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Summary, Conclusions and Recommendations
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In this chapter summary, conclusions and recommendations of the conducted research have been documented.

5.1. Summary

The study undertaken was entitled as “A Study on the Effect of Selected Yogic Kriyas and Pranayamas on Selected Autonomic Functions (A Noninvasive Study)”. The objectives of the conducted study were (i) to find out the effect of anulom vilom on the autonomic functions of sedentary females age ranging from 35 years to 45 years (ii) to find out the effect of kapalbhati on the autonomic functions of sedentary females age ranging from 35 years to 45 years (iii) to find out the effect of bhramari on the autonomic functions of sedentary females age ranging from 35 years to 45 years (iv) to find out the effect of agnisar on the autonomic functions of sedentary females age ranging from 35 years to 45 years. The study was delimited to the following yogic kriyas and pranayams (1) anulom vilom (2) kapalbhati (3) bhramari and (4) agnisar. The study was further delimited to the sedentary females age ranging from 35 years to 45 years. The limitations of the study were (1) the heterogeneity of dietary intake and life style if any of sedentary females were considered as the limitation of the study, although the considered sedentary females samples were with homogeneous socioeconomic status as they were interviewed during taking consent for experimentation on them and (2) consideration of larger sample size (N≥25) for each experimental and control group (matched) has overcome such limitation by randomization. It was hypothesized that (1) there will be positive effect of anulom vilom on the autonomic functions of sedentary females age ranging from 35 years to 45 years. (2) there will be positive effect of kapalbhati on the autonomic functions of sedentary females age ranging from 35 years to 45 years (3) there will be positive effect of bhramari on the autonomic functions of sedentary females age ranging from 35 years
to 45 years (4) there will be positive effect of agnisar on the autonomic functions of sedentary females age ranging from 35 years to 45 years.

Keeping in view the purpose of the study, a large number of sedentary female (n=244) were randomly selected from Prajapita Brahma Kumaris Ishwariya Vishwa Vidyalaya, Shiv Darshan Gyan Mandir, Jaitpur Ext., New Delhi-110044. The age of the sedentary females ranged from 35 years to 45 years. There were four experimental protocols namely anulom vilom, kapalbhati, bhramari and agnisar. For each experimental protocol one experimental and one control group were assigned. The corresponding experimental and control groups were homogeneous / matched groups in regard to age, resting heart rate, systolic blood pressure and diastolic blood pressure. Hence, there were four experimental groups and four control groups. The number of samples at pre test in experimental groups were [anulom vilom (n1)=35, kapalbhati (n2)=35, bhramari (n3)=35, agnisar (n4)=35] consisting of 140 samples. The number of samples at pre test in control groups were [anulom vilom (n1)=26, kapalbhati (n2)=26, bhramari (n3)=26, agnisar (n4)=26] consisting of 104 samples. The number of samples at post test in experimental groups were [anulom vilom (n1)=30, kapalbhati (n2)=30, bhramari (n3)=32, agnisar (n4)=30] consisting of 122 samples. The number of samples at post test in control groups were [anulom vilom (n1)=23, kapalbhati (n2)=23, bhramari (n3)=26, agnisar (n4)=25] consisting of 97 samples. The experimental groups were treated with selected yogic practices namely anulom vilom, kapalbhati, bhramari and agnisar (tailored programme), independently to independent group for 20 to 30 minutes, for six days per week, at least two days per week was the minimum eligibility attendance though each participants were motivated to have maximum number of attendance. The experimental treatments or training were administered for six weeks whereas the control groups were not given any treatment. Autonomic functions test were done at pre test and after six weeks of yogic training as the post test on the experimental groups. Simultaneously the control groups were tested. The selected twenty two variables were resting heart rate (bpm), systolic blood pressure (mmHg), diastolic blood pressure (mmHg), deep breathing test score (change in heart rate), expiratory inspiratory ratio, valsalva manoeuvre ratio, hand grip test score (mmHg), cold pressure test score (mmHg), lying to standing test score (mmHg), 30:15 ratio,
NN50 count (f), PNN50 count (%), SDSD(ms), RMSSD(ms), SDANN(ms), LF (normalised unit), HF (normalised unit), LF/HF ratio, LF-AP (ms^2), HF-AP(ms^2), total power -AP (ms^2) and SDNN (ms).

