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Original Research Article

# Effects of Exercise Training with a Sauna Suit on Cardiovascular Health: a Proof-of-Concept Study

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## *Abstract*

**Introduction:** Cardiovascular disease (CVD) is the leading cause of death worldwide, accounting for 17.3 million deaths per annum, a figure that is projected to grow to more than 23.6 million by 2030. It has been estimated that 80% of premature heart disease can be prevented through positive modification of CVD risk factors. It has been demonstrated that systemic thermal therapy by regular administration of heat through a variety of methodologies, such as sauna or taking a warm bath, can induce a number of advantageous responses in terms of cardiovascular health. However, no studies have investigated the effects of exercise training with a sauna suit, a practical and portable alternative to other thermal treatments, on cardiometabolic risk factors. The purpose of this study was to determine the effectiveness of exercise training with a sauna suit at positively modifying cardiometabolic risk factors. **Methods:** Twelve men (mean ± SD: age, height, weight, percentage body fat, and $VO_2max$ = 25.3 ± 7.3 yr, 179.6 ± 5.7 cm, 78.6 ± 7.6 kg, 14.6 ± 3.3 %, and 50.4 ± 8.8 mL/kg/min, respectively) completed a 6wk exercise training program (30min sessions performed 5 days/wk at a moderate-intensity of 55-60% heart rate reserve) while wearing a sauna suit. Cardiometabolic risk factors were measured at baseline and post-program. **Results:** After 6wk of exercise training with a sauna suit there were significant ($p < 0.05$) improvements in the following cardiometabolic risk factors: percentage body fat (relative Δ -1.5%), systolic (relative Δ -1.4%) and diastolic (relative Δ -3.1%) blood pressure, triglycerides (relative Δ -15.5%), HDL cholesterol (relative Δ +6.4%), and maximal oxygen uptake (relative Δ +8.5%). **Conclusions:** Findings from the present study support the feasibility of exercise training with a sauna suit to improve cardiovascular health. Indeed, the present study demonstrated that regular moderate-intensity exercise training with a sauna suit elicited improvements in cardiorespiratory fitness and positive modification to several key CVD risk factors.

**Key Words:** Heart Disease, Hyperthermic Conditioning, Physical Activity, Prevention

## Introduction

Cardiovascular disease (CVD) is the leading cause of death worldwide, accounting for 17.3 million deaths per annum, a figure that is projected to grow to more than 23.6 million by 2030[1]. It has been estimated that 80% of premature heart disease can be prevented through positive modification of CVD risk factors[2]. In particular, regular physical activity has been shown to confer a myriad of health benefits, including the prevention of numerous CVD risk factors such as hypertension, obesity, Type 2 diabetes, and dyslipidemia[3]. Moreover, contemporary evidence has demonstrated that systemic thermal therapy by regular administration of heat through a variety of methodologies (e.g., sauna and hot tub) can also induce a number of advantageous responses in terms of cardiovascular health. Indeed, chronic exposure to heat stress (in the form of sauna bathing) has been reported to be associated with a reduced risk of cardiovascular disease and mortality from all-causes[4]. Additionally, Krause and colleagues (2015) reported that heat therapy reduces fasting glycemia, glycated hemoglobin, body weight, and adiposity[5].

There is also evidence that exercise in conjunction with heat therapy provides cardiovascular health benefits. For instance, it has been demonstrated that 3 weeks of post-exercise sauna bathing elicits an improvement in cardiorespiratory fitness, most likely due to an increase in plasma volume[6]. However, to our knowledge, no studies have investigated the effects of exercise training with a sauna suit on cardiometabolic risk factors. It is plausible that exercise training with a sauna suit may provide fitness enthusiasts with a more practical and portable heat therapy alternative when compared to other thermal treatments. The purpose of this '*proof-of-concept*' study was to determine the potential effectiveness of exercise training with a sauna suit at positively modifying cardiometabolic risk factors. It was hypothesized that exercise training with a sauna suit would elicit improvements in cardiovascular health.

