An Empirical Study of Kapalbhati Pranayama on Respiratory Parameters of University Level Girls

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Abstract The objective of this study is to determine the effects of kapalbhati pranayama on respiratory parameters. The study was conducted on 50 university level girls of Department of Physical Education (T), Guru Nanak Dev University, Amritsar between the age group of 21-26 years (Mean $\pm$ SD: age 22.04 ± 1.63 yrs, height 5.41 ± 0.14 ft, body mass 60.88 ± 3.04 k). The subjects from experimental group were subjected to a 4-week training of kapalbhati pranayama. Student t test for paired samples was utilized to compare the means of the pre-test and the post-test. Significant differences were found in Tidal Volume (V_T), Expiratory Reserve Volume (ERV), Vital Capacity (VC) and Inspiratory Capacity (IC) in experimental group and insignificant between-group differences were noted in Inspiratory Reserve Volume (IRV) of university level girls. The result further indicates that no significant changes over that 4- week period were noted in the control group.

Keywords: Kapalbhati Pranayama, Tidal Volume (V_T), Expiratory Reserve Volume (ERV), Inspiratory Reserve Volume (IRV), Vital Capacity (VC) and Inspiratory Capacity (IC)

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1. Introduction

Yogic techniques produce remarkable physiological changes and have sound scientific basis [1,2,3]. Pranayam, the fourth step of ashtang yoga is an important component of yoga training. It is known that the regular practice of pranayama increases parasympathetic tone, decreases sympathetic activity, improves cardiovascular and respiratory functions, decreases the effect of stress and strain on the body and improves physical and mental health [4,5]. Kapalbhati Pranayama is a miraculous yoga breathing exercise, invented by Indian yogis thousands years ego, for complete body fitness. It affects even those diseases which are impossible to be cured by medicines like cancer, diabetes, asthma. Numerous patients have gained healthy and happy life by adopting it, in their daily life [6]. The ancient science of yoga makes use of the voluntary regulation of breathing to make respiration rhythmic and to calm the mind [6]. This practice is called 'Pranayama'. It is an art of controlling the breath. It involves taking in breath, retaining it then exhaling it [7,8]. Some studies have shown the various effects of Pranayama on young volunteers [9]. The beneficial effects of six weeks practice of different pranayamas are well reported and have sound scientific basis [10]. Different types of pranayama along with asanas produce different physiological responses in normal young individuals. Raja yoga meditation has shown to reduce the resting respiratory rate, increase tidal volume and minute volume [11]. In yoga tradition, it is taught that different pranayams have different effects. Raghuraj et al [12] have studied the acute effect of fast and slow pranayams on heart rate variability while Telles and Desiraju [13] have demonstrated the heart rate changes during the performance of different pranayams. Pranayama has immense therapeutic potential in a wide range of psychosomatic disorders, but there is currently lack of an adequate meta-analysis in relation to kapalbhati pranayama to assess its efficacy with respect to hematological parameters and as a result the present study was conducted to find out therapeutic effects of kapalbhati pranayama on respiratory parameters.

2. Material and Methods

2.1. Subjects

Fifty, university level girls of Department of Physical Education (T), Guru Nanak Dev University, Amritsar between the age group of 21-26 years (Mean $\pm$ SD: age 22.04 ± 1.63 yrs, height 5.41 ± 0.14 ft, body mass 60.88 ± 3.04 kg) volunteered to participate in the study. The subjects were purposively assigned into two groups:

- Group-A: Experimental (n_1=25)
- Group-B: Control (n_2=25)

Table 1. Distribution and Demographics of Subjects

Variables	Sample Size (N=50)		
	Total (N=50)	Experimental group (n_1=25)	Control group (n_2=25)
Age	22.04±1.63	20.92±1.22	23.16±1.16
Body Height	5.41±0.14	5.40±0.15	5.42±0.12
Body Mass	60.88±3.04	60.24±2.08	61.52±3.70

All the subjects were informed about the objective and protocol of the study. Distribution and demographics of subjects are brought forth in Table 1.

