weeks' dry sauna	↓ From 425±102 to 229±54 pg/mL	↓ 46.1	13
	26	II–III	2 Weeks' dry sauna	↓ From 514±141 to 204±92 pg/mL	↓ 60.3	22
	20	II–III	2 Weeks' dry sauna	↓ From 441±444 to 293±302 pg/mL	↓ 33.6	2
NO bioavailability	12	"Infants with severe CHF"	4 Weeks' dry sauna	↑ From 310 to 600 μmol/L in urine	↑ 93.5	16

Abbreviations: BNP, brain natriuretic peptide; CHF, congestive heart failure; CTR, cardiothoracic ratio; FMD, flow-mediated dilation; HRV, heart rate variability; LA, left atrial; LV, left ventricular; LVEDD, left ventricle end diastolic dimension; NO, nitric oxide; NYHA, New York Heart Association; PAP, pulmonary artery pressure; PCWP, pulmonary capillary wedge pressure; PVC, premature ventricular contraction; PVR, peripheral vascular resistance; RAP, right atrial pressure; SVR, systemic vascular resistance. Symbols: ↑, increased; ↓, decreased.

ventricular end diastolic dimension has also shown a similar trend to the reductions in CTR. Left ventricular end diastolic dimension was shown to decrease by 3.4% and 6.1% after 2 and 4 weeks of dry thermal therapy, respectively.^{2,14} These decreases in

cardiac geometry provide an indicator of improved cardiac status in patients treated with thermal therapy.

Cardiac Arrhythmias and Sudden Death. Patients with heart failure have a high prevalence of potentially

serious arrhythmias and, consequently, a high incidence of sudden cardiac death.^{23–25} The presence of ventricular arrhythmias also defines a high-risk patient group with either ischemic or nonischemic cardiomyopathy.^{26–29} This gives special importance to the

effect of thermal therapy on cardiac arrhythmias.

While the potential for increased arrhythmias during thermal therapy was initially a major concern with sauna therapy, early observations in patients post-myocardial infarction (MI) found that they tolerated thermal therapy without increased risk of cardiac arrhythmias and other complications.³⁰ In that study, sauna bathing at 90°C did not increase the risk of arrhythmias to levels higher than those of other everyday stress situations. Subsequently, the effects of 60°C dry sauna on arrhythmias was examined specifically in patients with advanced heart failure and provided significant reductions in cardiac arrhythmia.²² This study in 26 patients with dilated cardiomyopathy and ischemic cardiomyopathy showed a significant decrease in premature ventricular contractions from a mean of 2993 to 1476 per 24-hour period following 2 weeks of thermal therapy. An additional study with 30 NYHA class II and III patients reported a 73% reduction in premature ventricular contractions (from 3161 to 848 per 24-hour period) following 2 weeks of thermal therapy.¹³ Other forms of arrhythmias, such as couplets and episodes of ventricular tachycardia, were found to be decreased by 50% and 75%, respectively.

In addition to arrhythmia reduction, heart rate variability (HRV) was also found to be significantly increased following thermal therapy.¹³ Increased HRV is a sign of improved cardiac rhythm,^{31,32} while a low level of HRV is associated with an enhanced risk of ventricular fibrillation and an overall poor prognosis for heart failure patients.³³ Based on various studies, it has been speculated that the decreased incidence of ventricular arrhythmias following thermal therapy may be attributed to decreased ventricular stretch.¹³

Neurohormonal Markers. There is significant evidence³⁴ of short-term hormonal changes during sauna

bathing, for example, in norepinephrine (2- to 4-fold increase), renin activity (1.5- to 2-fold increase), angiotensin II (3-fold increase), and aldosterone (3- to 6-fold increase). In terms of longer-term impact, a 2-week study utilizing dry thermal therapy found no sustained changes in epinephrine, norepinephrine, or dopamine levels; however, significant reductions in brain natriuretic peptide (BNP) from baseline were noted.^{2,13} The level of BNP is an important prognostic indicator in patients with heart failure.^{35,36} The mean value of BNP was found to drop significantly in heart failure patients who received dry thermal therapy for 2 weeks.^{2,13,22} One such dry thermal therapy study showed a 60% decrease in BNP from 514 to 204 pg/mL.²² Another dry thermal therapy study showed a significant correlation between the percentage improvement in BNP concentration and the change in FMD, with increased FMD being a potential indicator of improved endothelial function in these patients.²

