

The Immediate Effect of Cold Circular Jet on Autonomic and Respiratory Variables in Healthy Volunteers

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Abstract:

Background & Objectives: Cold Circular Jet [CCJ] is specially made equipment that directs multiple small but powerful streams of water from all directions on the patient. It is clinically used as a treatment modality in Naturopathy however its effects on Autonomic and Respiratory variables (ARV) has not been reported. The present study was aimed at evaluating the effect of CCJ on ARV in healthy volunteers in causing sympathetic/parasympathetic activation immediately post treatment.

Methods: A Pre-post study was conducted consisting of 60 healthy students from the SDM College of Naturopathy and Yogic Sciences, Ujire. Group 1(n=30) were assessed for Heart Rate, Heart rate Variability, Pulse Plethysmography (PPG) and Respiration before and immediately after the intervention using the Polygraph [BIOPAC MP36]. Each subject underwent the CCJ for 10 minutes during the treatment. Group 2 (n=30) were assessed for the ARV in neutral position (NP) without intervention. Both the sessions of CCJ & NP were of 10 minutes duration conducted over a period of 12 days. Statistical analysis was performed by independent samples t-test and student's paired t-test using Microsoft Excel-version 14 (2011, USA.).

Results:No significant differences were seen between the sessions in heart rate (HR), pulse plethysmogram (PPG), respiratory rate (RR), R-R wave Interval (RRI), square root of mean of sum of the squares of differences between adjacent NN intervals (RMSSD), number of interval differences of successive NN intervals greater than 50-milliseconds (NN50), proportion of NN50 (pNN50), very low frequency (VLF), low frequency (LF), high frequency (HF), ratio of LF and HF (LF/HF). Within group analysis showed significant decrease in PPG, HR, LF/HF ratio and increase in pNN50. Insignificant increase in RR, RRI, RMSSD, NN50, HF and decrease in VLF, LF were observed in CCJ. In the NP group, PPG, HR were seen to be insignificantly reduced, other variables being more or less unchanged.

Interpretation & Conclusion: CCJ does not significantly improve the ARV compared to NP however within group analysis shows significant reduction in PPG, HR and LF/HF ratio and increase in pNN50. This indicates parasympathetic activity predominance. Therefore, CCJ may be considered as having some effects on ARV in healthy volunteers but requires further validation to prove its effects.

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I. Introduction

Naturopathy is a drugless system of medicine that uses a wide range of therapeutic modalities to treat the individual holistically. [1] It recognizes the existence of vital curative forces the lack of which leads to ill health. [2] It is a system of health care that incorporates hydrotherapy, clinical nutrition and dietetics, raw food and fruit diet, therapeutic fasting, physiotherapy, manipulation and massage, acupuncture, magneto-therapy, mud therapy, sun-bathing, chromotherapy and breathing exercises, psychological counselling to promote health, prevent, diagnose and treat disease. [1][3]

Hydrotherapy is the external or internal use of water in any of its forms (water, ice, steam) for health promotion or treatment of disease. [4] It includes the use of baths, packs, douches/ jets, compresses, enema as various treatment modalities [5] Cold Circular Jet [CCJ] is a specially made equipment that directs multiple small but powerful streams of water from all directions on the patient [6]. It is a hydrotherapeutic procedure, which circularly hits or percusses parts of the body, simultaneously, when the patient is standing at the center of the multiple circular rings. Cold circular Jet has been found more effective in the management of obesity based on clinical experience of several naturopathic physicians however its underlying mechanisms in relation to ANS is less understood.

Autonomic Nervous system is a part of the peripheral nervous system that controls visceral functions. It has sympathetic and parasympathetic divisions. [7] The sympathetic system promotes a "[fight or flight](#)" response, corresponding with arousal and energy generation and inhibits digestion. [8] The parasympathetic division promotes a "rest and digest" response and corresponds with calming of the nerves to return to regular function, enhancing digestion.[9] Autonomic and Respiratory Variables such as heart rate, HRV , PPG, respiratory rate are significant indicators of autonomic function.[10] SNS activity corresponds to increased heart rate, respiratory rate, PPG and decreased HRV and PSNS activity shows the opposite effect.[11][12]

To the best of our knowledge there is no such study reported on the effect of cold circular jet in relation to autonomic and respiratory variables in healthy/obese individuals. It is essential to understand the underlying physiological mechanisms before applying them as therapeutic agents in pathological conditions. Hence, this study was selected to evaluate the effects of cold circular jet on autonomic and respiratory variables in healthy volunteers.

II. Material And Methods:

A total of 60 healthy volunteers divided into the intervention group 1(n=30) and control group 2(n=30) were recruited from our residential SDM College of Naturopathy and Yogic Sciences. Each group consisted of 10 male and 20 female volunteers with age varied from 18 to 25 years and Body Mass Index (BMI) varied from 18- 28 kg/m². All the subjects were in the same campus with similar atmosphere and diet. The sample size was determined based on the number of subjects who volunteered to participate in the trial. Study subjects were included in the following inclusion and exclusion criteria.