2.2. Methodology

This study is designed as a retrospective cross-sectional study. The subjects from Group-A: Experimental were subjected to a 4-week training of kapalbhati pranayama. This lasted 4 weeks and consisted of daily sessions. The following respiratory parameters were measured 3 times with the use of a wet spirometer, the respective average values being used in the analysis:

- Tidal volume (V_T) - The subject was asked to inhale a normal breath and then to place the mouthpiece of the spirometer between the lips and exhale normally into the spirometer.
- Expiratory Reserve Volume (ERV) - After exhaling normally and placing the mouthpiece between the lips, the subject exhaled forcefully all the additional air possible.
- Inspiratory Reserve Volume (IRV) – After inhaling normally and placing the mouthpiece between the lips, the subject inhaled forcefully all the additional air possible.
- Vital Capacity (VC) – Following a maximum inspiration, all the air possible was forcibly exhaled through the mouthpiece. The vital capacity is the sum of the three primary volumes that can be directly exchanged with the atmosphere (VC=IRV + V_T + ERV).
- Inspiratory Capacity (IC) - After exhaling normally, breathes in as deeply as possible, place the mouthpiece and exhale normally. The inspiratory capacity is the sum of the inspiratory reserve volume and the tidal volume (IC=IRV + V_T).
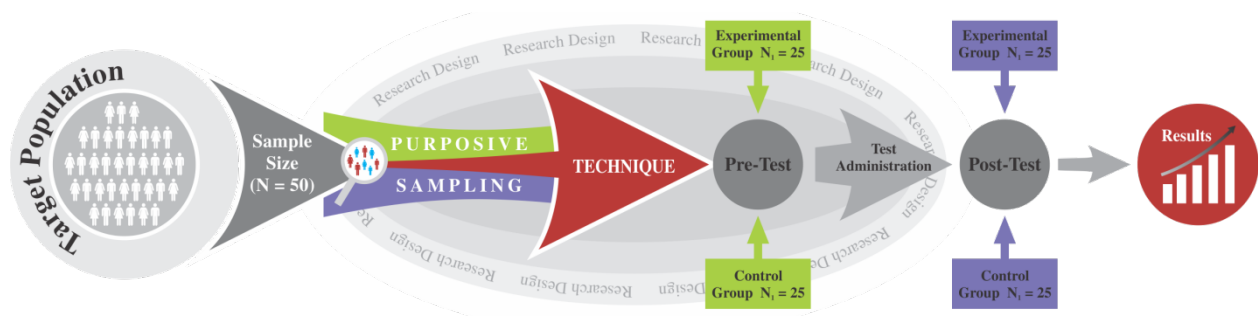

Figure 1. Study Design

Figure 2. Subjects Performing Tidal volume (V_T)

Figure 3. Subjects Performing Expiratory Reserve Volume (ERV)

Figure 4. Subjects Performing Inspiratory Reserve Volume (IRV)

Figure 5. Subjects Performing Vital capacity (VC)

Figure 6. Subjects Performing Inspiratory capacity (IC)

Table 2. Experimental Treatment

4-Weeks Kapalbhati Pranayama Training Programme			
Weeks	Schedule	Time	Duration
I^st Week	Preliminary Yogic Exercises	5 Minute	20 Minute
	Practice of Kapalbhati Pranayama (9 Rounds X 1 Set)	10 Minute	
	Relaxation Posture	5 Minute	
2nd Week	Preliminary Yogic Exercises	5 Minute	25 Minute
	Practice of Kapalbhati Pranayama (9 Rounds X 2 Set)	15 Minute	
	Relaxation Posture	5 Minute	
3rd Week	Preliminary Yogic Exercises	5 Minute	30 Minute
	Practice of Kapalbhati Pranayama (9 Rounds X 3 Set)	20 Minute	
	Relaxation Posture	5 Minute	
4rd Week	Preliminary Yogic Exercises	5 Minute	35 Minute
	Practice of Kapalbhati Pranayama (9 Rounds X 4 Set)	25 Minute	
	Relaxation Posture	5 Minute	

(a)   (b)

(c)   (d)

Figure 7. Subjects Performing Kapalbhati Pranayama

3. Statistical Analyses

Statistical analyses were performed using the Statistical Package for the Social Sciences for Windows version 16.0 software (SPSS Inc., Chicago, IL). Data is expressed as the mean ± SD. Student t test for paired samples was utilized to compare the means of the pre-test and the post-test. The level of significance was set at 0.05.

