Finger Induced Auto-Thermogenesis

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Abstract

Heat through hand-clasping with a specific finger pose (HCFP) is a tool for eliciting innate immune system response to control the SARs-CoV-2 virus. Fifteen male subjects participate in a study in which ECG and axillary temperature are measured, with and without HCFP. The heat induction is derived from temperature slope and we studied its effect on heart rate variability (HRV) and resting metabolic rate (RMR). Compared to the normal state, the average axillary temperature slope increases by 11.5% along with a significant increase in resting metabolic rate (RMR) ($p<0.05$) respectively. HRV enhances through an increase in SDRR and RMSSD by 23.75 and 24.44%, respectively. The Augmented-LFHF ratio reduces significantly ($p<0.001$). HCFP induces body-heat mediated by parasympathetic nervous system (PSNS) dominance with minimal changes in body temperature due to thermoregulation.

Keywords: HCFP, RMR, HRV

Introduction

The human autonomic responses are designed to maintain body energy stores (fat) through thermogenesis for weight regain or shedding, which is the basis of designing many drugs. Drugs and food (Garlic and cinnamon) are well known sources for auto-thermogenesis. Moreover, auto-thermogenesis improves innate immune system response which is a key parameter in resisting COVID19 spread as the virus mutates frequently. Specific finger poses as a source of auto-thermogenesis is not known so far. Therefore, this study focuses on inducing body heat by hand-clasping with specific finger pose (HCFP- also known as Linga-Mudra in Ayurveda and Siddha literature, the HCFP technique considered in our study is interlocking the fingers of the left and right hand with the right-hand thumb being kept upright).

The rising concerns over the mutative nature of COVID-19 [1], vaccine trials across the globe lack efficacy in human treatment. Such a scenario demands the immune system's readiness, which plays an essential role in overcoming the infections due to virus mutation. Over 600 million years of evolution shows activation of the immune system mediated by fever as a cardinal response to many viral infections that have been preserved in both warm and cold-blooded vertebrates. The thermal element of fever activates the innate and adaptive immune responses [2]. The effect of mild hyperthermia treatment on healthy adults reports an enhancement of innate and adaptive immunity [3]. Therefore, to bolster the immune system, mimicking the condition of hyperthermia is achieved externally through heat ingestion from various sources such as hot-water [4], sun-light that improves metabolic rate innervated by sympathetic activation and internally through peripheral vasoconstriction that not only reduces the heat transfer from the isothermal core to the non-isothermal shell but also improves the insulating capacity of the skin and subcutaneous tissues [5].

The sympathetic division of the autonomic nervous system (ANS) contributes to the effect of metabolic rate through active and passive heat acclimation. The metabolic rate through non-shivering thermogenesis includes many techniques, out of which sitting with clasping the hands is primitive. Its effect on the metabolic rate and ANS is unknown. This study hypothesizes that the HCFP technique induces overall heat generation. The study also explains the dependency of HRV on body heat other than body temperature.

Subjects and Methods

This study includes 15 participants (Height-160±10 cm, Weight-65±10kg) at Dharmathupatti-Madurai from 7th Aug 2020 to 12th Aug 2020.

A. Inclusion Criteria:

The inclusion criteria for the study is as follows

- Healthy participants with no medications.
- Age of 24-60 years old
- Agreed to participate in the trial followed by COVID-19 regulations as per WHO.

B. Exclusion Criteria:

- Female participants as we have collected the experimental data in the bare body to keep the body dry neglecting effects on heat transfer due to clothing.
- Participants with no symptoms of COVID-19.

C. Experimental Protocol:

The experiment duration is 50 minutes per subject. The duration constitutes three phases such as pre-hand-clasping normal (N-1-10 minutes), hand-clasping (HCFP-20 minutes), and post-hand-clasping normal (N-2-20 minutes). The experiment follows 10 minutes of the time window for the analysis such as N-1 (0-10 minutes), HCFP-1 (10-20 minutes), HCFP-2 (20-30 minutes), N-2 (35-45 minutes) as shown in Fig. 1.

