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Effect of Inspiratory Muscle Training on Autonomic Nervous System in Cervical Spinal Cord Injury Patients.

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Abstract

Objective: *To assess the effect of inspiratory muscle training on autonomic nervous system in Cervical Spinal Cord Injury (SCI) patients.*

Setting: *Indian Spinal Injuries Centre, Vasant Kunj, New Delhi, India*

Methodology: *A quasi experimental study was conducted for SCI participants. A 4-week IMT training program was carried out and baseline HRV and PFT findings were recorded and then recorded same parameters after the end of 4th week.*

Results: *28 subjects were included in this study and divided into two groups experimental (Group-A) and control (Group-B), mean age was 31.41 and 39.84 years. Significant difference was found in PFT parameters like MIP, MEP, FEV1 among groups.*

Conclusion*: Though there is no statistically significant differences found with time and between the groups. But there is percentage change and clinical significance as reported by patients showing reduced symptoms and improved PFT values observed in the groups.*

Keywords*: IMT, autonomic nervous system, HRV, CSCI*

Introduction

Spinal cord injury (SCI) is damage to the spinal cord that results in a loss or impairment of function resulting in reduced mobility or sensation (1). SCI and the resultant unstable autonomic control are responsible for increased mortality from cardiovascular and respiratory disease among individuals with SCI (2,3). In high cervical SCI, parasympathetic (vagal) control will remain intact, while the spinal sympathetic circuits will lose their tonic supraspinal autonomic control. On the other hand, in individuals with injury below the 5th thoracic segment, both the sympathetic and parasympathetic control of the heart and broncho-pulmonary tree remain intact. (3)

Inspiratory muscle training (IMT), as its name suggests, is a form of resistance training for inspiratory muscles. A systematic review identified the effects of IMT on the cardiac autonomic control at rest assessed by HRV spectral analysis. In general, the IMT performed at an intensity of 30% MIP resulted decreased cardiac sympathetic modulation i.e. low-frequency (LF) and increased parasympathetic i.e., high frequency (HF) at rest in patients with hypertension, heart failure, and diabetes mellitus (4,5,6).

However according to our knowledge there has been studies done on chronic SCI population with heterogenous population in nature but a dearth in literature showing the association and effect of inspiratory muscle training on autonomic nervous system in patients having acute cervical level of spinal cord injury. Therefore, this study is aimed to procure the effect of inspiratory muscle training on autonomic nervous system in cervical spinal cord injury patients.

Methodology

This quasi-experimental study was carried out after getting the institutional and ethical clearance from Indian Spinal Injuries Centre with reference no. REF ISIC/IIRS/RP/2018/140. A total of 28 SCI survivors were selected and screened on the basis of inclusion and exclusion criteria which includes traumatic SCI with level C4 – C7 aging between 18-50 years. And duration of injury was in between 1 to 6 months and non-tracheotomised (nTT) with AIS-A, AIS-B and AIS-C ISNCSCI classification. Patients were divided into two groups by convenient sampling method Group A (Experiment Group) and Group B (Control group). After taking the baseline measurements Group A received IMT training along with routine care and Group B received only routine care for 4 weeks. At 0-week Group A and Group B patients were evaluated for maximal inspiratory pressure. For Group A, on basis of PFT reading intensity considered as 30%MIP. At 1st week patient was reassessed and then reassessed 30%MIP was taken for IMT level. The procedure followed in 1st week was repeated in 2nd, 3rd and 4th week. At the end of 4th week, outcome measures High frequency (HF), Low frequency (LF), Normalized power in LF band, (LFnu), Normalized power in HF band (HFnu), LF/HF ratio, SDNN, Pnn50, RMSSD) were taken.

Data analysis

Data analysis was performed using the windows version of SPSS v.21. The data were assessed for normal distribution. Mean ± standard deviation was used for describing the sample characteristics. During the study 15 participants received interventions and 13 were kept in control group. For normal distribution paired t-test was used within the groups and independent t-test between the groups. For the data which is not normally distributed, non-parametric test was used. Wilcoxin signed rank test was used within the groups and Mann Whitney U test was used for between the groups.