## Methods

### Participants

12 healthy and physically active young-to-middle age adults (18 to 44 years of age) consented to participate in the study. Participants were eligible for inclusion into the study if they were low risk and physically active as defined by the American College of Sports Medicine[7]. This study was approved by the Human Research Committee at Western State Colorado University.

### *Experimental Design*

At baseline and post-program, measurements were obtained for all primary outcome variables presented in Figure 1. All baseline and post-program measurements were obtained from each participant at similar times of the day (± 2 hrs).

All participants completed a standardized 6wk exercise training program that consisted of 30min of exercise performed on a cycle ergometer at moderate-intensity (55-60% heart rate reserve – HRR) for 5 days/wk. All exercise sessions were directly supervised, completed while wearing a sauna suit (Kutting Weight, LLC., Los Angeles, CA), and performed in controlled environmental conditions (19°C). The intervention was based on pilot testing from four experimental trials: (1) 30 minutes of moderate-intensity exercise (55-60% HRR) with a sauna suit, (2) 20 minutes of vigorous-intensity exercise (75-80% HRR) with a sauna suit, (3) 30 minutes of moderate-intensity exercise (55-60% HRR) without a sauna suit (i.e., control), and (4) 20 minutes vigorous-intensity exercise (75-80% HRR) without a sauna suit (i.e., control). In the moderate-intensity exercise trial condition there was a **~45%** greater excess post-exercise oxygen consumption (EPOC) with the sauna suit (70 calories) vs. control condition (45 calories). Likewise, in the vigorous-intensity exercise trial condition there was a ~**20%** greater EPOC with the sauna suit (72 calories) vs. control condition (88 calories).The 150 min/wk exercise training with the sauna suit were substituted for pre-existing exercise training for each participant in a manner that resulted in overall exercise training volume and intensity remaining unchanged throughout the 6wk intervention period. This experimental design permitted examination of the effectiveness of ***exercise training with a sauna suit*** at positively modifying cardiometabolic risk factors. Participants were strictly instructed to maintain their other exercise training and dietary regimens.