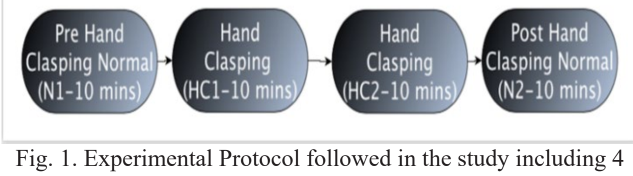

Fig. 1. Experimental Protocol followed in the study including 4 stages of Hand Clasping.

We have collected the ECG, transient body temperature of the participants. The ECG is collected by an ECG-Amplifier

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coupled with Arduino with a sampling frequency of 182 Hz. Adding info for ECG.

The transient body temperature is measured by an LM-35 sensor with a range of 55–150^{0}C and an accuracy of 0.2^{0}C at 25^{0}C. The ambient temperature is maintained at 30^{0}C. The LM-35 records the temperature under the arm (axillary temperature) at a sampling frequency of 1.2 Hz for 1.5 minutes as the reading saturates at 35.5-36.04^{0}C [6]. It provides the rising transient response of temperature. Afterward, the sensor is placed in ambient temperature to bring it back to the reference that lapses for another 1.5 minutes with manual intervention and is repeated for the experimental duration. The set-up is shown in Fig. 2.

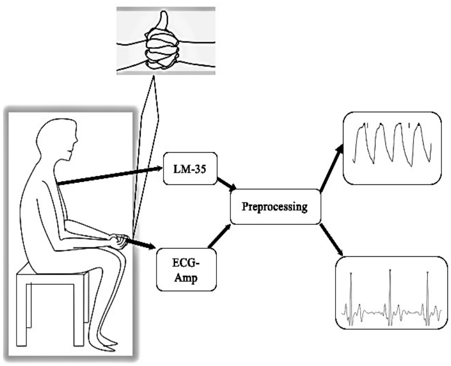

Fig. 2. Experimental Set up for HCFP with Temperature and ECG Sensor.

Statistical Measures:

The signals are filtered and processed prior to evaluation of heat generation and the impact of it on HRV. Following statistical measures are used in the analysis.

Heat Generation:

We quantify the relative heat generation through indirect calorimetry from the slope of the relative temperature change assuming that the heat due to spatial variation of skin temperature is very less compared to heat due to temporal variation.

$$q_g \;\alpha\; \frac{\partial T}{\partial t}_{max} \qquad (1)$$

The slope is found by signal processing as shown in flow chart below in Fig. 3.

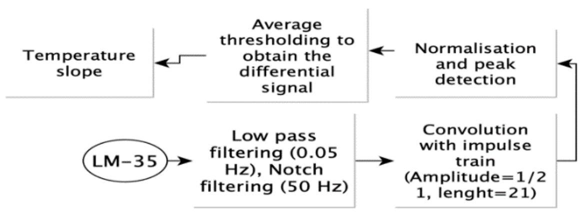

Fig. 3. Flow chart showing the signal processing of temperature signal from sensor (LM-35).

RMR: The heat generation affects the resting metabolic rate (RMR). RMR depends indirectly on volume of oxygen (V_{O2}) consumption [7]. We consider the inspiration and expiration volume as a proportionate measure of resting metabolic rate. The indirect calorimetry method uses 0.85 as the respiratory quotient and 21% by volume of oxygen in the air to calculate RMR using the modified Weir equation [8].

$$RMR = (0.21 * V_{air} * 3.941) + (0.85 * 0.21 * V_{air} * 1.11) * \left(\frac{4184}{60}\right) \qquad (2)$$

where V_{air} is the volume of air consumed which is the absolute difference of inspiration and expiration volumes and RMR is in Watts.

HRV metrics: HRV is used to deduce the effect of HCFP on ANS. HRV metrics are calculated for each session according to prior methods using traditional statistics and advanced signals processing in the frequency and time domains [9] as shown in the flowchart below in Fig. 4.

