COMPARATIVE STUDY ON EFFECT OF COLD SPINAL SPRAY AND COLD SPINAL BATH ON AUTONOMIC VARIABLES IN HEALTHY INDIVIDUALS

1Dr. Vidyasagar, 2Dr. Geetha kumari v, 3Dr. Prashanth Shetty, 4Dr. Sujatha K. J
1(Post graduate, Division of naturopathy, Department of post graduate studies, SDM College of naturopathy and yogic sciences, Ujire, Karnataka, India)
2(Dean, division of nutrition and physical therapy, SDM College of naturopathy and yogic sciences, Ujire, Karnataka, India)
3(Principal, SDM college of naturopathy and yogic sciences, Ujire, Karnataka, India)
4(Dean, Division of naturopathy, Department of post graduate studies, SDM College of naturopathy and yogic sciences, Ujire, Karnataka, India)

Abstract: *Cold spinal spray and cold spinal bath are the hydrotherapy treatments which are commonly used by naturopathy physicians, for the better employment of such treatments used in various disease conditions, the basic physiological effects should be well understood. Hence, this study aims at comparing the effects of cold spinal spray and cold spinal bath on autonomic variables in healthy volunteers. 60 healthy volunteers were randomly allocated into cold spinal spray and cold spinal bath. Intervention was given for the duration of 20 minutes. Subjects were assessed for blood pressure and Heart rate variability (HRV) before, after and at the end of one hour of intervention. Following result of cold spinal spray (CSS) and cold spinal bath (CSB), the immediate assessment showed a significant increase in the square root of the mean squared difference between adjacent N-N interval (RMSSD) and decrease low frequency (LF), systolic blood pressure (SBP) and diastolic blood pressure (DBP) in both groups and increases consecutive normal sinus (NN) intervals exceeds 50 ms (NN50) in CSS group and decrease in low frequency/high frequency ratio (LH/HF ratio) in CSB group. Whereas assessments after one hour in both groups showed a significant increase in RMSSD and increase in NN50, the fraction of consecutive NN intervals that differ by more than 50 ms (pNN50) and reduction in heart rate (HR), very low frequency (VLF), SBP, and DBP in CSS group is noted. When both the groups are compared with each other, there were significant changes seen in RMSSD in the immediate assessments and there were no significant differences were noted when assessed after one hour. Both immediate and post one hour results of these two hydrotherapeutic interventions reported a shift of sympatho-vagal balance towards parasympathetic dominance. Therefore, these treatments can be applied for improving cardiac health and for achieving relaxation.*

Keywords: Naturopathy; hydrotherapy; cold spinal spray; cold spinal bath; heart rate; blood pressure; autonomic nervous system.

I. INTRODUCTION

Naturopathy was practiced centuries ago with old knowledge of nature and natural way of living. It is entirely nontoxic in nature which utilizes naturally available elements for various therapies in order to treat various health conditions and brings the balance in the different functions of human system. Naturopathy medicine consists of multiple therapies including herbal therapies, acupuncture, massage, and nutrition therapy. Naturopathic medicine is also distinguished by the principle upon which its practice based on. [1]

Naturopathy is defined as a system of man building in harmony with the constructive principles of nature on physical, mental, moral and spiritual planes of living being. It is also having disease preventive and curative as well as restorative potential. [2] According to naturopathy, the primary cause of disease is lowered vitality, abnormal composition of blood and lymph and the accumulation of morbid matter and poisons, these all are due to violations of nature's law and this concept was formulated by Henry Lindlahr and it is considered as a fundamental principle of naturopathic medicine. [3]

Naturopathy can be traced back to the European ‘‘nature cure,’’ practiced in the nineteenth century, which was a system for treating disease with natural modalities such as water, fresh air, diet, and herbs. In the early twentieth century, naturopathy developed in the United States and Canada, combining nature cure, homeopathy, spinal manipulation, and other therapies. [4]

