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Effect of Cold Pack during Passive Heat Therapy on Heart Rate Variability in Healthy Individuals

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Abstract— Background*: Passive heat therapy is commonly used intervention in complementary and alternative medical system (CAM) for preventing and treating various ailments, relaxation, promotion of health and well-being. It has effect on autonomic, cardiovascular, hormonal, excretory and musculoskeletal system. Heart rate variability (HRV) has been used to indicate cardiac autonomic response and analysis the cardiovascular responses to heat stress. Clinically some forms of passive heat therapy are practiced with modification of using cold pack to avoid heat stress. The current study is designed to evaluate the effect of cold pack during passive heating therapy in healthy individuals on heart rate variability* ***Materials and Methodology****: Thirty healthy male and female volunteers between 18-30 years of age were divided into two groups. Group one underwent steam bath with cold chest pack on day-1 and steam bath without cold chest pack on day-2, the second group undergone in reverse order. Assessment was taken 5 minutes before and after the intervention. Statistical analysis was performed using R software.* ***Results****: A significant decrease in average low frequency band (LF), LF/HF ratio and a significant increase in average high frequency band (HF) were observed in SBCPK group when compared to SB group.* ***Conclusions****: The application of cold pack in passive heating therapy induces lesser sympathetic arousal than regular steam bath.*

Keywords— *Autonomic Nervous System, Chest Pack, Heart rate variability, Hydrotherapy, Passive heat therapy, Steam Bath.*

I. INTRODUCTION

Passive heat therapy, is commonly used intervention for relaxation, health promotion and rejuvenation since ages and various researchers are proven that it has effect on cardiovascular, hormonal, excretory and musculoskeletal system[1] Warm water immersion or hot tub bath, a form of passive heat therapy, have proved health benefits that include improved cutaneous microvascular and endothelial function as well as reduced arterial stiffness and blood pressure.[2,3] It has been showed that sauna and steam bath results elevations in core temperature and changes in cardiovascular hemodynamics, such as cardiac output and vascular shear stress. Steam bath is common form of passive heat therapy, it consider as primary treatment modality in complementary and alternative system of medice.[4,5] complementary and alternative medical system (CAM) is a group of diverse health care systems which can be used as an adjunctive or as an independent modality in treating and preventing various ailments. It plays an evident role in the disease prevention, promotion of health and well-being**.** [6, 7]

The steam bath also called as wet sauna or Russian Banya is the exposure to hot temperature chamber (40-70°C) with fully saturated steam. High air humidity in steam bath causes difficulties in evaporation of sweat from the surface of the skin and leads to a greater heat load, greater increase of heart rate, greater physiological strain.[8] Passive heat exposure, activate autonomic nervous system (ANS) and It is manifested by increased heart rate and elevated plasma catecholamines level.[9] Sympathetic system of ANS stimulates the activity of heart. It increases both the rate and strength of contraction there by increases cardiac output. Parasympathetic system of ANS reduces heart rate and reduces myocardial contractile strength which reduces the cardiac output.[10,11] Measure of heart rate (HR) fluctuations around the mean HR (Heart rate variability or HRV has been used to indicate cardiac autonomic response and its balance. HRV can be used to analysis the cardiovascular responses to heat exposure. [12] Clinically steam bath is modified with the use of cold chest pack to avoid heat stress especially in cardiac diseases as cold chest pack enhances the parasympathetic activity.[13,14] The current study is designed to evaluate the effect of cold pack during passive heating therapy in healthy individuals on heart rate variability.

II. MATERIALS AND METHODS

Thirty healthy male and female volunteers between 18-30 years of age were recruited from a residential college in Karnataka. Subjects with the history of any systemic illness and those who regularly use medicine, female subjects during menstruation,[15,16] individuals consuming alcohol and nicotine,[17] weak and debilitating persons are excluded. Study was conducted in Sri Dharmasthala Manjunatheswara Yoga Nature Cure Hospital, Shanthivana, Dharmasthala, Karnataka with the approval of the institutional ethics committee Written informed consent was obtained from all the subjects.