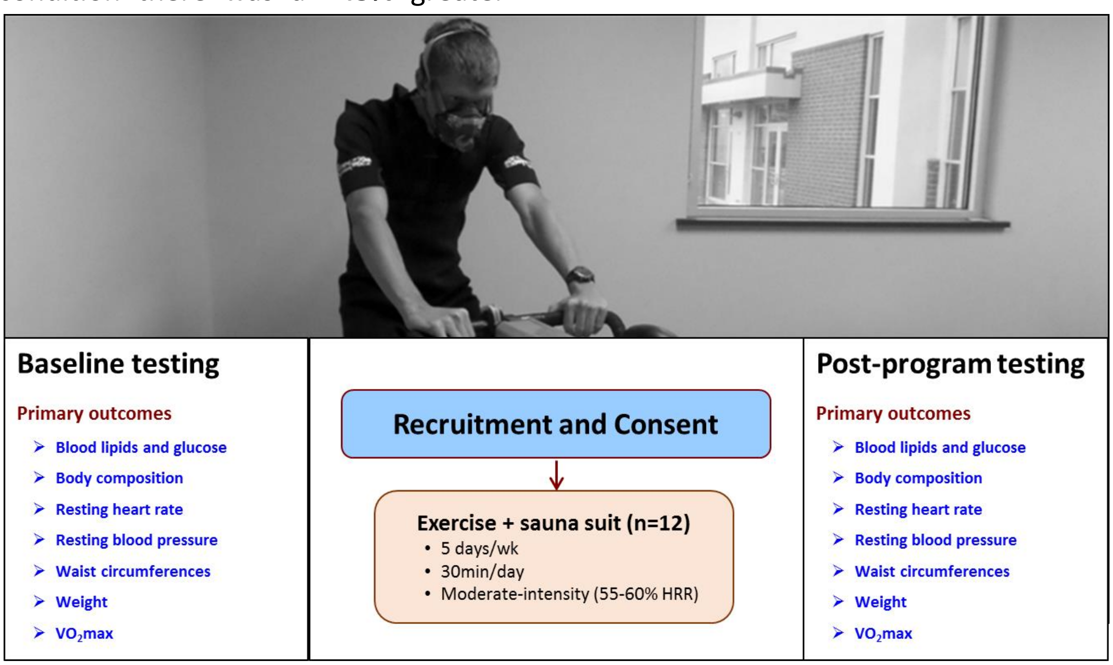


**Figure 1.** Experimental design for cardiometabolic responses to exercise training with a sauna suit.

## Protocols

*Physical and physiological measurements*

All physical measurements were obtained using standardised guidelines[7]. Briefly, participants were weighed to the nearest 0.1 kg on a medical grade scale and measured for height to the nearest 0.5 cm using a stadiometer. Percent body fat was determined via hydrostatic weighing. Waist circumference measurements were obtained using a cloth tape measure with a spring loaded-handle (Creative Health Products, Ann Arbor, MI). A horizontal measurement was taken at the narrowest point of the torso (below the xiphoid process and above the umbilicus). These measurements were taken until two were within 0.5 mm of each other.

*Fasting blood lipid and glucose measurement*

All fasting lipid and blood glucose analyses were collected and performed at room temperature. Participants' hands were washed with soap and rinsed thoroughly with water, then cleaned with alcohol swabs and allowed to dry. Skin was punctured using lancets and a fingerstick sample was collected into heparin-coated 40 μl capillary tube. Blood was allowed to flow freely from the fingerstick into the capillary tube without milking of the finger. Samples were then dispensed immediately onto commercially available test cassettes for analysis in a Cholestech LDX System (Alere Inc., Waltham, MA) according to strict standardized operating procedures. The LDX Cholestech measured total cholesterol, high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol, triglycerides, and blood glucose in fingerstick blood. A daily optics check was performed on the LDX Cholestech analyzer used for the study.

*Resting heart rate and blood pressure measurements*

The procedures for assessment of resting HR and blood pressure outlined elsewhere were followed[7]. Briefly, participants were seated quietly for 5 minutes in a chair with a back support with feet on the floor and arm supported at heart level. Resting HR was obtained by palpating the radial artery for pulse for 60 seconds. The left arm brachial artery blood pressure was measured using a sphygmomanometer in duplicate and separated by 1 minute. The mean of the two measurements was reported for baseline and post-program values.

*Maximal exercise test*

Participants completed incremental maximal exercise on a cycle ergometer (Viasprint 150P; Sensormedics Corp., Palm Springs, CA) at baseline and post-program during which gas exchange data, power output, and HR were assessed. Participants completed 2 minutes of pedaling at 50 Watts as a warm up. Workload was then increased in a steplike manner equal to 8-12 Watts/20 seconds to elicit volitional fatigue in approximately 10-12 minutes. The specific workload increment for each test was matched to participant fitness level. Pedal cadence was maintained at 70-90 rev/min, with volitional fatigue representing a failure to sustain pedal cadence greater than 40 rev/min. Workload at volitional fatigue was recorded as peak power output.

*Gas exchange and data analysis*

Prior to each maximal exercise test, the metabolic cart (TrueOne 2400, Parvo Medics, Sandy, UT) was calibrated with gases of known concentrations (16.02% $O_2$, 4.00% $CO_2$) and with room air (20.93% $O_2$ and 0.03% $CO_2$) as per the manufacture guidelines. Calibration of the pneumotachometer was done via a 3 Litre calibration syringe (Hans-Rudolph, Kansas City, MO). Throughout the maximal exercise test continuous pulmonary gas exchange data was obtained. In order to determine $VO_2$max from the maximal exercise test, the final 15 seconds of data were averaged constituting the final data point. The next closest data point was calculated by averaging the data during the 15 seconds prior to the final 15 seconds. The $VO_2$max was represented by the mean of the 2 processed data points provided a plateau was exhibited ($\Delta VO_2 \leq 150$ mL/min)[8].