Naturopathy medicine is the way of treating diseases and preventing diseases by using natural therapies including: clinical nutrition, hydrotherapy, naturopathic manipulation, traditional Chinese medicine/acupuncture and lifestyle counseling. [5]

Hydrotherapy is one of the oldest naturopathic medicines. Hydrotherapy is defined as the medical use of water in treatment of various diseases, water has been found to exert many biological effects on human body. Over a decades, external use of water, usually through immersion of whole body or immersion of parts of the body for the purpose of obtaining biological effects and it is called as “medical hydrology”. Water is used in any forms, for the maintenance of health or the treatment of various diseases. Water is having healing capacity and it is one of the oldest, cheapest and safest methods for treating many common ailments. The effect of water changes with it forms, temperatures and different techniques of applications made internally and externally. [6,7]

In ancient duration Egyptians, Hebrews, Greeks, Persian, and Hindus almost all employed therapeutic use of water in the treatment of diseases. Vincent Preissnitz, Sebastein Kneipp and John Harvey Kellogg contributed and promoted the use of hydrotherapy. In 400 B.C having the knowledge of physiological properties of hot and cold water Hippocrates used water for both medical and surgical conditions. [7]

In India hydrotherapy was popularized by Mahatma Gandhi and Lakshman Sharma they are greatly contributed and promoted naturopathy as well as hydrotherapy. Lakshman Sharma has designed the spinal bath and hip bath tubs, established nature cure sanatorium at Vijayawada, started nature cure journal in English. [8]

In hydrotherapy there are so many types of treatment procedures like packs, baths, douches, sprays, immersions and compresses are given with different temperature to treat various disorders. [9]

Spinal spray tub is an equipment which is made up of fiber glass material with a perforated tube in the mid of the tub, and this tub contains a 40 liters of water tank to circulate the water and connected with 0.5 HP motor and adjusted below the tub. Though this tub can circulate cold, neutral and hot water according to different temperature as requirement for patients. [9]

Spinal bath is a local, non-pressurized hydratic measure in which the spinal area is exposed to water of certain temperature for a specific duration to get desired effects. This procedure controls all organs of the body, since most of the nerve roots start from the spinal cord. They are the sensory centers, temperature controlling centers, vasomotor centers and sympathetic and parasympathetic centers in the brain and spinal cord. The small and large blood vessels of the heart, lungs, digestive system and brain contract or dilate depending on the temperature of water used in the spinal bath. Spinal bath also improves oxygen supply to the lungs and heart by increasing blood circulation. [10]

The physiological effect of cold on the human body have a various effect in various ways for example cold is having an excitant effect but in prolonged condition it is having a sedative effect, in some conditions cold act as a vital depressant. [7]

Even though spinal spray and spinal bath are extensively used in naturopathy for treating various disease conditions, their specific physiological effect is not yet studied in healthy individuals. Hence, the current study is designed to compare the effect of cold spinal spray and cold spinal bath on autonomic variables in healthy individuals.

II. Materials and methods

2.1 Participants

Sixty normal healthy volunteers of both the genders and ages ranging between 18 to 28 years were recruited. Students from college of Naturopathy and Yogic Sciences, were recruited for the study. Prior to study, approval was obtained from institutional ethical committee. The subjects were instructed about the study and all the subjects who are willing to take part were given an information sheet about the study in English written were considered. A signed informed consent was obtained from each individual after going through the study details mentioned in the information sheet (fig-1). Inclusion criteria, age 18 to 28 years old both males and females. Individuals with any of diseases like diabetes, cancer, hypertension, anxiety and depression. [11] Substance abuse, complaint of infectious disease and open wounds. Female subjects during menstruation, [12] those who are under any medications during the study where excluded from the study. [13]

2.2 Design of the study

This is a two group with pre – post and prolong interventional study. The study designed to compare the effect of cold spinal spray and cold spinal bath on autonomic variables in healthy individuals.