INCLUSION CRITERIA:

- Age: 18-25 years
- Gender: Male and Female
- BMI: <30 kg/m²
- Subject with no known disease conditions or regular use of regular/relevant medications [43]

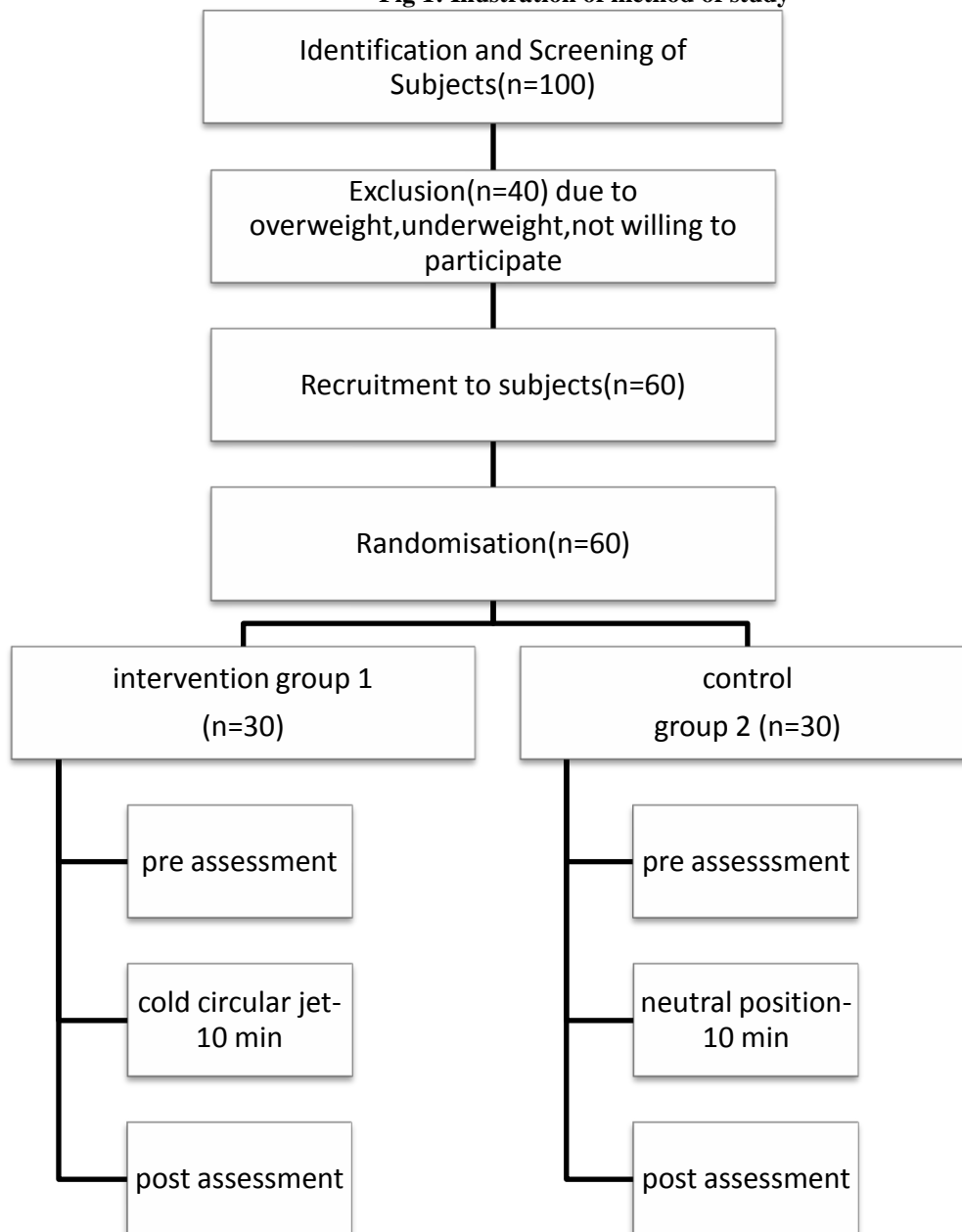
EXCLUSION CRITERIA:

- Subjects with a history of mental illnesses
- Subjects with a history of alcohol/ substance abuse.
- Subjects undergoing menstruation/ pregnancy.
- Individuals with cold sensitivity
- Subjects who have undergone naturopathy treatments for the past two weeks
- Subjects unwilling to participate in the study.

STUDY DESIGN:

- A Pre-post study design was used under which subjects were randomized from their respective classes. Group 1 (n=30) consisted of healthy students belonging to the 1st year of study and Group 2(n=30) consisted of students studying 2nd year of college. Each participant was assessed in a single session at the same time over a period of 12 days. Session for group 1 consisted of cold circular jet and Group 2 was standing in neutral position without intervention. Recordings of the ECG, PPG, and RS were made 5 minutes before and after each session. The duration of each session was 10 minutes. Figure-1 will show the illustration of method of study.

Fig 1: Illustration of method of study



Procedure methodology

Subjects from Intervention Group 1(n=30) received Cold Circular Jet and Control Group 2(n=30) stood in neutral position while being assessed.

Cold Circular Jet (CCJ):

Subjects were given CCJ in the treatment section of the Naturopathy Hospital for a period of 10 minutes. Prior to the intervention, each subject was asked to enter the treatment ring in minimal clothing, and shower cap. During the intervention, the subject stood erect in the center of the circular ringed equipment such that multiple small but powerful jet streams percussed simultaneously on the various parts of the body. After the intervention, the subject was dried with a towel and dressed before the post assessment.

Neutral Position (NP):

The subjects were asked to stand in NP for 10 minutes in the air-conditioned cabin of the research lab. Each subject stood erect with their feet together, hands placed by the side of the thighs, palms facing inwards. Subjects were asked to keep their eyes closed and breathe normally. The NP position was used as a control

variable to imitate the standing position of the subjects who were given CCJ. Control variables are essential in scientific research to indicate how a subject or system reacts under normal conditions (i.e., without intervention).