The selected equipments were (1) digital polygraph and transducers: A two channel computerized polygraph model PC-2004 (Medicaid Systems, Chandigarh, India) was used in the study. The polygraph had two channels – ECG and respiration. The polygraph was connected to master switch to regulate power into the system and the polygraph was connected to computer where signals were recorded in the ‘Physio-pac’ software. The software had one separate channel which gave heart rate at every second. Both ECG and respiration were recorded simultaneously and were measured. Recorders provided a permanent visual record of an electrical signal. The electronic recording system consisted of three important components. Firstly, the electrode or transducer picked up the bioelectrical potentials whereas the transducer converted the physiological signal to be measured into a usable electrical output. Secondly, the signal conditioner converted the output of the transducer into an electrical quantity suitable for operating the writing system. Thirdly, the writing system provided a visible graphic representation of the quantity of the physiological variable of interest. The signal conditioner consisted of a preamplifier and the main amplifier. Both these amplifier satisfied specific operating requirements such as input impedance, gain and frequency response characteristics for a faithful reproduction of the input signal. (2) hand grip dynamometer: A very efficient hand grip dynamometer (Lafayette Instrument Company, USA) was used to measure maximum voluntary contraction. It was held in hand comfortably. It had a scale in kilogram (Kg) and a pointer which shows the isometric strength on pressing the dynamometer.(3) improvised manometer for valsalva manoeuvre test: A mercury momanometer was used for valsalva manoeuvre test consisted of a bulb filled with mercury (standard mercury manometer). At the end it was connected to a mouth piece through a rubber tubing. (4) stethoscope and sphygmomanometer: A standard stethoscope and sphygmomanometer were used to measure the blood pressure. (5) ice box and thermometer: An ice box was used to maintain the temperature at 10 degree Celsius for cold pressure test and to check the temperature of water a standard thermometer was used.
To test the autonomic function tests (reactivity and activity) wiz. lying to standing test (LST), deep breathing test (DBT), valsala manoeuvre test (VM), hand grip test (HGT), cold pressure test (CPT) and heart rate variability (activity) respectively, tester attended training in Biomechanics Laboratory, Indira Gandhi Institute of Physical Education and Sports Sciences (IGIPESS), Vikas Puri, New Delhi, under the supervision of Dr. Dhananjoy Shaw (Associate Professor, IGIPESS).

Standard instruments were used to perform the autonomic functions testing. The digital polygraph of Medicaid Company, Chandigarh, India was used for the research. The variables of heart rate variability (HRV) were analyzed by using the HRV softwares developed by AIIMS, New Delhi and Biomedical Signal Analysis Group, Department of Applied Physics, University of Kudopio, Finland. Before any recording the instruments were calibrated and ensured for best performance.

The reliability of data was ensured by recording a set of data by research scholar, simultaneously the same samples were recorded by Dr. Dhananjoy Shaw and Dr. Pawan Dabas as second set of data. When correlation between two sets of data on same samples was exceeded .99, the researcher was considered competent enough to record the data.

In the pre recording procedure the subjects were made comfortable and were explained about the entire procedure before the recording was made. The ECG electrodes were fixed as limb leads. The electrode pins were then connected to the electrode board which was in turn was connected to the digital polygraph. The stethograph was strapped around the subjects stomach and was connected to digital polygraph. The sphygmomanometer cuff was tied around the left arm of the subjects for recording the blood pressure. After this subjects were asked to lie down. After the application of electrodes and stethogram, the subjects were asked to lie down for 10 to 15 minutes in supine position.