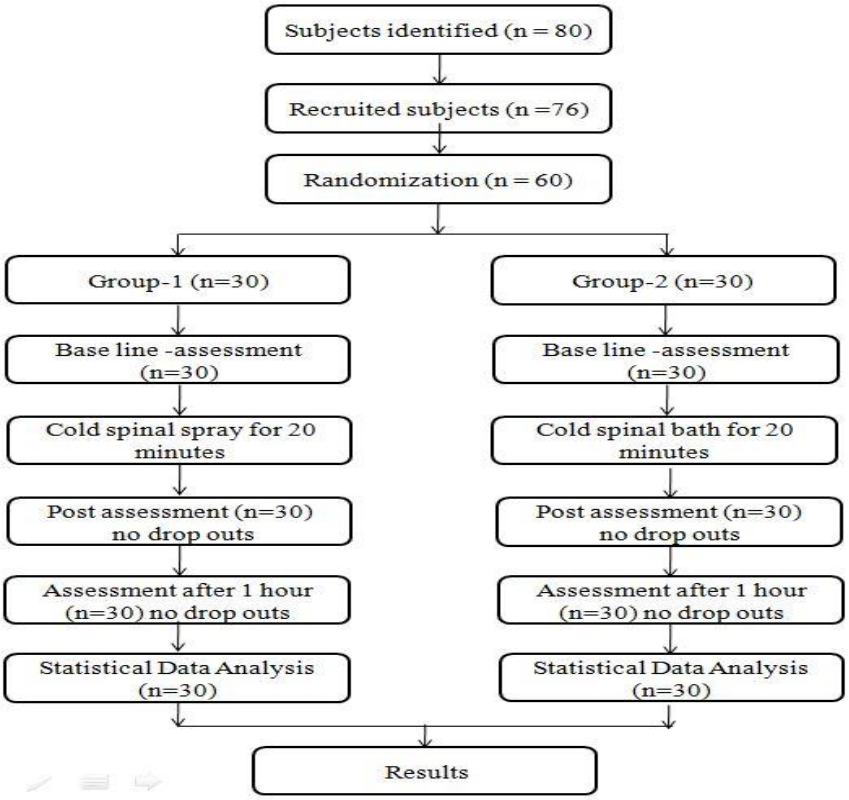

Figure 1: Illustration of Study Plan

2.3 Assessments

In the present study, the autonomic variables measured were the heart rate, and heart rate variability (HRV), Respiratory rate (Respirogram) and blood pressure. The HRV spectrum is believed to be a useful indicator of cardiac sympathetic activity (reflected by low frequency [LF] band power values) and parasympathetic activity (reflected by high frequency [HF] band power values). [14]

2.4 Intervention

2.4.1 General description about spinal spray therapy

A spinal spray tub consists of a fiber perforated tube at the center of the tub, this tub is connected with a pipe to a 0.5 H.P. motor adjusted below the tub which is connected to water supply.

The subject is asked to be in minimum dress and made to lie down in the supine position on the tub and start the machine. There will be constant spray from perforated tube, ascending to surface of the body directly to the spinal cord region for a span of 20 minutes. Temperature of the water of cold spinal spray will be measured by hydratic thermometer (water thermometer). [7]

2.4.2 General description about spinal bath therapy

Spinal bath was given in tubs specially made for the purpose. Tub helps to maintain the constant water temperature. The water level in the tub was an inch and a half to two inches. The temperature of the water in the spinal bath for cold was 18-24° C (64-75° F). Water temperature was measured by using a digital thermometer. The subject's lies down in a spinal bath tub with minimum dress, with the head on the side that is most slanted, his buttocks at the opposite side end and his feet outside and adjusts himself to the water of the tub such that water should touch the entire length of the spine, from the nape of the neck to the lowest portion of the spine. Intervention was given for 20 minutes. [7]