Results

***Demographic data**

This study involved 28 SCI survivors who were divided into two groups and their basic details and baseline parameters were recorded. The majority of the subjects were male, and the population was homogenous as the below table 1 were showing

Variables	Group A (Experimental)	Group B (Control)
Age (in years) Mean ± S.D	31.41 ± 8.79	39.84 ± 14.19
Gender	Male = 14 Female = 1	Male = 12 Female = 1
Chronicity (in months) Mean ± S.D	5.2 ± 5.23	30.84 ± 17.3
AIS Level	A = 9 B = 5 C = 1	A = 4 B = 8 C = 1

*** Baseline measurements of HRV parameters**

VARIABLES	GROUP A MEAN±SD	GROUP B MEAN±SD	P-value p ≥ 0.05)
HRV			
LF	2917.40 ±173.6	3592.46±3593.80	0.481
HF	6505.28±1404.45	8004.20±5433.42	0.312
LF/HF RATIO	0.4507±0.5638	0.4195±0.8474	0.256
LFNU	29.871±1.410	29.32±4.08	0.626
HFNU	70.122±1.410	70.67±4.08	0.626
RMSSD	231.72±8.96	230.46±7.96	0.699
SDNN	1560.8±5.49	154.79±6.20	0.563
pNN50	82.87±1.16	82.59±1.51	0.590
NN50	1363.33±56.101	1350.07±22.3	0.433
MEAN HR	161.94±2.85	163.06±3.45	0.359
TOTAL POWER	11105.91±2288.14	13346.97±10139.97	0.412

***Baseline measurements of PFT parameters**

PFT	Group A MEAN±SD	Group B MEAN±SD	p-value ($p \geq 0.05$)
MIP	15.08±1.67	12.91±0.98	0.000
MEP	17.35±6	11.93±1.86	0.002
FEV1	1.66±0.26	1.40±0.56	0.006
FVC	2.33±0.75	2.07±0.86	0.765
FEV1/FVC	76.26±14.51	68.54±16.2	0.404
PEFR	158.2±43.14	130±56.99	0.256

*Wilcoxin test for within group (experimental)

PFT	Group A MEAN±SD	Group B MEAN±SD	p-value ($p \geq 0.05$)
MIP	15.08±1.67	12.91±0.98	0.000
MEP	17.35±6	11.93±1.86	0.002
FEV1	1.66±0.26	1.40±0.56	0.006
FVC	2.33±0.75	2.07±0.86	0.765
FEV1/FVC	76.26±14.51	68.54±16.2	0.404
PEFR	158.2±43.14	130±56.99	0.256

***Wilcoxin test for within group (control)**

VARIABLES	PRE (MEDIAN)	POST (MEDIAN)	Z	P-value ($p \geq 0.05$)
LF	2571.82 (1595.05-15383.07)	2840.46 (1858.36-6079.44)	-0.839	0.402
HF	6157.58 (4743.16-25163.99)	5883.67 (4540.20-17718.29)	-0.140	0.889
TOTAL POWER	9800.21 (7465.66-45999.44)	9800.21 (7975.14-27659.77)	-0.350	0.727

***Paired t-test (experimental)**

VARIABLES	GROUP A MEAN ±SD	p-value ($p \geq 0.05$)
LF/HF (%)	PRE- 0.4507± 0.056 POST- 0.4268±0.028	0.158
LFNU	PRE- 29.87± 1.41 POST- 30.97± 2.72	0.178
HFNU	PRE- 70.12± 1.41 POST- 69.09±2.72	0.178
RMSSD(ms)	PRE- 231.72± 8.96 POST- 231.55±6	0.944
pNN50(%)	PRE- 82.8± 1.16 POST- 82.80±0.787	0.813
NN50(%)	PRE- 1363.86±56.10 POST- 1357.86± 42.03	0.613
SDNN(ms)	PRE- 156.81± 5.49 POST- 154.81± 3.96	0.439
MEAN HR	PRE- 161.94± 2.85 POST- 161.98± 2.92	0.974

*** Pre and Post difference of both groups**

VARIABLES	MEAN ± SD	t	P-value (Significance p ≥ 0.05)
LF/HF (%)	-0.01± 0.100	-0.737	0.471
LFNU	0.75±4.80	0.377	0.711
HFNU	-0.75±4.80	-0.377	0.711
RMSSD(ms)	3.13±13.81	-1.328	0.201
pNN50(%)	- 2.64±29.66	-0.575	0.574
NN50(%)	- 7.44±70.48	0.533	0.590
SDNN(ms)	1.47±9.58	-1.614	0.124
MEAN HR	-1.12±9.58	1.201	0.244

Discussion

In SCI population the autonomic disturbances are found to be disturbed. This distribution can be easily accessed through HRV which is a non-invasive, practical and reproducible measure of autonomic nervous system (7). Respiration has been considered as a powerful modulator of heart rate variability, baroreflex and chemoreflex sensitivity (8). It has been observed that IMT training promotes favourable changes in HRV of diseased individuals. In a study by Abreu et al 2018 on effect of IMT training on cardiovascular autonomic control, it was found that autonomic function was improved with IMT training. Study included nine healthy cyclists performed IMT for 11 weeks and were given 1hour/session for over 3 weeks and the intensity was set at 60% of MIP. They concluded that IMT training improved HRV, due to decreased sympathetic modulation and improved para-sympathetic activity (9).