Statistical analysis

The statistical analysis of the data was done with the use of Microsoft Excel version 14 (2011, USA.). Mean and Standard Deviation [14] were used to summarize data of study participants of each group(n=30). Baseline and post intervention assessments were performed by student's independent samples-t-test to study the statistical significance of differences between the intervention and control groups i.e. CCJ and NP .The students paired samples-t-test was used to compare the baseline and post intervention assessments of each group. P value < 0.05 was considered as significant. [14]

III. Result

There were no significant differences of the ARV between the Cold Circular Jet session and standing in Neutral Position at baseline assessment. (Table 1.)The result of the study showed that there is no statistically significant difference between the CCJ and NP of post intervention assessment (Independent sample-t-test) in the autonomic and respiratory variables such as HR, RR, RRI, Mean RR, SDNN, RMSSD, NN50, pNN50, VLF, LF/HF ratio. However PPG, LF showed a significant decrease (p<0.05) and HF significantly increased post test (Table.2)

The result of within the group analysis done by using the paired samples-t-test showed the statistically significant reduction in PPG and HR both in CCJ and in NP. Though there were significant reductions in PPG and HR in both the sessions the reduction was highly significant in CCJ session (P<0.01) than NP. Further, Mean HR showed significant decrease in the NP session

There was a significant increase in pNN50 and a statistically significant decrease in LF/HF ratio in the CCJ session (p<0.01). There were no statistically significant differences observed either in the CCJ or NP sessions in variables such as RR, Mean RR, SDNN, Mean HR, RMSSD, VLF, LF, HF.

Though there are no significant changes in the above variables, within the group RR was increased in the CCJ session. RRI and Mean RR, SDNN was increased more in CCJ session than in NP. RMSSD, NN50 were both found to increase only in the CCJ session. VLF, LF was reduced in CCJ and remained more or less same in NP session. HF was increased more in the cold circular jet. LF/HF ratio was decreased more in cold circular jet than in NP sessions. (Table.3)

**Table 1. Baseline Assessment of CCJ (n=30) and NP (n=30)
Independent Sample t test**

Variables	Sessions	Mean ± S.D	P value
HR(b/m)	CCJ	92.19±16.63	0.230
	NP	88.86±18.08	
PPG(b/m)	CCJ	88.56±21.18	0.169
	NP	84.35±10.82	
RR(cycles/min)	CCJ	18.32±21.18	0.071
	NP	19.75±10.82	
RRI(ms)	CCJ	0.70±0.11	0.192
	NP	0.72±0.09	
Mean RR(ms)	CCJ	697.74±81.60	0.207
	NP	717.71±104.96	
SDNN(ms)	CCJ	66.69±33.62	0.279
	NP	62.27±23.79	
Mean HR(b/m)	CCJ	88.12±11.21	0.262
	NP	86.10±13.11	
RMSSD(ms)	CCJ	59.80±51.25	0.438
	NP	58.05±33.70	
NN50(count)	CCJ	83.40±63.84	0.063
	NP	87.63±66.56	
pNN50(%)	CCJ	20.87±17.41	0.460
	NP	21.32±16.83	
VLF(%)	CCJ	56.28±93.99	0.088
	NP	32.04±18.61	
LF(n.u)	CCJ	58.88±19.71	0.098
	NP	52.22±19.71	
HF(n.u)	CCJ	41.12±19.71	0.063
	NP	49.95±19.47	
LF/HF(ms ²)	CCJ	2.60±3.30	0.077
	NP	1.63±1.55	

* P value < 0.05; ** P value < 0.01. RRI= Intervals between consecutive R-waves; PPG= Pulse plethysmogram; RR= Respiratory rate; HR= Heart rate; SDNN= Standard Deviation of NN Intervals RMSSD= the square root of the mean of the squares of differences between adjacent NN intervals; NN50= the number of interval differences of successive NN intervals greater than 50 milliseconds; pNN50= Proportion derived by dividing NN50 by the total number of NN intervals; VLF= Very low frequency band of the HRV; LF= Low frequency band of the HRV; HF= High frequency band of the HRV; LF/HF ratio= Ratio of low frequency to high frequency; CCJ=Cold Circular Jet; NP= Neutral Position.

**Table 2: Post Test Assessment of CCJ (n=30) and NP (n=30)
Independent Samples t test**

Variables	Sessions	Mean ± S.D	P value
HR(b/m)	CCJ	81.89±20.05	0.300
	NP	84.37±16.28	
PPG(b/m)	CCJ	74.99±9.86	0.025*
	NP	79.87±9.00	
RR(cycles/min)	CCJ	19.63±3.62	0.481
	NP	19.67±3.31	
RRI(ms)	CCJ	0.79±0.12	0.110
	NP	0.75±0.12	
Mean RR(ms)	CCJ	789.46±116.32	0.102
	NP	752.176±107.93	
SDNN(ms)	CCJ	70.43±45.20	0.236
	NP	63.64±23.92	
Mean HR(b/m)	CCJ	78.35±12.26	0.082
	NP	82.77±12.00	
RMSSD(ms)	CCJ	69.63±64.18	0.201
	NP	58.54±32.31	

NN50(count)	CCJ	109.53±67.80	0.274
	NP	99.20±64.29	
pNN50(%)	CCJ	31.31±17.91	0.100
	NP	25.41±17.31	
VLF(%)	CCJ	27.71±14.27	0.119
	NP	31.93±12.58	
LF(n.u)	CCJ	42.80±19.59	0.042*
	NP	51.93±20.59	
HF(n.u)	CCJ	57.2±19.59	0.042*
	NP	48.07±20.56	
LF/HF(ms ²)	CCJ	1.10±1.39	0.068
	NP	1.68±1.56	