Quality of Life and Heart Failure-Related Symptoms. Heart failure is a debilitating disease; patients usually suffer from low exercise capacity in addition to many restrictive symptoms such as leg edema and dyspnea. Besides the physical manifestations, depression and sleep disorders are not infrequent in such patients. Consequently, quality of life (QOL) deteriorates with the progression of heart failure. The impact of thermal therapy on the QOL of heart failure patients has been the subject of various studies.

A German study on home-based hydrotherapy conducted QOL studies during a 6-week course of thermal therapy in patients with NYHA class II or III heart failure.¹⁰ QOL, which was assessed using a validated questionnaire, was significantly improved in terms of physical capacity, enjoyment, and relaxation. Heart failure-related symptoms were also found to be significantly improved in this study.

A group of Swedish researchers examined an exercise program in a temperature-controlled swimming pool.³⁷ In this study, 15 patients with NYHA class II or III heart failure were instructed to perform exercises in the warm water (30–34°C) for 45 minutes, 3 times a week for 8 weeks. The patients who exercised in warm water saw significant improvement in terms of maximum exercise capacity. Two different questionnaires, the Short Form-36 Health Survey Questionnaire and the Minnesota Living with Heart Failure Questionnaire, were used. The results demonstrated that exercise capacity improvement was also associated with improvement in QOL for these patients.

Dry sauna thermal therapy was also found to improve other related symptoms in heart failure. One thermal therapy study noted significantly decreased rates of mitral regurgitation during and after thermal therapy in 20 of 26 patients with mitral regurgitation at baseline.¹¹ Two weeks of dry thermal therapy in 20 patients with dilated and ischemic cardiomyopathy was found through a self-assessment QOL questionnaire to improve a composite of symptoms including dyspnea, fatigue, edema, sleeplessness, appetite loss, and constipation in 17 out of 20 patients.¹³ Longer treatments for 4 weeks were also shown to significantly decrease NYHA class (1.2-class reduction) in a study involving 56 NYHA class III and IV patients.¹⁴

Thermal Therapy Safety Profile

When considering the potential use of thermal therapy as a therapeutic modality, one may question the safety of this practice. Since heart failure is a complex syndrome that is frequently compounded by other conditions such as CAD and MI history, it is of paramount importance to understand the established safety profile of thermal therapy.

Thermal Therapy and CAD. A great deal of experience of thermal exposure with conditions such as CAD came

from the studies on Finnish sauna.³⁸ The benefits and risks of Finnish sauna were studied comprehensively in a meta-analysis that covered literature from 1966 to 2000.³⁴ This meta-analysis included 130 original papers that examined sauna treatment in relation to major health problems and physiologic systems. The authors reported that sauna is safe for most individuals with coronary heart disease, stable angina pectoris, and old MI.³⁴ Patients with coronary heart disease were found to tolerate sauna well; only 2% reported chest pain during sauna, whereas 60% had chest pain during normal daily life.³⁴ Other reports from Norway and Germany supported that sauna is well tolerated by CAD patients.³⁸ When comparing thermal treatment with exercise, several studies reported that the occurrence of myocardial ischemia in CAD patients during sauna was found to be significantly less than during exercise.^{39,40}

Thermal Therapy and MI. It was found that the risk of MI⁴¹ and sudden death⁴² are lower during sauna bathing than during other daily activities. A 10-year follow-up of 117 post-MI patients showed that 82% continued regular sauna use.⁴¹ During the 10-year follow-up, no occurrences of sudden death, reinfarction, or serious arrhythmia were attributed to sauna bathing in these post-MI patients. In addition, cardiac arrhythmias were rare during thermal therapy compared with during physical exercise.