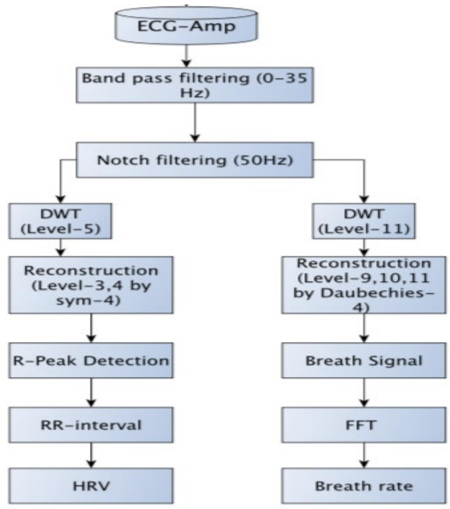

Fig. 4. Flow chart showing the signal processing of the ECG-signal.

We use the Augmented LFHF to show the overall sympathovagal ratio of ANS where the augmented LF includes both LF and VLF power of HRV and augmented HF includes both HF and VHF power of HRV. The cardio-respiratory coupling is assessed through the ratio of heart rate (HR) to breath rate (BR) [20]. The median value of the HRV metrics is used for statistical analyses.

Results and Discussions

HRV: There is a significant shift of power from low-frequency zone to high-frequency zone. Therefore, the Augmented-LFHF reduces significantly (p<0.05) as in Fig. 5.

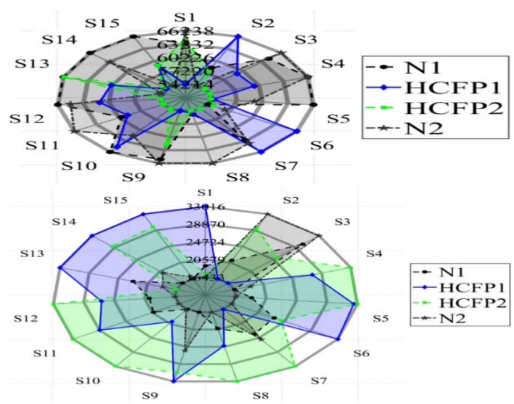

Fig. 5. The upper and lower spider plot shows the Augmented LF (augLF=LF+VLF) and augmented HF (augHF= HF+VHF) respectively across all subjects (S1-S15).

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The peak frequency also shifts from low to high frequency zone with a (p<0.05) as shown in Figs. 6 and 7.

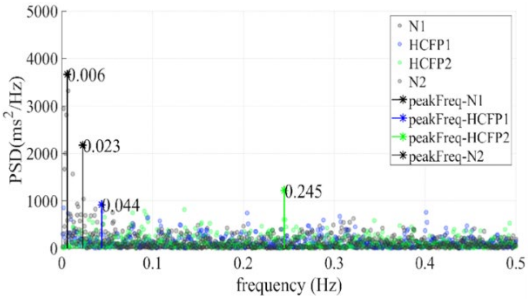

Fig. 6. Spectral distribution of each session along with the peak frequency for a typical subject.

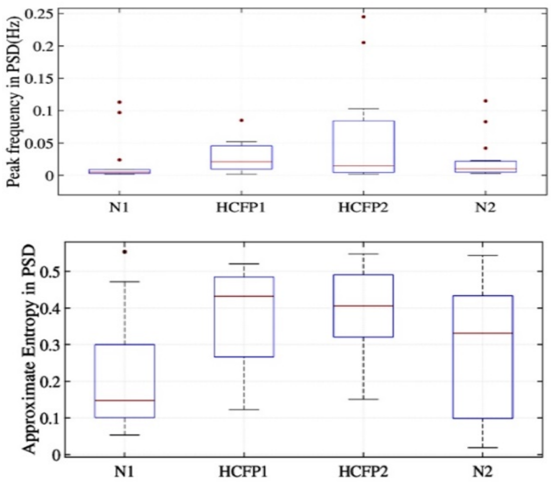

Fig. 7. Peak frequency and approximate entropy in the PSD.

The entropy generation is high in high frequency zones as approximate entropy increases significantly (p<0.05) during HCFP-1 and HCFP-2 compared to N-1 as shown in Fig. 7.