* P value < 0.05; ** P value < 0.01

Table 3: Baseline and Post test Assessment of CCJ (n=30) and NP (n=30). Students paired t test

Variables	Sessions	Baseline Mean ± S.D	Post test Mean ± S.D	P value
HR(b/m)	CCJ	92.19±16.63	81.89±20.05	0.0004**
	NP	88.86±18.08	84.37±16.28	0.0001**
PPG(b/m)	CCJ	88.56±21.18	74.99±9.86	0.0002**
	NP	84.35±10.82	79.87±9.00	0.0138*
RR(cycles/min)	CCJ	18.32±21.18	19.63±3.62	0.048
	NP	19.75±10.82	19.67±3.31	0.445
RRI(ms)	CCJ	0.70±0.11	0.79±0.12	1.546
	NP	0.72±0.09	0.75±0.12	1.080
Mean RR(ms)	CCJ	697.74±81.60	789.46±116.32	5.165
	NP	717.71±104.96	752.176±107.93	1.156
SDNN(ms)	CCJ	66.69±33.62	70.43±45.20	0.307
	NP	62.27±23.79	63.64±23.92	0.359
Mean HR(b/m)	CCJ	88.12±11.21	78.35±12.26	1.098
	NP	86.10±13.11	82.77±12.00	0.002**
RMSSD(ms)	CCJ	59.80±51.25	69.63±64.18	0.150
	NP	58.05±33.70	58.54±32.31	0.462
NN50(count)	CCJ	83.40±63.84	109.53±67.80	0.008
	NP	87.63±66.56	99.20±64.29	0.0627
pNN50(%)	CCJ	20.87±17.41	31.31±17.91	0.001*
	NP	21.32±16.83	25.41±17.31	0.0148
VLF(%)	CCJ	56.28±93.99	27.71±14.27	0.058
	NP	32.04±18.61	31.93±12.58	0.488
LF(n.u)	CCJ	58.88±19.71	42.80±19.59	5.63E
	NP	52.22±19.71	51.93±20.59	0.457

HF(n.u)	CCJ	41.12±19.71	57.2±19.59	5.63E
	NP	49.95±19.47	48.07±20.56	0.368
LF/HF (ms²)	CCJ	2.60±3.30	1.10±1.39	0.002**
	NP	1.63±1.55	1.68±1.56	0.418
* P value < 0.05; ** P value < 0.01.				

Figure 1:

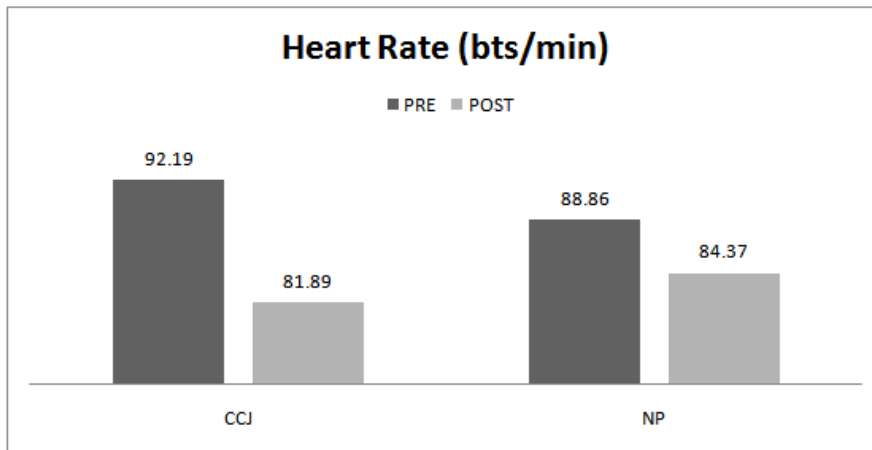


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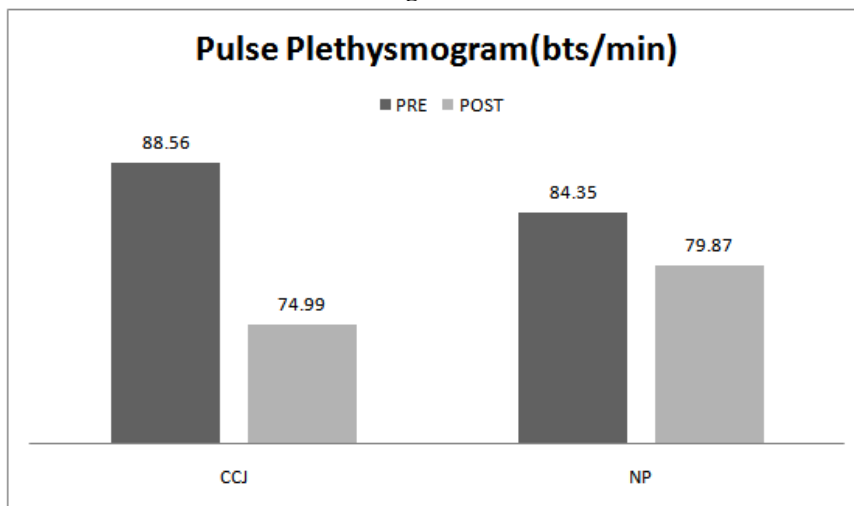