The study design used is cross over trail. Volunteers were recruited and divided into 2 groups. Subjects of both the groups underwent 15 minutes of steam bath with cold chest pack (study session) and steam bath without cold chest pack (control session). 15 subjects of group A underwent steam bath with cold chest pack (SBCPK) on day-1 and steam bath without chest pack (SB) on day-2, while the order was reversed in the group B. Baseline and post-test assessments were performed before and after each session.

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Procedure:

SBCPK Group: Steam bath with cold chest pack,[4, 13, 18] Subjects were asked to drink one to two glass of water before entering the steam chamber. They were made to sit in the chamber with minimal clothing and a cold compress on head. A cotton cloth of approximately 2.5 m long and 0.5 m wide is dipped in cold water of 55^0F to 65^0 F (12-18^0 C) temperatures and wrapped around the chest wall over heart and covering both front and back by the second rib above and sixth rib below. After the intervention the subject dried himself with a dry towel and dressed up for the post assessment which will be done after 5 minutes of intervention.

SB group: The Steam bath without chest pack, Subject has to follow same procedure like steam bath with chest pack without the application of cold chest pack and post assessment will be done after 5 minutes of intervention

The Electrocardiogram (ECG) was assessed using MP150 data acquisition system (BIOPAC System Inc, U.S.A) and data were acquired at the sampling rate of 1024 Hz [19] then the Data was averaged for each 5 minute block period. The HRV power spectrum was obtained using Fast Fourier Transform analysis (FFT) using the software Kubios HRV.[20] Frequency domain and time domain components were analyzed separately.

The energy in the HRV series of the following specific bands in Frequency domain analysis were studied viz. the low frequency component (LF), high frequency component (HF). The low frequency and high frequency values were expressed as normalized units. LF: HF was also calculated. The following components of time domain analysis of HRV obtained; the mean RR interval (the mean of the intervals between adjacent QRS complexes or the instantaneous heart rate), RMSSD (the square root of the mean of the sum of the squares of differences between adjacent NN intervals), SDNN (Mean of the standard deviations of all NN intervals).[19]

Data Analysis:

The normality assumption is verified using Shapiro Wlik test. The paired sample t test is used to check whether pre and post averages of these variables are same or not for normally distributed variables. Non parametric version of paired sample t test i.e. Wilcoxon Signed Rank test is adopted whenever the normality assumption is violated. Statistical analysis was done using R software version 3.6.3. The level of statistical significance considered is $p \leq 0.05$ for the analysis and interpretation

III. RESULT

In the frequency domain analysis Heart Rate and Heart Rate Variability there is a decrease in the LF and LF/HF ratio and an increase in HF in SBCPK group while comparing the post test measurements of SBCPK and SB groups in frequency domain analysis of the heart rate variability. Within SBCPK group LF increases and HF, LF/HF ratio did not show any significant change. Similarly in SB group the average of LF and LF/HF are increased and the HF decreased. In the Time domain analysis, There is no significant change in time domain analysis of heart rate variability while comparing the post test measurements of SBCPK and SB groups. RMSSD within SBCPK group did not show any significant change and mean RR, SDNN decreases. In SB group the average of mean RR, SDNN, RMSSD, are decreased.

Table 1: Analysis of the heart rate variability. Values are group mean ±S.D.