Autonomic functions test: Recording of resting variables: Activity Variables:A battery of five tests was used to assess the autonomic function status of the subjects. The procedure followed for the autonomic function tests is: After the rest for 10 to 15 minutes in supine position, the electrophysiological signals (ECG and respiration) were...
stored in computer for a period of five minutes. After the recording was over, the resting blood pressure was recorded. The stored data and the blood pressure were used for the analysis of autonomic activity (tone). The tracing of ECG and respiration were continued on the computer software for the measurement of autonomic reactivity. Scoring: The recorded ECG were analyzed for HRV (time domain and frequency domain) variables using softwares.

Reactivity Variables: Lying to standing test: The subjects were instructed about the test. The test was conducted after 10 minutes of supine rest. Then she was told to attain the standing posture within three seconds and recordings were taken. Recording: The subjects were asked to stand on both the legs and equal weight to be put on both the legs. The blood pressure and heart rate were recorded at base line (pre recording) and serially at 0.5th, 1st, 2nd, 2.5th and 5th minutes following the standing posture. 30:15 ratio were calculated from ECG.

Deep breathing test: The subjects were instructed that in deep breathing test, breathing should be smooth, slow and deep. The investigator gave the hand signal to maintain the rate and timing of the breathing. The subjects were instructed to breath at the rate of six breaths per minute. If cycles were not appropriately done, it was repeated again in order to get six complete cycles. (i.e. each cycle consisting of five second inspiration followed by five second expiration). Recording: Inspiratory and expiratory periods were identified with the help of stethographic respiratory tracings. The mean ratio of expiratory and inspiratory R-R intervals (E:I) and the heart rate differences were calculated from the ECG tracings.

Valsalva manoeuvre test: After three to five minutes of deep breathing test the subjects were asked to perform valsalva manoeuvre test. The subjects were asked to increase the intrathoracic pressure after normal inspiration by expiring forcefully into the mouthpiece attached to a mercury manometer. The expiratory pressure was raised to 40 mmHg and maintained for 15 seconds. A small air leak in system is useful to prevent the closure of glottis during the manoeuvre. At the end of 15 seconds pressure was released and the subjects were asked to sit quietly and breathe normally. Due care was taken to prevent deep breathing before and after the manoeuvre. During and post
manoeuvre phases were identified with the help of stethographic respiratory tracing and ECG tracing. Recording: The valsalva, bradycardia and tachycardia ratios were calculated from the ECG recorded during the test.

Hand grip test: The subjects have taken three to five minutes rest after valsalva manoeuvre test, thereafter the baseline blood pressure was recorded. The subjects were instructed about the test and researcher demonstrated the procedure of hand grip test using a hand grip dynamometer. After the instructions and demonstration, the subjects were asked to grip the grip dynamometer using maximum voluntary contraction (MVC) force with their dominant hand for a few seconds and the process was repeated three times with sufficient rest in between. The maximum value of the three readings was considered as their MVC. A mark was made on dynamometer at 30% of MVC. The subjects were asked to grip the hand grip dynamometer and to maintain (sustained) the grip on the dynamometer up to mark for four minutes. Recording: The blood pressure (BP) was recorded on the contra-lateral arm at 1st, 2nd, 4th (or any time just before release of grip if it is less than four minutes). One more reading was taken two minutes after the release of the grip i.e. at sixth minute.

Cold pressure test: After the base line blood pressure was recorded, the subjects were asked to immerse right hand in cold water of 10 degree celsius for one minute. Recording: The BP was recorded at just before the hand was taken out of the water (i.e. at the end of one minute of immersion) The BP was taken again at 2.5 minutes and 5 minutes after performing the autonomic function test, the hand was withdrawn from the cold water. After performing the autonomic function tests, the subjects were disconnected from the digital polyrite.

Extraction and calculation of the selected variables (scoring): The parameters studied were the indicators of autonomic activity and indicators autonomic reactivity. Both the autonomic activity and reactivity were determined and detailed as following for two sub divisions of autonomic nervous system (ANS) i.e. parasympathetic and sympathetic. For the parasympathetic and sympathetic activity following parameters were studied. (1) heart rate variability (HRV): (i) time domain analysis (ii) frequency domain analysis.
The measurement of parasympathetic and sympathetic reactivity was done by using a battery of five tests. The parameters derived from these tests have been described as follows:

Parasympathetic reactivity variables (extraction and calculation): deep breathing test score (change in heart rate): Change in heart rate was calculated from ECG tracings of the minimum and maximum R-R intervals during expiration and inspiration respectively during deep breathing test for six respiratory cycles.