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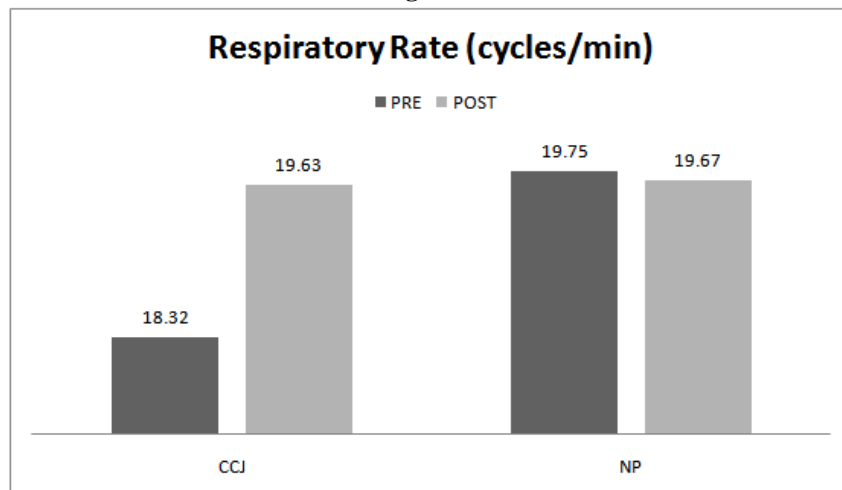


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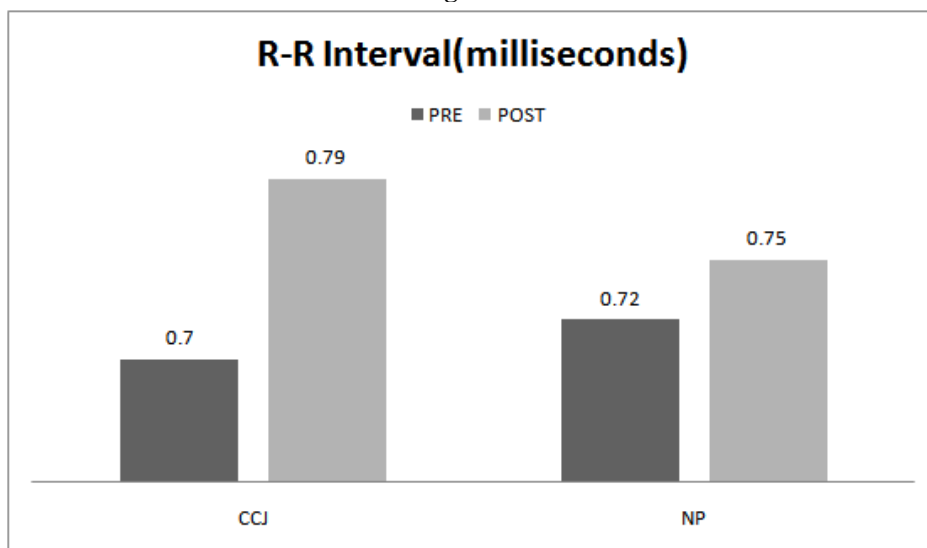


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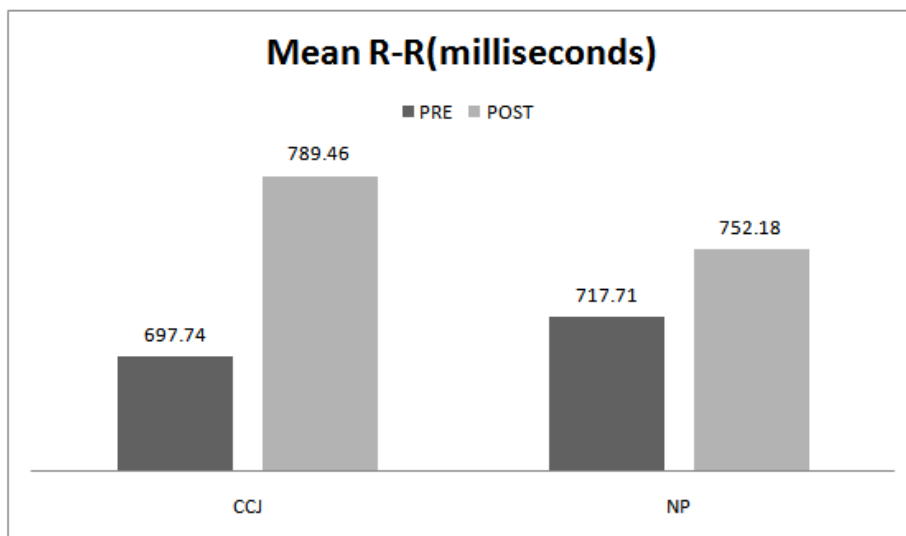


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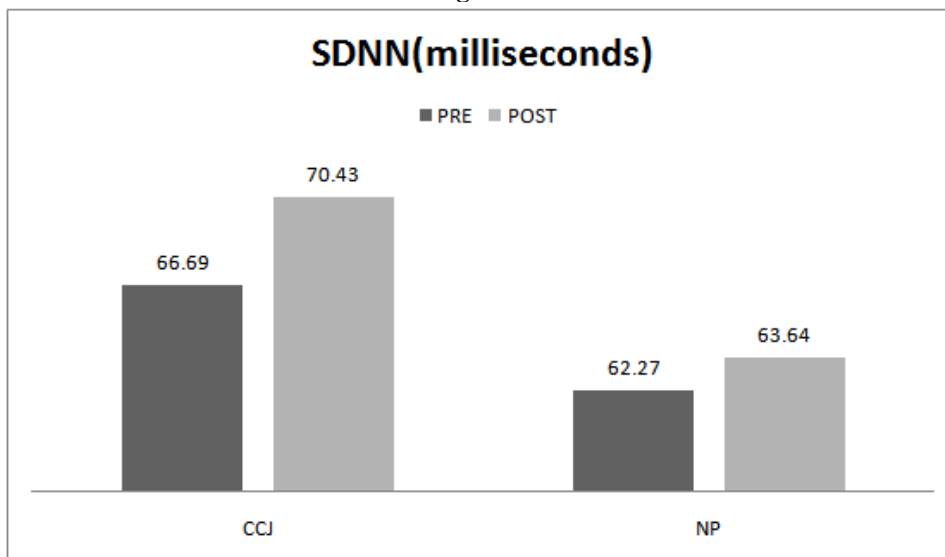