All the cumulative effects clearly show the parasympathetic dominance of ANS on HR. The SDRR/RMSSD represents sympathovagal balance in the time domain that resembles LFHF in the frequency domain [10]. The HRV improves as SDRR, RMSSD increases by 23.75% and 24.44% respectively. The change in HRBR is minimal, however, it has a decreasing trend from N-1 to N-2 as shown in Table 1 indicating a rising influence of respiration rate over HR.

***Temperature Slope**:* The rate of temperature change quantifies heat generation. Figure 8 shows the process of obtaining the temperature slope, while Fig. 9 shows exponential curve fitting to any three slope changes during each session respectively.

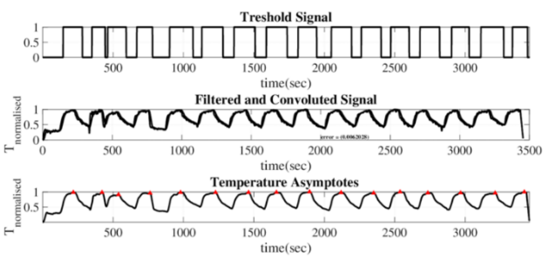

Fig. 8. Temperature slopes in a session for the experimental duration of a typical subject.

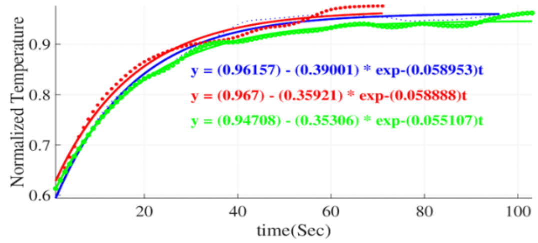

Fig. 9. Exponential curve fitting to any three temperature slopes. Blue-N1, red-HCFP and green-N2.

We observe an increase in slope by 11.54 % during HCFP-1 and drops during subsequent sessions as shown in Table 1 which resembles the resting heat production during sleep.

TABLE I
TIME DOMAIN PARAMETERS OF HRV AND TEMPERATURE SLOPE

Parameters	HCFP-1(%)	HCFP-2(%)	N-2 (%)
HRBR	-8.9	0.14	-3.77
SDRR	23.75	-7.07	-17.39
RMSSD	24.47	6.84	-53.6
$\frac{\partial T}{\partial t}_{avg}$ (rad)	11.54	-22.41	-2.22
T_{skin}	-0.3	0.09	-0.03

('+' sign indicates % increase and '-' sign indicates % decrease, HCFP-1(%), HCFP-2(%) AND N-2(%) are the percentage change in HCHP-1 with respect to N-1, percentage change in HCHP-2 with respect to HCFP-1, and percentage change in N-2 with respect to HCFP.)

The phenomenon of the generation of resting heat during sleep phases mediated by parasympathetic dominance. The skin temperature almost stays constant as the change in skin temperature is minimal across the sessions as shown in the Table 1. The heat generation does not alter the body temperature due to active thermoregulation, which resembles latent heat addition due to HCFP. Most of the literature shows a rise in body temperature by 1 to 2^0C during passive heat stokes, dips down during active heat strokes [11] due to evaporation loss. The reason for such a response is because the subjects are not making any movements during hand-clasping causing passive heat generation, unlike the passive heat stroke where the thermal equilibrium at skin-surrounding interface changes due to boundary heat addition.

The feverish conditions produce heat due to immune system response to the pathogen infiltration. The proactive immune system with dysfunction of "cholinergic anti-inflammatory pathway" results in cytokine storm causing immune response becoming hyperactive [12]. The deteriorative effect is alarming during the SARS-CoV-2 virus as well, causing lungs failure suggesting a higher concentration of cytokine [13] such as interleukin-1 (IL-1) IL-6, and tumour necrosis factor (TNF) that act systemically to induce fever [2]. The cholinergic anti-inflammatory pathway comprises the vagus nerve signals leading to acetylcholine-dependent interaction on monocytes and macrophages, resulting in reduced cytokine production [14,15]. The action potential in the vagus nerve through electrical or mechanical stimulation inhibits inflammatory cytokinesis and prevents tissue injury [16,17]. The thermal stimulation through HCFP to the vagus nerve also hinders cytokinesis. We observe the thermal stimulation by HCFP

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from increase in temperature slope with significant shift in power from low to high frequencies in HRV showing vagal dominance. However, decrease in VLF power is higher than that of LF-power, signifying core heating with unchanged body temperature. As VLF-power rises significantly in response to core cooling, peripheral vasoconstriction and shivering [18]. Therefore, a reduction in VLF-power signifies thermoregulation with increased core-heat.