2.4.3 Temperature: Cold spinal spray and cold spinal bath: 18-24^0 C (64-75^0 F)

2.4.4 Pressure: cold spinal spray pressure, 1Pressure per inch (PSI).

2.5 Data extraction

2.5.1 Heart rate and heart rate variability (HRV)

The subjects were lying supine on the bed and recording leads were connected to the four-channel polygraph equipment (BIOPAC, Montana, USA; model No: BSL 4.0 MP 36) and monitored on a closed-circuit TV. Instructions were given to the subjects to remain relatively undisturbed during the session

The heart rate in beats per minute was calculated by counting the R waves of the QRS complex in the EKG in successive epochs of 60 seconds and averaged for each 5- minute block period. The HRV power spectrum was obtained using fast Fourier transform analysis (FFT). The energy in the HRV series of the following specific bands was studied, viz., the low frequency component (0.05-0.15 Hz), high frequency component (0.15-0.50 Hz) and very low frequency component (0.0-0.05 Hz). The low frequency and high frequency values were expressed as normalized units. The low frequency and high frequency values are expressed as normalized units. Both time domain and frequency domain values were analyzed. In time domain mean RR, mean HR, RMSSD, NN50, pNN50 and in frequency domain VLF, LF, HF, LF/HF values were extracted from Fast Fourier Transform Analysis using the software Kubios 2.0 version. [15, 16]

2.5.2 Respirogram

Respiration was recorded using a volumetric pressure transducer [stethograph] connected to AC amplifier of the polygraph and with sensitivity set as required. The stethograph was fixed around the trunk about 8 cm below the lower costal margin as the subject lying supine on the bed. [17]

2.5.3 Digital pulse volume

For this recording, the transducer was placed on the volar surface of the digital phalanx of the left thumb to record the digital pulse volume (DVP), also called the finger plethysmogram. Photoplethysmography allowed normal non-invasive recording of arterial blood volume pulse. The Photoplethysmogram described the changes in the absorption of light by haemoglobin using waveforms. The amplitude of the DVP was sampled from the peak of the pulse waves at 30-second intervals and presented in mm. [17]

2.5.4 Blood pressure

Blood pressure was recorded before and after the interventions by using a standard mercury sphygmomanometer, auscultating over the right brachial artery. The systolic pressure was noted as the first clear tapping sound (korotkoff sounds) and diastolic pressure was noted as the reading at which the korotkoff sounds appeared muffled. [18]

2.6 Materials used

Channel Polygraph.
Sphygmomanometer.
Spinal bath tub.
Spinal spray tub
Water of required temperature.

2.7 Data analysis

The raw data obtained from each subject in each recording session were tabulated separately. The groups mean values ± standard deviation values were calculated for all the variables. Statistical analysis was done by using SPSS (Version 23.0). P values less than 0.05 were accepted as indicating significant value and less than or equal to 0.001 considered as highly significant value.

III. Results

The study was done to assess the effect of cold spinal spray and cold spinal bath on blood pressure and autonomic variables in healthy individuals and to compare the effect of cold spinal spray and cold spinal bath on blood pressure and autonomic variables in healthy individuals. The data obtained was analysed for normality by using Kolmogorov Smirnov test. The pre, post test1 (values of study variables measured immediately after the intervention) and post-test 2 (values of study variables measured at the end of one hour of the intervention) of group 1 and group 2 were analysed by using Wilcoxon Signed Ranks test and comparative analysis between the group 1 and group 2 were done by using Mann Whitney ‘U’ test.

Results of the present study indicates, after the immediate exposure to cold spinal spray (group 1) there is highly significant increase in time domain values of NN50 ($p<0.001$), and significant increase in RMSSD ($p<0.05$) and significantly decrease in frequency domain, LF ($p<0.05$) and SBP ($p<0.05$) and DBP ($p<0.05$),

and there are no significant changes observed in other variables measured immediately after the cold spinal spray. Whereas assessments done after one hour of the cold spinal spray intervention showed a significant reduction in time domain mean HR ($p<0.05$), frequency domain VLF ($p<0.05$), and highly significant decrease in blood pressure, viz., SBP and DBP ($p<0.001$). Significant increase is also seen in time domain NN50 ($p<0.001$), pNN50 ($p<0.05$), and RMSSD ($p<0.05$) and there are no significant changes were observed in other variables measured at the end of 1 hour of cold spinal spray (Table 1).