Determination of both the first ventilatory threshold (VT1) and second ventilatory threshold (VT2) were made by visual inspection of graphs of time plotted against each relevant respiratory variable (according to 15 second time-averaging)[9]. The criteria for VT1 was an increase in $VE/VO_2$ with no concurrent increase in $VE/VCO_2$ and departure from the linearity of VE. The criteria for VT2 was a simultaneous increase in both $VE/VO_2$ and $VE/VCO_2$. Overall ventilatory threshold was recorded as the mean of VT1 and VT2. All assessments were done by two experienced exercise physiologists. In the event of conflicting results, the original assessments were reevaluated and collectively a consensus was agreed upon.

**Statistical analyses**

All analyses were performed using SPSS Version 22.0 (Chicago, IL) and GraphPad Prism 6.0. (San Diego, CA). Measures of centrality and spread are presented as mean ± SD and percentage (%) change from baseline to post-program. Primary outcome measures were the change in cardiometabolic risk factors, including $VO_2$max, systolic blood pressure, diastolic blood pressure, weight, waist circumference, body composition, blood lipids, and blood glucose. Paired t-tests were used to compare the mean cardiometabolic risk factors values between baseline and post-program. The probability of making a Type I error was set at $p \leq .05$ for all statistical analyses.

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## Results

The intervention was well tolerated for all 12 participants. Each of the 12 participants completed all 30 scheduled exercise training sessions. Moreover, across 360 total exercise sessions spanning a total of 180 hours training in the sauna suit, there were no adverse events experienced across all exercise training sessions and all physiological responses remained within normal ranges.

*Cardiometabolic outcomes*

The physical and cardiometabolic characteristics for participants at baseline and 6 weeks post-training are shown in Table 1. After 6wk, there were significant improvements ($p$ < 0.05) in resting heart rate, resting systolic and diastolic blood pressure, body composition, HDL cholesterol, and triglycerides. In contrast, body weight, waist circumference, total cholesterol, LDL cholesterol, and blood glucose were relatively unchanged ($p$ > 0.05) following 6wk of exercise training.

*Maximal exercise test outcomes*

The maximal exercise test outcomes for participants at baseline and 6wk post-training are shown in Table 2. After 6wk, there were significant improvements ($p$ < 0.05) in peak power output, ventilatory threshold, and $VO_2$max.

**Table 1.** Physical and cardiometabolic characteristics at baseline and 6wk. (Values are mean ± SD).

| Characteristic | Baseline | 6wk | relative % change |
|---|---|---|---|
| Age (yr) | 25.3 ± 7.3 | ____ | ____ |
| Height (cm) | 179.6 ± 5.7 | ____ | ____ |
| Body weight (kg) | 78.6 ± 7.6 | 78.2 ± 7.0 | -0.5% |
| Waist circumference (cm) | 81.4 ± 5.7 | 80.8 ± 5.6 | -0.7% |
| Body fat (%) | 14.6 ± 3.3 | 13.1 ± 2.9* | -10.3% |
| Resting HR (b/min) | 60.6 ± 9.2 | 57.4 ± 9.3* | -5.3% |
| Systolic blood pressure (mmHg) | 118.8 ± 3.0 | 117.1 ± 2.6* | -1.4% |
| Diastolic blood pressure (mmHg) | 79.7 ± 4.8 | 77.2 ± 5.0* | -3.1% |
| Total cholesterol (mg/dL) | 177.0 ± 19.2 | 171.3 ± 14.1 | -3.2% |
| HDL cholesterol (mg/dL) | 54.8 ± 14.3 | 58.3 ± 11.9* | +6.4% |
| LDL cholesterol (mg/dL) | 96.7 ± 18.0 | 94.5 ± 16.8 | -2.3% |
| Triglycerides (mg/dL) | 106.3 ± 58.1 | 89.8 ± 52.4* | -15.5% |
| Blood Glucose (mg/dL) | 84.3 ± 6.0 | 83.0 ± 6.4 | -1.5% |

* Within-group change is significantly different from baseline, $p$ < 0.05.