Resting Metabolic Rate (RMR):

The RMR constitutes a majority of the energy requirement linked proportionally to oxygen consumption in most individuals. The inhalation and exhalation volume of air from the breathing signal, as shown in Fig. 9, provides an indirect measure of oxygen consumption and corresponding RMR change with time is shown in Fig. 10.

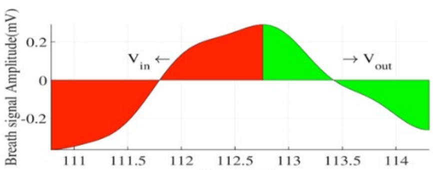

Fig. 9. Inhalation and exhalation volumes from a breath cycle

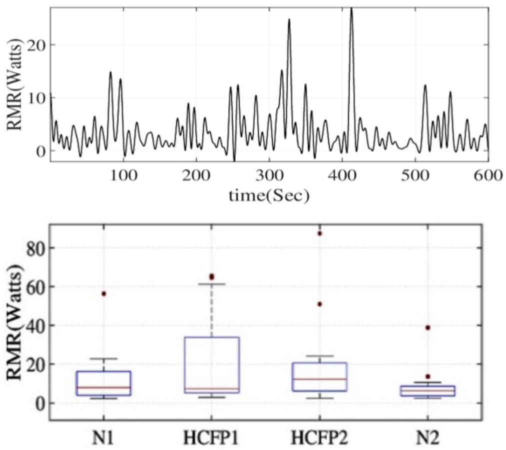

Fig. 10. The top plot shows the RMR of a typical subject in a session and the bottom Box-plot shows the change in RMR considering all subjects.

We observe a significant increase (p<0.05) in RMR during HCFP-2 compared to post-normal phase, N-2. This is because of lower resting energy expenditure (REE) due to hyper parasympathetic activity [19] at HCFP-2, and the heat enhancement is related to energy storage in adipose tissue through modulation of both sympathetic and parasympathetic outflow. The RMR reduces by 8.44% during HCFP-1 compared to N-1, however, during HCFP-2 it increases by 68.61% compared to HCFP-1 which resembles the temperature slope change during sleep stages as the REM-stage follows a negative temperature slope and SWS-stage follows a high-temperature slope. Therefore, a parasympathetically mediated heat generation process occurs while simply sitting with HCFP.

Limitation, Future work, and Scope

The manual intervention during temperature recording is automated along with the clinical approach in assessing other physiological milieus such as blood glucose level. Similar to HRV, BRV [21] gives added information on lung functionality. The parasympathetic mediated heat causes efficient usage of oxygen diffusion to blood thereby reducing the oxygen demand of the body which is currently a big challenge during COVID19. Similar to HCFP, long duration yoga asana for days (40 hours) also elevates the parasympathetic tone of HRV [22] with higher bio-heat and aids in reducing biological oxygen demand.

Conclusion

The study postulates body heat generation by HCFP and assessing physiological changes through HRV. Experimental results show that hand-clasping causes heat in the body continuously during HCFP-1 and HCFP-2. The average slope in a temporal change of temperature also rises during HCFP-1. The heat generation causes an enhancement in HRV with the high-frequency dominance with relatively small changes in the body temperature. Therefore, the nature of heat due to HCFP could be PSNS dominated latent heat generation process. The mechanism behind this increase in heat generation remains unknown which largely depends on the arterial network under the palm where blood reaches a stagnation state due to clasping. The current pandemic shows a higher death rate for patients diagnosed with comorbidities such as diabetes mellitus-II and internal heat generation by simple means of this hand clasping technique may be beneficial in augmenting recovery from COVID-19.

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