Expiratory – inspiratory ratio (E:I) : It is the ratio of the minimum and maximum R-R intervals during expiration and inspiration respectively during deep breathing test. The maximum and minimum R-R intervals were measured from ECG for six respiratory cycles. All maximum and minimum R-R intervals were averaged and E:I ratio was worked out with the help of following formula.

\[
\frac{\text{Maximum R-R interval during expiration}}{\text{Minimum R-R interval during inspiration}}
\]

Valsalva manoeuvre ratio: The valsalva manoeuvre ratio was calculated from the ECG recorded during the manoeuvre. It is the ratio of the maximum R-R interval during phase IV to the minimum R-R interval during Phase II according to following formula.

\[
\frac{\text{Maximum R-R interval during phase IV}}{\text{Minimum R-R interval during Phase II}}
\]

30:15 ratio: This ratio was calculated from the ECG recorded during lying to standing test. There is an increase in heart rate (tachycardia) immediately on standing up from lying posture around 15th beat and decrease in heart rate (bradycardia) around 30th beat. The ratio of maximum and minimum R-R interval around 30th and 15th beat respectively on standing up was 30:15 ratio

Sympathetic reactivity variables (extraction and calculation): Blood pressure (BP) responses to lying to standing test: During the lying to standing test BP was
measured at zero minute i.e. in lying position and at 0.5th, 1st and 2nd minute of standing up. The differences in systolic pressures at 0.5th, 1st, and 2nd minute of standing from that of respective lying (baseline; zero minute) pressures were calculated.

Blood pressure (BP) responses to hand grip test: During the test the BP was measured at 0, 1st, 2nd, 4th and 6th minute of the onset of isometric contraction. The systolic, diastolic and mean pressure differences from the (baseline; zero min) were calculated at 2nd and 4th minute of contraction.

Blood pressure (BP) responses to cold pressure test: The BP was measured at 1st and 2.5th minute of immersion of hand in cold water for one minute. The diastolic pressure differences at 1st minute of the (base line ; zero minute) was calculated.

Following training protocol and training procedure was adopted:

Training protocol: (1) each group was trained for six weeks. (2) Each selected group was administered with 20 to 30 minutes yogic training (specific Kriya / Pranayama) according to the designated group for six days per week and at least twice a week was compulsory attendance for each sample or participant.

Training procedure: Following yogic kriyas and pranayamas were taken (i) anuloma viloma: (ii) kapalabhati (iii) bhramari and (iv) agnisar

Test-retest design for eight matched groups (each corresponding experimental and control groups were homogenous in regard to age, resting heart rate, systolic blood pressure and diastolic blood pressure) was adopted.

The randomly drawn subjects for each category have been appropriately explained and defined, which served as a scientific reference for the applications and furtherance for the experimentation for testing the hypotheses.

For any experimentation process the defined category/classification need to be examined for their homogeneity, which has been justified. The findings have been documented in the tables and supported with bar diagrams as illustrations. The scenario of significant findings was enlisted the significant differences between the pre test and post test of each selected experimental groups and control groups to understand the
experimental effects of each treatments namely anulom vilom, kapalbhati, bhramari and agnisar for each selected variables. Further the findings were comprehensively summarized, illustrated the changes in the mean values as well as their statistical significance for each selected variables between the pre test and post test of each selected experimental groups and control groups independently to understand the experimental effects of each treatments namely anulom vilom, kapalbhati, bhramari and agnisar. To meet the purposes of the study mean, standard deviation and “t” test were computed as statistics and the drawn hypotheses were tested at 0.05 level of significance.