Variables	Group	Mean with SD		P value - Within the groups		P value - Between the groups	
		Pre	Post	Two tailed	One tailed	Two tailed	One tailed
LF	SBCPK	56.70±16.94	61.68±14.74	0.3234*		0.03842**	0.01921 Alt: greater
	SB	53.60±19.46	68.54±17.81	0.0001666**	0.0000 Alt: less		
HF	SBCPK	43.31±16.97	38.15±14.75	0.2493*		0.04716**	0.02358 Alt: less
	SB	46.17±19.25	31.40±17.80	0.0001809**	0.0000 Alt: greater		
LF/HF	SBCPK	1.84±1.53	2.18±1.76	0.4465**		0.02303**	0.01152 Alt: greater
	SB	1.64±1.28	3.60±3.34	0.000**	0.0000 Alt: less		
Mean RR	SBCPK	739.73±77.16	685.2±86.93	0.0000**	0.0000 Alt: greater	0.978	-
	SB	737.93±67.44	684.73±70.77	0.00000*	0.0000 Alt: greater		
SDNN	SBCPK	45.63±12.79	43.29±45.30	0.01013**	0.005064 Alt: greater	0.6345	-
	SB	61.06±50.30	37.17±14.0	0.0000**	0.0000 Alt: greater		
RMSSD	SBCPK	40.96±19.42	43.42±57.31	0.3036**		0.3876	-
	SB	64.03±9.06	32.17±16.56	0.0000**	0.0000 Alt: greater		

* Paired sample t test

** Wilcoxon signed rank test

Within the group: Level of significance≤ 0.05

Alternative hypothesis state that,

- Alt: less-The median of autonomic variable before therapy is less than that after therapy.
- Alt: greater- The median of autonomic variable before therapy is greater than that after therapy.

Between groups: Level of significance ≤ 0.05

- Alt. less: The median of autonomic variable in SB group is less than that in SBCPK group.

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- Alt. greater: The median of autonomic variable in SB group is greater than that in SBCPK group.

IV. DISCUSSION

The aim of the study is to evaluate effect cold pack during passive heating therapy. Steam bath, one form of the passive heat therapy, is a simple, cost- effective treatment modality in CAM.[21] Clinically cold chest pack is used with steam bath as alternative of steam bath treatment for cardiac patient in the view to reduce of cardiac excitation by heat stress.[4] In the present study average LF and LF/HF ratio of experimental group is lesser than that of control group, the average HF behaves opposite. Mean RR, SDNN measures of the heart rate variability (HRV) have been recognized as predictors of vagal modulation. [22,23] Reduction of these indices in steam bath with or without chest pack is suggestive of sympathetic arousal. The average LF, LF/HF is less and the average HF is more in steam bath with chest pack group than control group. LF band consider as an index of cardiac sympathetic activity and HF band is an index of cardiac parasympathetic activity. The LF/HF ratio is considered to mirror sympatho/vagal balance.[24] These changes indicate that there is lesser sympathetic arousal in steam bath with chest pack group. RMSSD is decreased in steam bath group and no change observed in stream bath with cold chest pack group. Similar to the current study, another study done by Eduardo Carballeira et al to identify the effects of superficial cooling on physiological responses while training in a warm environment explained that RMSSD, a parasympathetic-based HRV index, showed a significant decrease in the control group and no changes after the session in cold vest group indicates either reduced cardiovascular strain during training or a more rapid parasympathetic reactivation after the training session.[25]

The Cold stimulation triggers peripheral vasoconstriction, leading to a shift in blood volume towards the core resulting increase in central pressure, in turn activates the baroreflex which is responsible for reducing sympathetic nerve activity and shifting autonomic heart rate control towards a parasympathetic dominance.[26] The immediate effect passive heating therapy can activates the reflex release of sympathetic vasoconstrictor tone due to sudden environment change.[27] The current study mainly focuses the significant decrease of LF and LF/HF ratio and increase of HF in steam bath with cold chest pack group suggest that the application cold chest pack reduces the sympathetic arousal and induces a rapid parasympathetic reactivation than the steam bath without cold chest pack. Thus cold pack can be use as protective measure to maintain cardio autonomic balance. Assessments during the intervention could be studied for the better understanding of physiology because well complaint blood vessels in the young aged healthy subject would buffer the circulatory and thermal changes. So the further research has to be conducted in individual with abnormal cardio autonomic rhythm.

V. CONCLUSION

Reduction in LF band, LF/HF ratio and increase in HF band frequency in steam bath with chest pack indicate that the application of cold pack in steam bath enhances parasympathetic activity than regular steam bath. Thus the application of cold pack in passive heating therapy induces lesser sympathetic arousal.

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