**Table 2.** Performance variables at baseline and 6wk. (Values are mean ± SD).

| Variable | Baseline | 6wk | relative % change |
|---|---|---|---|
| Peak power output (Watts) | 357.8 ± 66.6 | 371.3 ± 66.3* | +3.8% |
| Ventilatory threshold (%) | 66.9 ± 7.7 | 72.5 ± 7.1* | +8.4% |
| $VO_2$max (mL/kg/min) | 50.4 ± 8.8 | 54.7 ± 8.3* | +8.5% |

* Within-group change is significantly different from baseline, $p < 0.05$.

## Discussion

The primary finding of the present study is that a short-term training program consisting of moderate-intensity exercise in conjunction with thermal treatment (i.e., wearing a sauna suit) augmented cardiovascular health. Indeed, classical CVD risk factors, including body composition, HDL cholesterol, and triglycerides were all significantly improved post-intervention. Moreover, cardiorespiratory fitness, an independent and powerful predictor of CVD risk and premature mortality, was also increased. Although administration of heat through a variety of methodologies, including sauna and hot tub, has been previously demonstrated to enhance cardiovascular health, to our knowledge, the physiological responses to exercise training with a sauna suit has not been scientifically explored. As such, the results of this novel '*proof-of-concept*' study are encouraging and support use of a practical and portable sauna suit as a form of thermal treatment to enhance exercise-related health outcomes and prevent CVD.

### Cardiorespiratory response to exercise training with a sauna suit

We found that 6wk of moderate-intensity exercise training with a sauna suit increased $VO_2$max by an absolute amount of 4.3 mL/kg/min. In terms of metabolic equivalents (METs) this equates to ~1.2 METs (3.5 mL/kg/min = 1.0 METs). This magnitude improvement in $VO_2$max is comparable to that reported elsewhere in the literature for more high-intensity interval training (HIT). For example, Helgerud and colleagues reported a 4.9 mL/kg/min increase in $VO_2$max in a cohort of moderately trained men following 8 weeks of HIT consisting of 4 x 4 minutes of running at 90-95% maximal HR[10]. In the past decade being aerobically or physically "unfit" has garnered considerable attention as an independent and powerful predictor of an increased CVD risk and premature mortality[11]. For example, a meta-analysis by Williams[12] showed that there was an ≈40% increase in relative risk for CVD in adults in the lowest quartile of aerobic fitness when compared to the highest quartile, while more recently Blair[13] proposed that a low level of aerobic fitness accounted for more overall deaths compared to those attributable to traditional CVD risk factors, such as obesity, smoking, hypertension, high cholesterol, and diabetes. Accordingly, the results from this current study have novel public health relevance, as a large number of adults fall into defined low aerobic fitness categories[14]. Overall, the improvement in $VO_2max$ (i.e., 1.2 METs) in the present study likely has potentially important long-term prevention implications as a recent work has reported that a 1 MET increase in $VO_2max$ was associated with an 18% reduction in CVD-related mortality[15].

**Cardiometabolic responses to exercise training with a sauna suit**

The blood lipid changes in the present study are also comparable with those typically reported in the literature following aerobic-based exercise training. For instance, in a review on the lipid and lipoprotein adaptations to exercise, Durstine et al. (2001) reported that 15 to 20 miles per week of brisk walking or jogging was associated with an average 2 to 3 mg/dL increase in HDL cholesterol and 8 to 20 mg/dL decrease in triglycerides[16]. Our findings of a 3.5 mg/dL improvement in HDL cholesterol and 16.5 mg/dL reduction in triglycerides are in close agreement with those previously reported. Moreover, low HDL cholesterol values represent a strong modifiable and independent risk factor for CVD[17]. Indeed, it has been estimated that for every 1 mg/dL increase in HDL cholesterol, the risk for a coronary heart disease (CHD) event is reduced by 2% in men[18]. Our data therefore suggests men reduced their risk for a CHD event by ~7% with substitution of 150 minutes per week of exercise with a sauna suit to their overall training regimen.