The major findings were as following:

1. Resting heart rate (bpm) for all the experimental groups and control groups having insignificant difference between the pre test and post test.
2. Systolic blood pressure (mmHg) for all the experimental groups and control groups having insignificant difference between the pre test and post test.
3. Diastolic blood pressure (mmHg) registered significant difference in regard to kapalbhati experimental group as well as agnisar experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.
4. Deep breathing test score (change in heart rate) documented significant difference in regard to anulom vilom experimental group, bhramari experimental group and agnisar experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.
5. Expiratory inspiratory ratio registered significant difference in regard to anulom vilom experimental group as well as bhramari experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.
6. Valsalva manoeuvre ratio documented significant difference in regard to kapalbhati experimental group as well as agnisar experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.
7. Hand grip test score (mmHg) documented significant difference in regard to kapalbhati experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.

8. Cold pressure test score (mmHg) registered insignificant difference between the pre test and post test for all the experimental groups and control groups.

9. Lying to standing test score (mmHg) documented significant difference in regard to anulom vilom experimental group, kapalbhati experimental group as well as agnisar experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.

10. 30:15 ratio registered significant difference in regard to bhramari experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.

11. NN50 count (f) documented significant difference in anulom vilom experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.

12. pNN50 count (%) registered significant difference in regard to anulom vilom experimental group and agnisar experimental group, whereas insignificant difference between the pre test and post were recorded for rest of the comparisons.

13. SDSD (ms) documented insignificant difference between the pre test and post test for all the experimental groups and control groups.

14. RMSSD (ms) registered insignificant difference between the pre test and post test for all the experimental groups and control groups.

15. SDANN (ms) documented significant difference in regard to bhramari experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.

16. LF (normalized unit) registered significant difference in kapalbhati experimental group as well as agnisar experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.

17. HF (normalized unit) documented significant difference in regard to kapalbhati experimental group and agnisar experimental group, whereas insignificant
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difference between the pre test and post test were recorded for rest of the comparisons.

18. LF/HF Ratio registered significant difference in regard to kapalbhati experimental group and agnisar experimental group, whereas insignificant difference between the pre test and post test were recorded for rest of the comparisons.

19. LF- AP (ms$^2$) documented insignificant difference between the pre test and post test for all the experimental groups and control groups.

20. HF- AP (ms$^2$) registered insignificant difference between the pre test and post test for all the experimental groups and control groups.

21. TP- AP (ms$^2$) documented insignificant difference between the pre test and post test for all the experimental groups and control groups.

22. SDNN (ms) registered insignificant difference between the pre test and post test for all the experimental groups and control groups.

5.2. Conclusions

The findings have been comprehensively and critically apprised to draw the following conclusions.

1. The variables namely deep breathing test score (change in heart rate), expiratory inspiratory ratio, cold pressure test score (mmHg), lying to standing test score (mmHg), NN50 count (f), pNN50 count (%) and LF/HF ratio, a total of seven variable out of twenty two variables documented significant experimental effect of anulom vilom pranayama.

2. The variables namely diastolic blood pressure (mmHg), valsalva manoeuvre ratio, hand grip test score (mmHg), lying to standing test score (mmHg), LF (normalised unit), HF (normalised unit) and LF/HF ratio, a total of seven variable out of twenty two variables documented significant experimental effect of kapalbhati kriya.

3. The variables namely deep breathing test score (change in heart rate), expiratory inspiratory ratio, 30:15 ratio and SDANN (ms), a total of four variables out of twenty two variables documented significant experimental effect of bhramari pranayama.
4. The variables namely diastolic blood pressure (mmHg), deep breathing test score (change in heart rate), expiratory inspiratory ratio, valsala manoeuvre ratio, lying to standing test score (mmHg), NN50 Count (f), pNN50 Count (%), LF (normalised unit), HF (normalised unit) and LF/HF ratio, a total of ten variable out of twenty two variables documented significant experimental effect of agnisar kriya.