4. Results

Table 3. Descriptive Statistics (Mean & Standard Deviation) and Paired Sample t-test of Tidal Volume (V_T) of University Level Girls

Tidal Volume (V_T)						
Group	Number	Mean	*Standard Deviation*	Standard Error of the Mean	t-value	p-value
Experiment (Pre-test) Experimental (Post-test)	25	383.88 403.84	8.97 18.39	1.79 3.68	8.1566*	0.0001
Control (Pre-test) Control (Post-test)	25	367.96 361.68	17.36 36.64	3.47 7.33	0.8913	0.3816

The results of Respiratory Parameters (i.e., Tidal Volume (Vt), Expiratory Reserve Volume (ERV), Inspiratory Reserve Volume (IRV), Vital Capacity (VC) and Inspiratory Capacity (IC) of university level girls are brought forth in Table 3- Table 7.

4.1. Tidal Volume (V_T)

The Mean and Standard Deviation values of Tidal Volume (V_T) of pre-test and post-test of experimental group was 383.88 ± 8.97 and 403.84 ± 18.39 respectively.

However, the Mean and Standard Deviation values of Tidal Volume (V_T) of pre-test and post-test of control group were 367.96 ± 17.36 and 361.68 ± 36.64. The t-value in case of experimental group was 8.1566* and for control group it was 0.8913.

Significant between-group differences were noted in Tidal Volume (V_T) since the calculated value of (t=8.1566*) is greater than tabulated value of $t_{.05}$ (24) = 2.06 for the selected degree of freedom and level of significance.
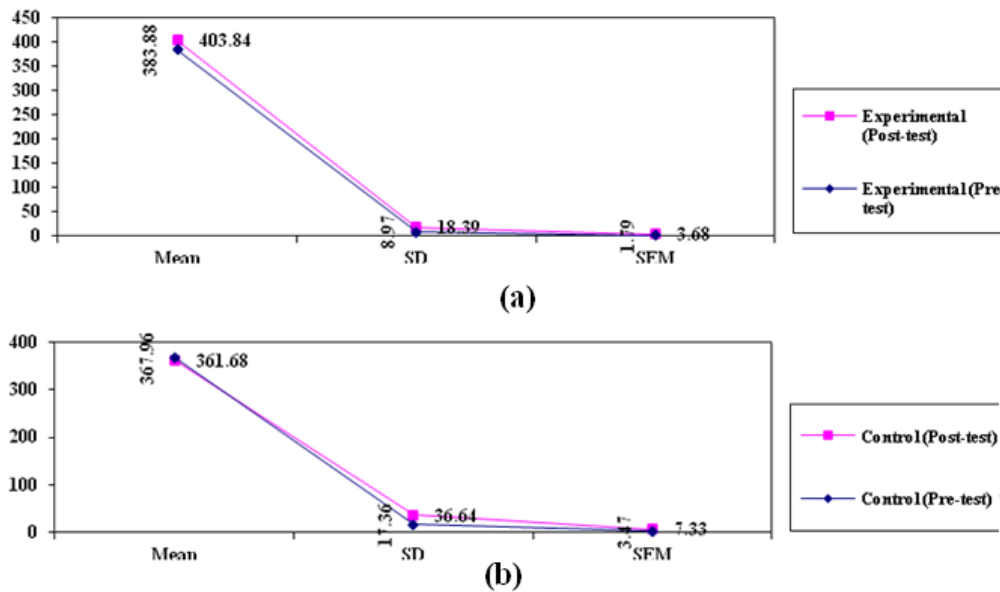

Figure 8. Descriptive Statistics (Mean & Standard Deviation) and Standard Error of the Mean of Tidal Volume (V_T) of (a) Experimental (Pre & Post) and (b) Control (Pre & Post) group of University Level Girls

Table 4. Descriptive Statistics (Mean & Standard Deviation) and Paired Sample t-test of Expiratory Reserve Volume (ERV) of University Level Girls

Expiratory Reserve Volume (ERV)						
Group	Number	Mean	*Standard Deviation*	Standard Error of the Mean	t-value	p-value
Experiment (Pre-test) Experimental (Post-test)	25	737.80 765.68	26.85 17.29	5.37 3.46	8.4172*	0.0001
Control (Pre-test) Control (Post-test)	25	717.84 721.04	19.20 17.17	3.84 3.43	1.8293	0.0798