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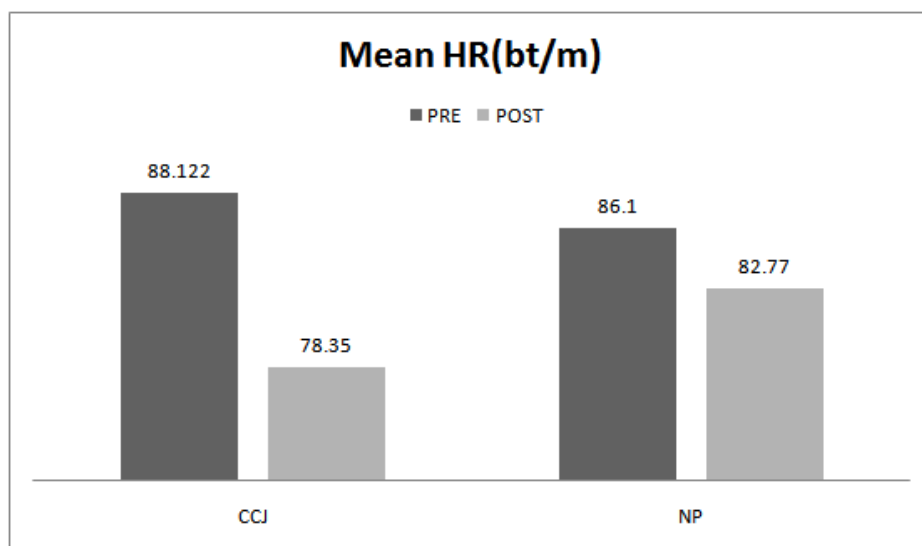


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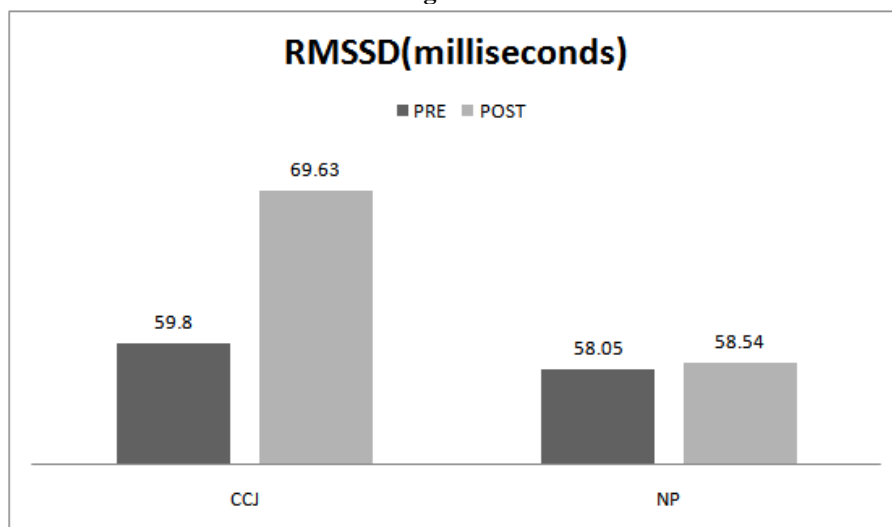


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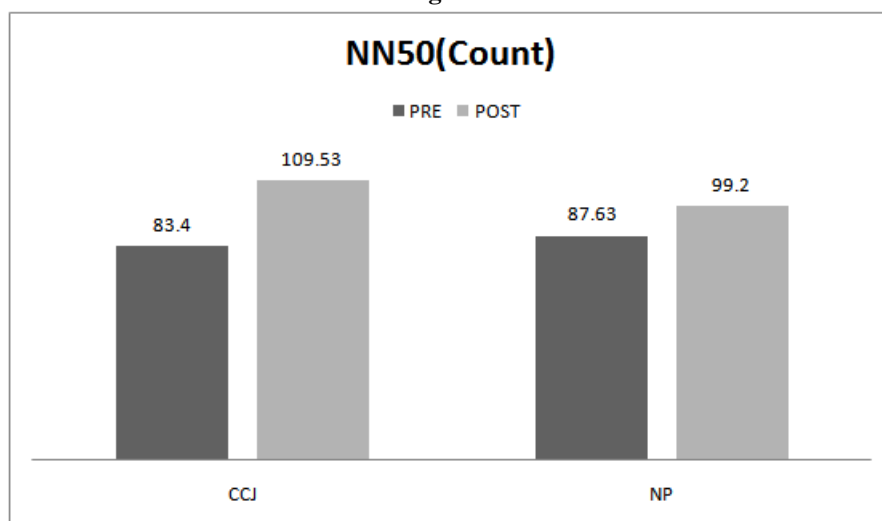