Table 1: Changes in study variables of participants of cold spinal spray group during study period

Variables	Mean ± SD			p-Value	p-Value
	Pre-test	Post-test 1	Post-test 2	Pre-test vs. Post-test 1	Pre-test vs. Post-test 2
PR	91.8±2.36	91.4±1.3	91.8±2.72	0.233	0.750
RR	15.7±1.84	15.9±1.83	15.8±1.74	0.271	0.813
Mean RR	1503±174	1489±191	1465±195	0.719	0.069
Mean HR	42.01±6.16	41.41±6.40	40.63±5.94	0.289	<0.05*
RMSSD	188±154	251±189	275±199	<0.05*	<0.05*
NN50	117±34.5	131±37	130±32	<0.001*	<0.001*
PNN50	58±17	61±17	65±16	0.217	<0.05*
VLF	34.6±23.3	30.6±19	28.9±18.9	0.206	<0.05*
LF	55.3±17.7	49.9±16.9	47.9±18.1	<0.05*	<0.05*
HF	49.7±16.6	54.3±15.8	52.4±18.3	0.096	0.734
LF/HF	1.38±1.54	1.03±1.16	0.88±0.606	0.075	0.060
SBP	106.7±7.8	102.7±11.4	100.2± 6.8	<0.05*	<0.001*
DBP	70.9± 6.53	67.6±7.76	64.1±4.89	<0.05*	<0.001*

Results of the present study indicates, after the immediate exposure to cold spinal bath (group 2) there is significant increase in time domain values of significant ($p<0.05$) increase in RMSSD and significant ($p<0.05$) decrease in frequency domain, LF, LF/HF ratio and there are no significant changes observed in other variables measured immediately after the cold spinal bath.

Table 2: Changes in study variables of participants of cold spinal bath group during study period

Variables	Mean ± SD			p-Value	p-Value
	Pre-test	Post-test 1	Post-test 2	Pre-test vs. Post-test 1	Pre-test vs. Post-test 2
PR	92.4±2.32	92.1±1.67	93.04±2.13	0.484	0.221
RR	15.5±1.16	15.8±1.24	15.61±1.83	<0.05*	0.586
Mean RR	1556±149	1542±165	1574±164	0.813	0.262
Mean HR	39.6±4.27	41.14±5.31	39.9±5.18	0.517	0.459
RMSSD	217±170	351±203	321±208	<0.05*	<0.05*
NN50	116±34	121±28	116±31	0.750	0.393
PNN50	62±19.5	64.9±16	64±15	0.658	0.574
VLF	28.9±18.1	25.3±15.1	24.9±9.8	0.430	0.797
LF	50.7±17.4	43.3±13.3	43.1±16.9	<0.05*	0.060
HF	49.2±17.4	51.1±14.6	51.6±16.1	0.280	0.156
LF/HF	1.37±1.11	0.80±0.642	1.171±0.94	<0.05*	0.299
SBP	107.6±9.05	105.6±8.45	105.8±8.46	<0.001**	0.352
DBP	74.1±12.9	69.5±9.38	73.1±12.1	<0.001**	0.131

Whereas assessments done after one hour of the cold spinal bath intervention showed a significant reduction in time domain mean HR ($p<0.05$), frequency domain VLF ($p<0.05$), and highly significant decrease in blood pressure, viz., SBP and DBP ($p<0.001$). Significant ($p<0.05$) increase is seen in RMSSD values measured at the end of 1 hour of cold spinal spray and there are no significant changes were observed in other variables measured at the end of 1 hour of cold spinal bath (Table 2).