5. The highest number of autonomic (sympathetic and parasympathetic) variables found to be significant variables to study the experimental or training effect in agnisar kriya followed by anulom vilom pranayama, kapalbhati kriya and bhramari pranayama.

6. In anulom vilom pranayama, among the seven significant autonomic (sympathetic and parasympathetic) variable three were activity variables and four were reactivity variables.

7. In kapalbhati kriya, among the seven significant autonomic (sympathetic and parasympathetic) variables three were activity variables and four were reactivity variables.

8. In bhramari pranayama, among the four significant autonomic (sympathetic and parasympathetic) variables one was activity variable and three were reactivity variables.

9. In agnisar kriya, among the ten significant autonomic (sympathetic and parasympathetic) variables five were activity variables and five were reactivity variables.

10. It is concluded that autonomic (sympathetic and parasympathetic) reactivity variables found to be superior variables to study the experimental or treatment effect of yogic pranayamas and kriyas.

11. The variables namely lying to standing test score (mmHg) and LF/HF Ratio were common autonomic (sympathetic and parasympathetic) variables demonstrated significant experimental effect in the three selected kriyas and pranayamas namely anulom vilom pranayama, kapalbhati kriya and agnisar kriya.

12. The variables namely deep breathing test score (change in heart rate) and expiratory inspiratory ratio were common autonomic (sympathetic and parasympathetic) variables demonstrated significant experimental effect in the
three selected kriyas and pranayamas namely anulom vilom pranayama, bhramari pranayama and agnisar kriya.

13. The variables namely diastolic blood pressure (mmHg), valsalva manoeuvre ratio, LF (normalised unit) and HF (normalised unit) were common autonomic (sympathetic and parasympathetic) variables demonstrated significant experimental effect in the two selected kriyas namely kapalbhati kriya and agnisar kriya.

14. The variables namely NN50 count (f) and pNN50 (%) count were common autonomic (sympathetic and parasympathetic) variables demonstrated significant experimental effect in the two selected kriyas and pranayamas namely anulom vilom pranayama and agnisar kriya.

15. The variable namely hand grip test score (mmHg) was the only unique autonomic variable demonstrated significant experimental effect of kapalbhati kriya.

16. The variable namely SDANN (ms) was the only unique autonomic variable demonstrated significant experimental effect of Bhramari Pranayama.

17. From the above conclusions, it may be summarized that the selected kriyas and pranayamas having significant experimental effect on autonomic (sympathetic and parasympathetic) variables, therefore the selected autonomic (sympathetic and parasympathetic) variables are good dependent variables hence, validated for experimentation in yogic kriyas and pranayamas specifically as well as in general.

5.3. Recommendations

Based on the findings and conclusions drawn from the findings, following have been recommended.

1. The findings as a whole concluded that the selected kriyas and pranayamas having significant experimental effect on autonomic (sympathetic and parasympathetic) variables and the selected autonomic (sympathetic and parasympathetic) variables are good dependent variables. Hence, should be included for professional practices, experimentations and clinical applications.
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2. The conducted study further increased the scope of experimentation paradigm for physical/physiological/psychological/autonomic wellbeing tests domains. Hence, enriched the academic and scientific practices and book of knowledge. Therefore, it is strongly recommended to propagate such academic endeavor by means of seminars, conferences, workshops, lectures, publications and practicums, so that the practice of fitness promotions can be encouraged in India particularly in Delhi more scientifically and authentically.

3. Similar type of study may be conducted in different states of India independently or collectively.

4. Similar type of study may be conducted on male populations belonging to different states of India independently or collectively.

5. Similar type of study may be conducted on different age groups of male and female populations from sports, games, fitness groups and people with active lifestyle as well as sedentary lifestyle, also targeting to different ethnic groups of different altitude habitat and environments, including different socio economic status and/or body composition and/or somato type.

6. Sex differences in regard to the selected autonomic variables may be evaluated for different states of India independently or collectively to understand the physical/physiological/psychological/autonomic wellbeing practices as well as for normative references.

7. Similar type of study may be conducted on other yogic asanas, meditations, kriyas and pranayamas.