4.2. Expiratory Reserve Volume (ERV)

The Mean and Standard Deviation values of Expiratory Reserve Volume (ERV) of pre-test and post-test of experimental group was 737.80 ± 26.85 and 765.68 ± 17.29 respectively. However, the Mean and Standard Deviation values of Expiratory Reserve Volume (ERV) of pre-test and post-test of control group were 717.84 ± 19.20 and 721.04 ± 17.17. The t-value in case of experimental group was 8.4172* and for control group it was 1.8293.

Significant between-group differences were noted in Expiratory Reserve Volume (ERV) since the calculated value of (t=8.4172*) is greater than tabulated value of $t_{.05}$ (24) = 2.06 for the selected degree of freedom and level of significance.
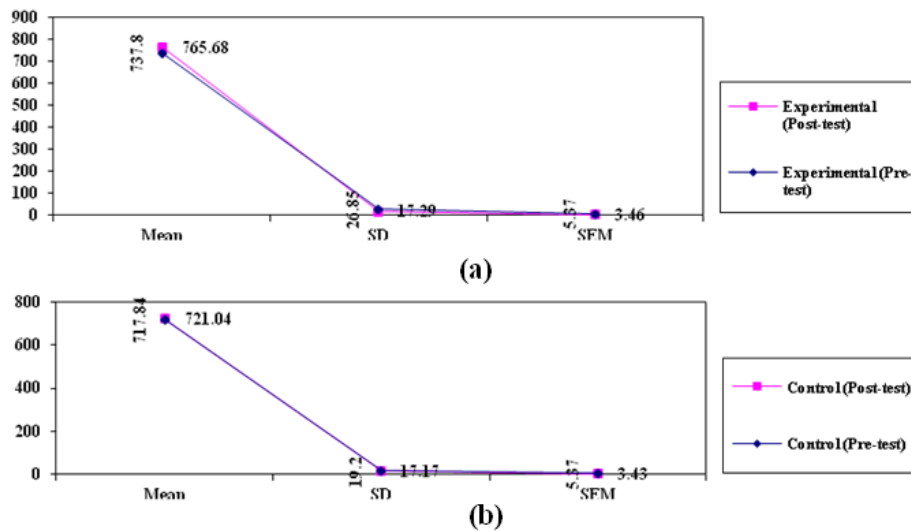
Figure 9. Descriptive Statistics (Mean & Standard Deviation) and Standard Error of the Mean of Expiratory Reserve Volume (ERV) of (a) Experimental (Pre & Post) and (b) Control (Pre & Post) group of University Level Girls

Table 5. Descriptive Statistics (Mean & Standard Deviation) and Paired Sample t-test of Inspiratory Reserve Volume (IRV) of University Level Girls

Inspiratory Reserve Volume (IRV)						
Group	Number	Mean	*Standard Deviation*	Standard Error of the Mean	t-value	p-value
Experiment (Pre-test)	25	2235.32	12.00	2.40	1.6054	0.1215
Experimental (Post-test)		2230.84	11.35	2.27		
Control (Pre-test)	25	2154.48	51.06	10.21	0.2372	0.8145
Control (Post-test)		2154.84	54.59	10.92		

4.3. Inspiratory Reserve Volume (IRV)

The Mean and Standard Deviation values of Inspiratory Reserve Volume (IRV) of pre-test and post-test of experimental group was 2235.32 ± 12.00 and 2230.84 ± 11.35 respectively. However, the Mean and Standard Deviation values of Inspiratory Reserve Volume (IRV) of pre-test and post-test of control group were $2154.48 \pm$ 51.06 and 2154.84 ± 54.59. The t-value in case of experimental group was 1.6054 and for control group it was 0.2372.