Table 3: Comparison of observed difference of the study variables at different time points between cold spinal spray and cold spinal bath group during the study period

Variables	Time point	Observed difference		p-Value
		Cold Spinal Spray (n=30)	Cold Spinal Bath (n=30)	
PR	Pre-test - Post-test 1	0.5±2.2	0.3±2.3	0.078
	Pre-test - Post-test 2	0.1±3	-0.6±1.9	0.089
RR	Pre-test - Post-test 1	-0.3±1.3	-0.3±1.1	0.433
	Pre-test - Post-test 2	-0.2±1.6	0±1.9	0.506
Mean RR	Pre-test - Post-test 1	13.6±136.4	14.2±193.2	0.301
	Pre-test - Post-test 2	37.5±122.4	-17.6±154.6	0.523
Mean HR	Pre-test - Post-test 1	0.6±2.8	-1.5±5.9	0.912
	Pre-test - Post-test 2	1.4±3.9	-0.3±4.8	0.652
RMSSD	Pre-test - Post-test 1	-63±126.5	-133.6±192.1	<0.05*
	Pre-test - Post-test 2	-87.1±135.9	-103.7±228.3	<0.05*
NN50	Pre-test - Post-test 1	-13.8±13.8	-4.4±23.4	0.128
	Pre-test - Post-test 2	-12.8±14.6	0.9±22	0.304
PNN50	Pre-test - Post-test 1	-1.9±9.9	-3±17.2	0.520
	Pre-test - Post-test 2	-5.5±9.3	-2.2±14.1	0.807
VLF	Pre-test - Post-test 1	3.9±18.9	3.5±18.4	0.420
	Pre-test - Post-test 2	5.7±15.9	4±19.3	0.830
LF	Pre-test - Post-test 1	5.5±13.7	7.4±18.4	0.131
	Pre-test - Post-test 2	7.4±15.7	7.6±20.9	0.203
HF	Pre-test - Post-test 1	-4.6±11.6	-1.9±15.2	0.231
	Pre-test - Post-test 2	-2.7±16.3	-2.3±10.9	0.824
LF/HF	Pre-test - Post-test 1	0.4±0.8	0.6±1.1	0.492
	Pre-test - Post-test 2	0.5±1.3	0.2±1.3	0.344
SBP	Pre-test - Post-test 1	4±9.8	2.0±2.9	0.331
	Pre-test - Post-test 2	6.5±6.4	2.2±7.9	0.203
DBP	Pre-test - Post-test 1	3.3±7	4.6±9.2	0.431
	Pre-test - Post-test 2	6.8±7.9	1.0±10.2	0.524

*Values are expressed as group mean ± S.D. pre-test-baseline values, post-test 1-values measured immediately after the intervention, post-test 2-values measures at the end of 1 hr. of intervention. Statistical test used: Mann Whitney 'U' test, *p<0.05-Significant, ** p <0.001-highly significant.*

When the observed difference between the pre-test and post-test 1 values of study variables of participants compared between the cold spinal spray (group-1) and cold spinal bath (group-2), it showed significant ($p<0.05$) changes in RMSSD and there were no significant changes were found in the observed difference between the pre-test and post-test 1 values of other study variables (Table 3). When the observed difference between the pre-test and post-test 2 values of study variables of participants compared between the cold spinal spray (group-1) and cold spinal bath (group-2), it also showed significant ($p<0.05$) changes only in RMSSD and there were no significant changes were found in the observed difference between the pre-test and post-test 2 values of other study variables (Table 3).

IV. Discussion

The main aim of the study was to evaluate and compare the physiological effect of cold spinal spray and cold spinal bath with respected to changes on various functions viz. heart rate, heart variability, respiratory rate, pulse rate, blood pressure in normal healthy volunteers. All the 60 subjects underwent intervention for the duration of 20 minutes over the spinal spray tub and spinal bath tub in supine position.