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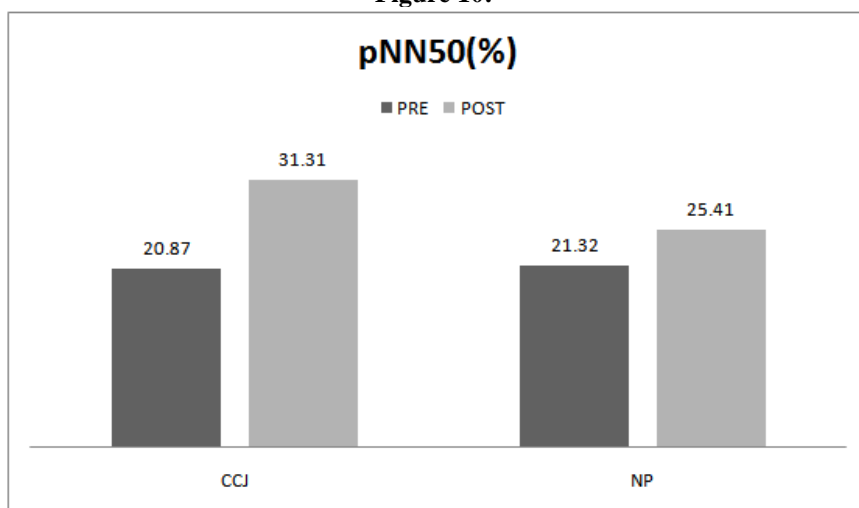


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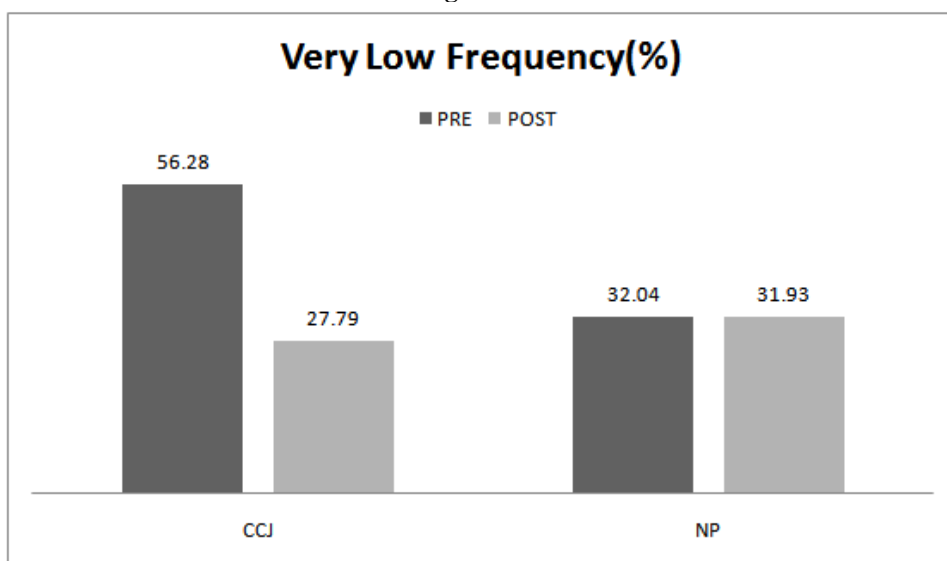


Figure 12:

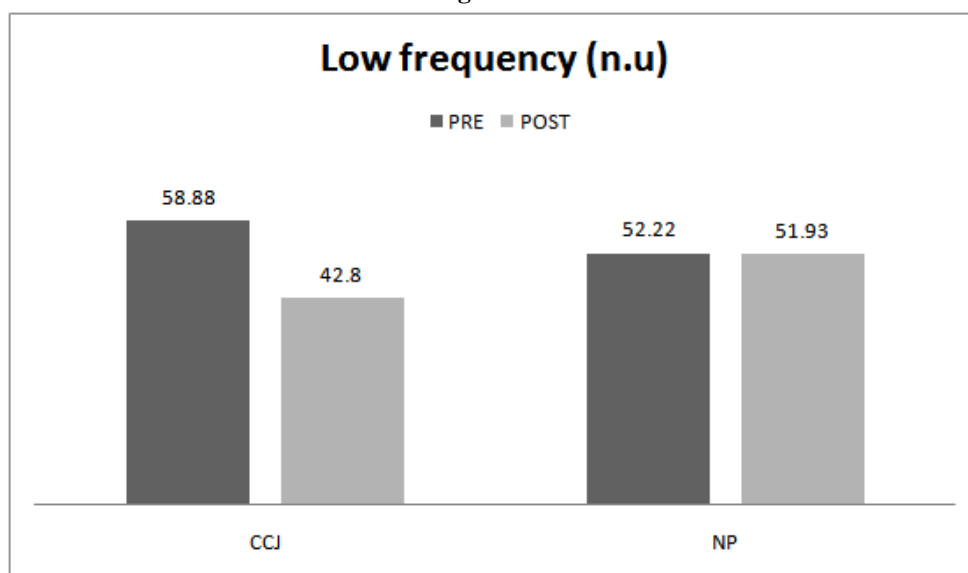


Figure 13:

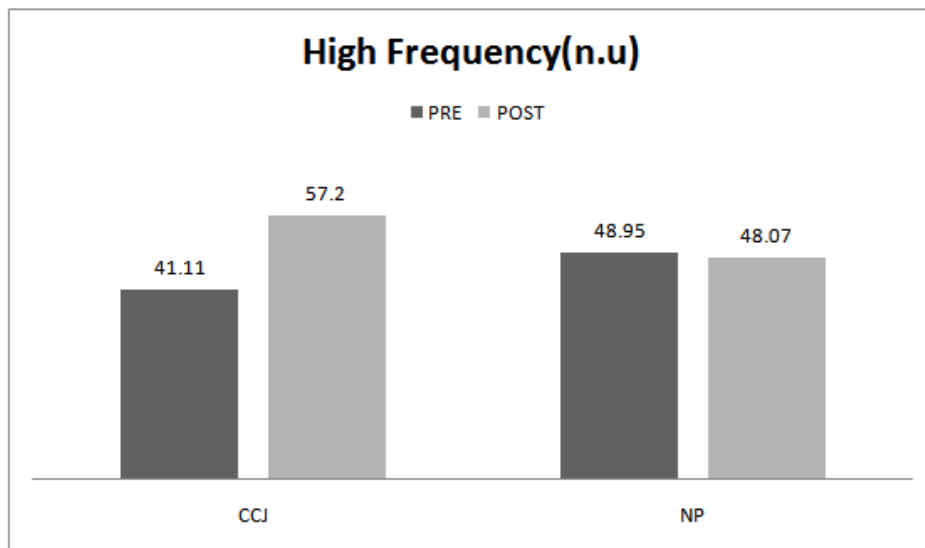
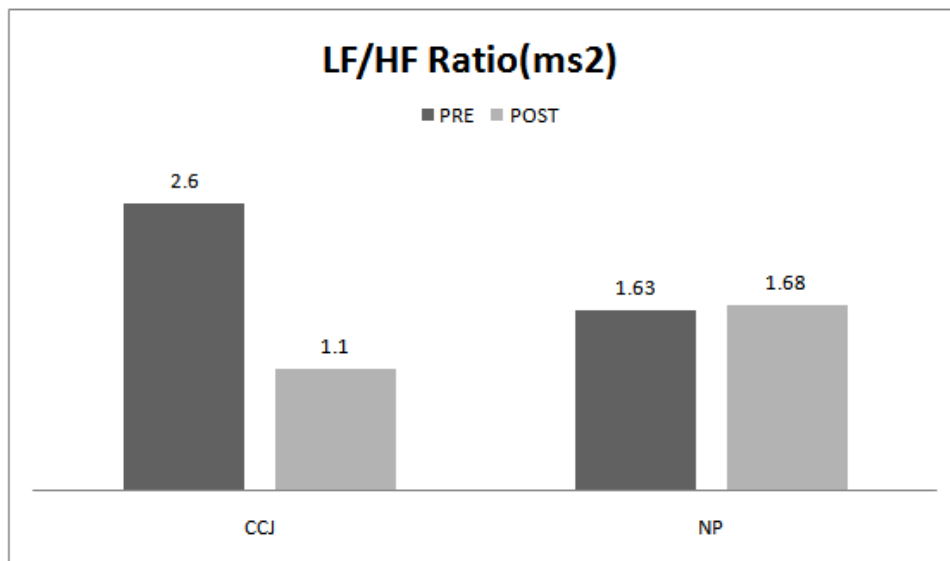


Figure 14:



IV. Discussion

The result of the study showed no significant difference between the Cold Circular Jet (CCJ) and standing in Neutral Position (NP) in all the autonomic and respiratory variables (ARV) such as HR PPG, RR, RRI, mean RRI, SDNN, RMSSD, NN50, pNN50, VLF, LF, HF, LF/HF ratio. It indicates that in influencing the ARV in healthy individuals, Cold Circular Jet is not superior to standing in Neutral Position.

In this study, within the group analysis of both CCJ and NP session showed significant reduction in PPG and HR. The reduction of PPG and HR indicates the physiological influence of the cold circular jet or standing in neutral position on the NTS in Medulla involved in the autonomic control of the heart sympathetic nerve activity. [15] The reduction maybe due to parasympathetic influence of vagus nerve on the heart mediated through Baroreceptors on NTS in response to the peripheral vasoconstriction that occurs as a result of cold stress. [16]

The increase in RR though not significant could be due to the sudden cold stress causing increased oxygen demand and gasping effect [5]. However this shows an increase in Sympathetic activity which is contradictory to the overall parasympathetic effect on the heart.

The increases in RRI, Mean RRI, RMSSD, NN50 and statistically significant increase in pNN50 more in the CCJ session indicate relaxative effect due to PSNS. The significant increase in time domain analysis of HRV such as RMSSD, NN50, and pNN50 are the indicative of vagal tone; [17] vagal modulation of cardiac function; [18] and strongly associated with cardiac vagal influence, and thus represents parasympathetic

activity.[19] It indicates that cold circular jet for 10 minutes may have some effect on parasympathetic activity.

Insignificant decrease in LF and insignificant increase in HF after CCJ but statistically significant reduction in LF/HF ratio indicates it may have some effect on parasympathetic activity which supports the significant reduction in HR and PPG.

Hence, cold circular jet reduces the HR, PPG and LF/HF ratio with improving parasympathetic activities as per the frequency domain results whereas neutral position standing reduces the HR and PPG without altering either sympathetic or parasympathetic activities. The difference in the results between time domain and frequency domain limits; significant increase in RR, limits understanding of its effects on autonomic variables and validity of its result.

LIMITATIONS

- Study was conducted among healthy individuals, which limits the scope of this study in its application to obese/hypertensive patients.
- The duration of the cold circular jet might not be sufficient to produce the significant changes in time domain of the HRV variables.
- Furthermore, difference in temperature between the treatment room and research lab, influence of noise during treatment time as well as inability to use noise free data may have altered the results and caused bias.
- Short-term HRV limits the ability of measurement of time domain analysis accurately. Measurement of HRV through 24-hr Holter monitoring would help to understand this better.
- Direct measurement of sympathetic activity like measurement of peripheral arterial resistance, Galvanic Skin Resistance, and optical sensors would have given better understanding of the state of the sympathetic nervous system.
- Further studies are required (Randomized control trials) in a large sample size with longer duration, adequate care and advanced techniques to evaluate its effect with underlying mechanism.

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