Insignificant between-group differences were noted in Inspiratory Reserve Volume (IRV) since the calculated value of (t=1.6054) is less than tabulated value of t_{05} (24) = 2.06 for the selected degree of freedom and level of significance.
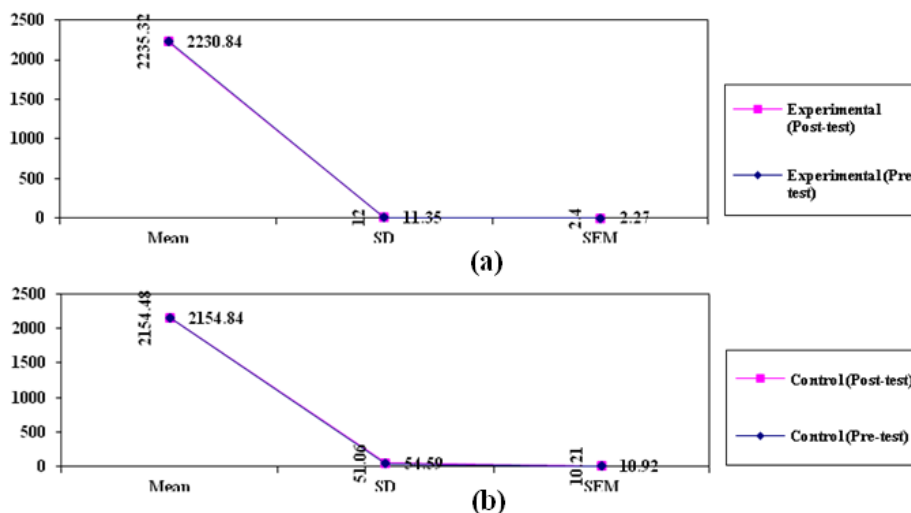

Figure 10. Descriptive Statistics (Mean & Standard Deviation) and Standard Error of the Mean of Inspiratory Reserve Volume (IRV) of (a) Experimental (Pre & Post) and (b) Control (Pre & Post) group of University Level Girls

Table 6. Descriptive Statistics (Mean & Standard Deviation) and Paired Sample t-test of Vital Capacity (VC) of University Level Girls

Vital Capacity (VC)						
Group	Number	Mean	*Standard Deviation*	Standard Error or the Mean	t-value	p-value
Experiment (Pre-test)	25	3357.00	31.68	6.34	7.8941*	0.0001
Experimental (Post-test)		3400.36	26.41	5.28		
Control (Pre-test)	25	3240.28	61.97	12.39	0.3886	0.7010
Control (Post-test)		3237.56	77.50	15.50		

4.4. Vital Capacity (VC)

The Mean and Standard Deviation values of Vital Capacity (VC) of pre-test and post-test of experimental group was 3357.00 ± 31.68 and 3400.36 ± 26.41 respectively. However, the Mean and Standard Deviation values of Vital Capacity (VC) of pre-test and post-test of control group were 3240.28 ± 61.97 and 3237.56± 77.50.

The t-value in case of experimental group was 7.8941* and for control group it was 0.3886.

Significant between-group differences were noted in Vital Capacity (VC) since the calculated value of (t=7.8941*) is greater than tabulated value of $t_{.05}$ (24) = 2.06 for the selected degree of freedom and level of significance.
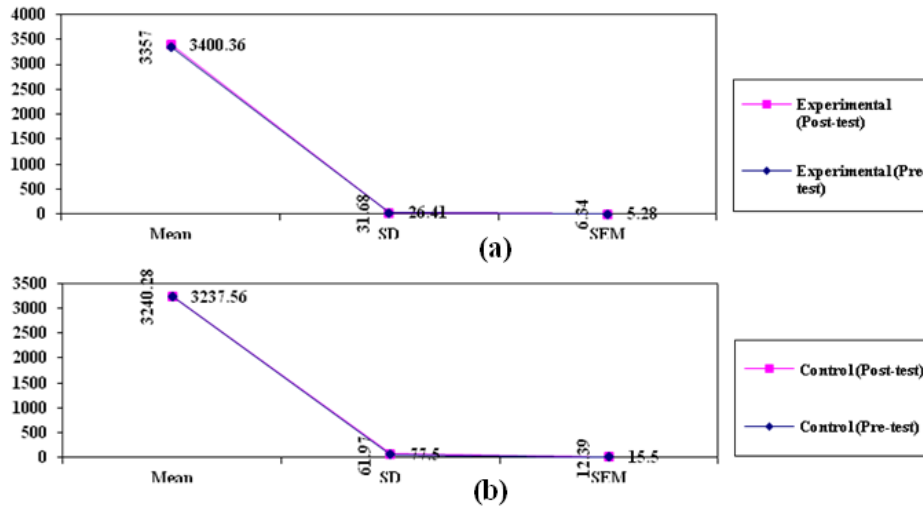