Thermal Therapy and Pharmacotherapy. The ability of patients to maintain standard heart failure medication use when receiving thermal therapy is vitally important. Reports from Finnish sauna studies have shown that the combination of sauna with cardiovascular drugs, such as calcium antagonists, digitalis, diuretics, and long-acting nitrates, does not produce harmful reactions.³⁸ One early report suggested that β -blockers, particularly those

with marked bradycardic effect, may impact the increase in heart rate due to heat stress, thus creating a hypotensive reaction. However, in more contemporary studies, patients who received thermal therapy continued using their regular medication for heart failure before and during the course of thermal therapy without reported adverse effects.^{2,14} The effect of hyperthermia on the absorption, distribution, and elimination of orally administered drugs, including propranolol, captopril, and midazolam is minor.³⁴ However, the absorption of transdermally and subcutaneously administered drugs was found to be increased, which should be taken in consideration during the application of thermal therapy.

Cautions and Contraindication of Thermal Therapy. There are few conditions that were found to be negatively affected by hyperthermic exposure or are a contraindication for this practice. One risk group could be patients on the antiepileptic drug topiramate. Environmental temperature was found to be a risk factor for topiramate-related hyperthermia⁴³; therefore, thermal therapy is not recommended for patients undergoing treatment with topiramate.

Patients with pulmonary hypertension should also be cautioned. While no specific mention of pulmonary hypertension was found in the literature reviewed, the monograph for epoprostenol sodium, a vasodilator used in the treatment of primary pulmonary hypertension, indicates that patients should avoid situations that promote vasodilation such as saunas, hot baths, and sunbathing. Severe hypotension has been seen in patients treated with chronic epoprostenol infusions under such circumstances.

Another risk factor could be pregnancy. Although there is evidence that sauna bathing is safe during pregnancy,³⁴ sauna bathing for pregnant women in early pregnancy was suspected to increase risk of neural tube defects.^{44,45}

Other conditions that were reported to be contraindicated for thermal therapy include the following:

- Unstable angina pectoris (ie, angina that has developed for the first time recently or worsening of preexisting angina for no apparent reason).⁴⁶
- Recent MI.³⁴ However, in a study that involved 102 MI patients, the mean time for restarting sauna bathing for persons accustomed to Finnish sauna was reported to be 6.7 weeks (the range was 3–24 weeks).³⁰
- Decompensated heart failure, uncontrolled hypertension, and/or severe aortic stenosis.³

Summary

Based on the literature reviewed, the following findings were obtained:

- 1) Preponderance of evidence: Most of the studies reviewed have been relatively small observational studies and involve different forms of thermal therapy; however, the preponderance of the evidence highlights repeatable and compelling data across a myriad of heart failure symptoms and markers that significant clinical benefits can be obtained using thermal therapy (See Table).
- 2) Limited adverse events: Thermal therapy offers many potential benefits; as a nonpharmacologic treatment, it is generally devoid of adverse reactions. None of the studies reported major adverse events.
- 3) Widespread applicability: Unlike exercise training, heart failure patients who are physically unfit, in frail health, or aged or who have orthopedic limitations would not generally be exempt from use of thermal therapy.
- 4) QOL improvements: Thermal therapy has also been shown to promote mental and physical relaxation, leading to improved QOL including increased appetite, sleep quality, and general well-being.

Given these findings, as well as the noninvasive nature of thermal therapy, this approach may be an ideal adjunct therapy for widespread application in the treatment of heart failure.

Conclusions

As an adjunct, thermal therapy can generally be utilized with standard heart failure treatments to enhance clinical outcomes without additional risk in a large cross-section of heart failure patients. Of importance, thermal

therapy has shown substantial clinical benefits across a variety of heart failure-related areas such as hemodynamics, endothelial function, cardiac geometry, arrhythmias, and sudden death, among others. Given these important attributes and the potential clinical

benefits, a large-scale randomized study of thermal therapy is warranted to further elucidate these findings.

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