Heart rate variability (HRV) have a dynamic balance which arises from activation or inhibition of the sympathetic and parasympathetic nervous systems. [19] Results of the individuals who underwent cold spinal spray group showed a significant increase in NN50, RMSSD and reduced LF, SBP and DBP immediately after the intervention which indicate a sympathetic withdrawal. Whereas assessments after one hour showed a significant reduction in time domain mean HR, frequency domain VLF, and SBP, DBP also significant increase in time domain NN50, pNN50, and RMSSD this shows parasympathetic dominance followed after one hour of the interventions.

A result of individuals who underwent cold spinal bath showed significant increase in time domain RMSSD and a significant reduction in frequency domain LF and LF/HF Ratio immediately after the intervention and whereas the assessments after one hour to the intervention showed a significant increase in time domain RMSSD and other parameters remained unchanged.

When the observed difference between the pre-test and post-test 1 values of study variables of participants compared between the cold spinal spray (group-1) and cold spinal bath (group-2), it showed significant ($p<0.05$) changes in RMSSD and there were no significant changes were found in the observed difference between the pre-test and post-test 1 values of other study variables (Table 3). When the observed difference between the pre-test and post-test 2 values of study variables of participants compared between the cold spinal spray (group-1) and cold spinal bath (group-2), it also showed significant ($p<0.05$) changes only in RMSSD and there were no significant changes were found in the observed difference between the pre-test and post-test 2 values of other study variables (Table 3).

In the HRV low frequency (LF) band of the HRV is mainly related to sympathetic, cardiac and autonomic balance when expressed in normalized units, while the efferent vagal activity is a major contributor to the high frequency (HF) band. The LF/HF ratio is correlated with the sympathovagal balance, respectively, and suggests the HRV power spectrum including its LF component, is mainly determined by parasympathetic system. [20, 21]

Cold water stimulates local region by increasing HRV time domain components (RMSSD, NN50, pNN50) which are recognized to be strongly dependent on the vagal modulation with parasympathetic activation. HRV specific components may be related to different mechanism in different conditions due to interaction with other biological signals have to consider. Most of the investigations suggest that HF, RMSSD and pNN50 reflect to short time HRV and are predominantly a response to change parasympathetic tone. [22-24]

Another possible mechanism may be due to the cold water temperature which influence upon the neck and spine stimulates baroreceptor; baroreceptors are sensitive which increases blood volume and hydrostatic pressure thereby increasing central blood volume, stroke volume, cardiac output and central venous pressure. This increase in central venous pressure is likely to stimulate arterial pressure and lower cardiopulmonary pressure. This process is known to induce parasympathetic activity and inhibit sympathetic activity. [25, 26]

Since the physiological changes following a cold spinal spray and cold spinal bath are not documented so far, the present study made an attempt to understand the effect in normal healthy volunteers and also made an attempt to compare the effect of these treatments on HRV. There were no adverse effects reported during or after the intervention. It can be speculated from the results of the present study that, following cold spinal spray and cold spinal bath, the physiological changes found are mediated through symaptho-vagal changes. Further studies are warranted to explain the in depth mechanism involved on exposure to cold spinal spray and cold spinal bath.

The main limitation of the study was that, it was not possible to record the assessments during the intervention to have a better understanding of the Physiology, Sample size is small and power analysis is not done.

From the results obtained we can conclude that cold spinal spray and cold spinal bath shows reduced sympathetic tone with the parasympathetic dominance immediately. However, the prolonged effect of both the interventions shows a shift of sympatho-vagal balance towards parasympathetic dominance. From the results of present study, we are not able to find substantial difference in the effect of cold spinal spray and cold spinal bath on blood pressure and heart rate variability.

Abbreviations: *SBP=Systolic blood pressure, DBP=diastolic blood pressure, HR=heart rate, mean RR= mean of R-R interval, RMSSD=The square root of the mean squared difference between adjacent N-N intervals, NN50=consecutive normal sinus (NN) intervals exceeds 50 ms, pNN50=The fraction of consecutive NN intervals that differ by more than 50 ms, VLF=very low frequency power, LF=low frequency Power, HF=high frequency power and LF/HF=low frequency/high frequency ratio.*

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