In a previous meta-analysis[19], it was reported that aerobic exercise training will elicit average reductions in resting systolic and diastolic blood pressure of 3 to 4 mmHg and 2 to 3 mmHg, respectively. The decreased resting systolic blood pressure (-1.7 mmHg) and diastolic blood preeure (-2.5 mmHg) measurements observed in the present study are consistent in magnitude with those previously reported in the literature. Next to low cardiorespiratory fitness, hypertension has been implicated in the second highest number of overall deaths according to one study[13]. Although the reductions in systolic and diastolic blood pressure in the present study appear rather modest in nature, the reality is these training adaptations represent a positive impact on overall CVD risk as it has been demonstrated that blood pressure decreases of as little as 2 mmHg are associated with a 6% decrease in stroke mortality and a 4% decrease in coronary artery disease[20].

**Heat treatment and cardiovascular health: possible mechanisms**

The array of cardiovascular health benefits elicited by exercise training with a sauna suit are likely underpinned by a number of plausible mechanisms. For example, it has been demonstrated that heat therapy leads to elevations in nitric oxide – a potent vasodilator[5]. Ultimately, increased concentrations in nitric oxide can lead to improvements in insulin signaling, body composition, and inflammation[5].

Additionally, increased plasma volume is a hallmark adaptation to chronic heat exposure[6]. In turn, it is well known that increased plasma volume is an important factor mediating improvements in $VO_2$max.

### Methodological Considerations

Possible limitations to the present study merit discussion. First, the present study did not include a control group. Therefore, it cannot be entirely excluded that similar results could be achieved with an exercise alone intervention of equal 6wk duration. Nevertheless, the fact that the 150 min/wk of exercise training with the sauna suit were substituted for pre-existing exercise training for each participant in a manner that resulted in overall exercise training volume and intensity remaining unchanged throughout the 6wk intervention strengthens the likelihood that it was specifically ***exercise training with a sauna suit*** that elicited positive modifications in cardiorespiratory fitness and cardiometabolic risk factors. Additionally, the chronic physiological responses to exercise training with a sauna suit may be more pronounced with a longer training period beyond the 6wk duration of the present study.

## Conclusions

The main findings of the current study indicate that exercise training with a sauna suit confers numerous cardiovascular health benefits. Previous research has shown that chronic exposure to heat stress (in the form of sauna bathing) is linked with reduced risk for both cardiovascular disease and mortality from all-causes[4]. The favorable changes in various cardiometabolic risk factors (body composition, blood pressure, and lipid profile) and cardiorespiratory fitness observed in the present study following exercise training with the sauna suit provide a likely mechanistic explanation for why chronic exposure to heat stress improves long-term health. Overall, exercise training completed while wearing a sauna suit provides individuals with a practical and safe heat treatment alternative to achieve important health and fitness goals.

### Practical Application

- To our knowledge, this '*proof-of-concept*' study is the first to investigate the effects of exercise training with a sauna suit on cardiovascular health.
- The present study provides preliminary evidence that supports use of a practical and portable sauna suit as a form of thermal treatment to enhance exercise-related health outcomes and prevent CVD.
- Overall, these findings are important for exercise physiologists, fitness professionals, and others who design exercise programs and promote physical activity in the adult population.

### Competing interests

This investigation was supported financially by Kutting Weight, LLC. Kutting Weight, LLC was not involved in development of the study design, data collection and analysis, or

preparation of the manuscript. There are no other potential conflicts of interest related to this article.

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