Figure 11. Descriptive Statistics (Mean & Standard Deviation) and Standard Error of the Mean of Vital Capacity (VC) of (a) Experimental (Pre & Post) and (b) Control (Pre & Post) group of University Level Girls

Table 7. Descriptive Statistics (Mean & Standard Deviation) and Paired Sample t-test of Inspiratory Capacity (IC) of University Level Girls

Inspiratory Capacity (IC)						
Group	Number	Mean	*Standard Deviation*	Standard Error of the Mean	t-value	p-value
Experiment (Pre-test) Experimental (Post-test)	25	3740.88 3804.20	31.99 40.32	6.40 8.06	8.5348*	0.0001
Control (Pre-test) Control (Post-test)	25	3608.24 3599.24	65.65 101.82	13.13 20.36	0.6513	0.5211

4.5. Inspiratory Capacity (IC)

The Mean and Standard Deviation values of Inspiratory Capacity (IC) of pre-test and post-test of experimental group was 3740.88 ± 31.99 and 3804.20 ± 40.32 respectively. However, the Mean and Standard Deviation values of Inspiratory Capacity (IC) of pre-test and post-test of control group were 3608.24 ± 65.65 and 3599.24 ± 101.82. The t-value in case of experimental group was 8.5348* and for control group it was 0.6513.

Significant between-group differences were noted in Inspiratory Capacity (IC) since the calculated value of (t=8.5348*) is greater than tabulated value of $t_{.05}$ (24) = 2.06 for the selected degree of freedom and level of significance.
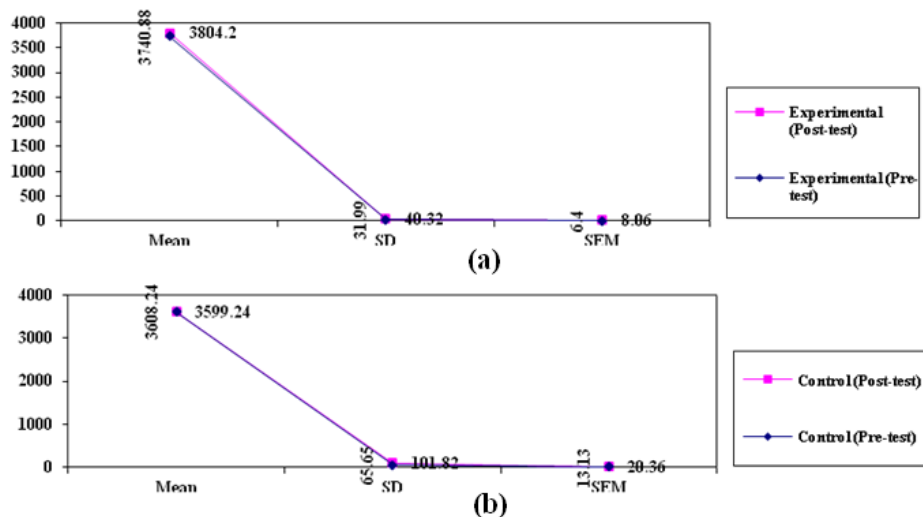

Figure 12. Descriptive Statistics (Mean & Standard Deviation) and Standard Error of the Mean of Inspiratory Capacity (IC) of (a) Experimental (Pre & Post) and (b) Control (Pre & Post) group of University Level Girls

5. Conclusion

In summary, the present work manifests an overriding endeavor to explore effects of kapalbhati pranayama on Respiratory Parameters of university level girls. Significant differences were found in Tidal Volume (V_T), Expiratory Reserve Volume (ERV), Vital Capacity (VC) and Inspiratory Capacity (IC) in the experimental group subjected to 4- week training of kapalbhati pranayama and insignificant between-group differences were noted in Inspiratory Reserve Volume (IRV). However, no significant changes over that 4- week period were noted in the control group.

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