This study concluded that IMT improved autonomic control. It is due to increase in vagal modulation and reduction in sympathetic nervous activity (SNA) (10).

Although several studies have been concluded to assess the effect of inspiratory muscle training on SCI patient in later phase of rehabilitation. As per the best of our knowledge there is no study has been done to correlate the effect of inspiratory muscle training on heart rate variability in early phase of respiratory training in SCI population.

Heart Rate Variability

Spectral analysis of HRV quantifies the dynamic, frequency dependent changes in HR which reflects autonomic function or modulation of sinus node activity (11).

Time Domain Variables

Parameter	Unit	Description
SDNN	ms	Standard deviation of NN intervals
SDANN	ms	Standard deviation of the average NN intervals for each 5 min segment of a 24 h HRV recording
NN50	%	Percentage of successive RR intervals that differ by more than 50 ms
RMSSD	ms	Root mean square of successive RR interval differences

Table:1(12). HRV time-domain measures.

Frequency Domain Variables

Parameter	Unit	Description
LF power	ms^2	Absolute power of the low-frequency band (0.04–0.15 Hz)
HF power	ms^2	Absolute power of the high-frequency band (0.15–0.4 Hz)
LF/HF	%	Ratio of LF-to-HF power

Table: 2 HRV Frequency-Domain Measure

INSPIRATORY MUSCLE TRAINING EFFECT ON SDNN, LF, HF & LF/HF RATIO

There is no statistically significant difference observed in SDNN, LF, HF and LF/HF ratio (parameters of HRV)in pre-post intervention within Group A and Group B respectively.

When the experimental group was compared to control group, there is no statistically significant difference observed in SDNN, LF, HF and LF/HF ratio (parameters of HRV)

Whereas a percentage change of 0.81% in Group A and a percentage change of -3.002% in Group B was observed in SDNN of time domain. In addition to time domain, the frequency domain followed the same trend and showed percentage change of 1.277% in Group A and a percentage change 11.84% in Group B was observed in LF outcome.

Likewise, a percentage change of 3.17% in Group A and -4.15% in Group B was also observed in HF outcome, followed by the same lines, LF/HF ratio showed similar trend of percentage change 6.66% in Group A and -2.43% in Group B respectively.

Although there is no statistically significant difference was observed but there is a clinical significance was observed in the study which was reported by patients in terms of improved symptoms and improved PFT findings.

The improvement in the clinical symptoms and PFT findings can be explained on the basis of the fact that regular breathing exercises shifts the stronger sympathetic control towards the parasympathetic dominance of autonomic balance (13). which can also be explained with the higher values of SDNN in experimental group as compared to control group explaining the possibility of the improved vagal dominance in IMT training group, resulting in improved autonomous control.

The results indicate that post training in experimental group showed an increase in parasympathetic dominance at resting (HF= 3.17, LF/HF ratio= 6.66) with decrease in sympathetic dominance (LF=1.277) as compared to controls. These results show positive influence of inspiratory muscle training with increasing intensity in cervical spinal cord injured patients showing improvement in parasympathetic dominance, which can result in an increased cardiovagal reflex activity which leads to increased oscillation of RRI from a better match of heart rate to inspiration (14).

The same findings have been observed by Legg ditter-line et al 2018, who studied the effect of respiratory training on heart rate variability and baroreflex sensitivity in chronic spinal cord injury patients. In this study, there were no significant changes in LF and HF bands when experimental group is compared with control group. Although HRV increased in experimental group in both LF and HF bands in last 5 minutes of sitting position. A major limitation of this study was small sample size which is heterogenous in nature (14).

Another study by Laoutaris et al 2008, on the effect of IMT on autonomic activity, endothelial activity and N terminal pro brain natriuretic peptide levels in patients with CHF. Found that high intensity IMT improved PI max and SIP max without any change on HRV and other variables (15).

Another study by Stillings, Gonzales and Scheuermann 2006, on healthy subjects to investigate the effects of IMT on HRV. Showed improvement in FVC, FEV1 but it did not affect the resting HR, LF and HF components of heart rate variability (16).

A study by Ferreira et al 2011 on the effect of IMT on blood pressure and sympathetic activity in hypertensive patients. Concluded that IMT improved autonomic control which was explained by an increase in vagal modulation and reduction in sympathetic nervous activity(SNA)(4).

To conclude that IMT training improves pulmonary function outcomes that can ultimately lead to improved cardiac-autonomic response particularly in a population with significant increase in mortality from cardiovascular and pulmonary diseases.

Conclusion

There are no statistically significant differences found with time and between the groups, but there is percentage change and clinical significance as reported by patients showing reduced symptoms and improved PFT values observed in the groups. But this percentage change was very small, and does not illustrate a statistically significant difference between the two groups.

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