Clinical and Experimental
Health Sciences

Efficacy of Alternate Nostril Breathing on Pulmonary Function and Physical Functional Capacity in Healthy Adults Across Different Age Groups: Randomized Control Trial

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Received: 05.08.2023 **Accepted:** 29.11.2024

ABSTRACT

Objective: Lung function and functional capacity gradually decline even in asymptomatic individual with age. Alternate nostril breathing (ANB) is a breathing exercise used to modulate the pace of breathing. The present study aimed to evaluate the efficacy of ANB on pulmonary function and physical functional capacity in normal adults across different age groups.

Methods: 48 participants aged 20-50 years were stratified based on age and were assigned into young (experimental and control group) and old age strata (experimental and control group) for this randomized controlled trial. Pulmonary function (FEV_1, FVC, FEV_1/FVC, PIFR, and PEFR) and physical functional capacity (6MWD) were assessed before and after the test. Experimental groups practiced ANB for 15 minutes for 4 weeks (6 days/week) in front of primary researcher. No intervention was given to control groups. Between groups analysis was done by Mann Whitney U test whereas, Wilcoxon signed rank test was used for within group analysis.

Results: Significant differences were found in median values of FEV_1 (2.21-2.47, p=.002), FVC (2.39-2.77, p=.003), PEFR (5.30-6.45, p=.002), and PIFR (3.85-4.22, p=.05) between total experimental and total control groups, but not in FEV_1/FVC (p=.41)and PIFR (p=20). Post treatment analysis of total experimental group showed significant improvement in FEV_1 (p= .0001), FVC (p=.0001), PEFR (p= .0001), PIFR (p= .002) and 6MWD (p= .0001), while total control group had no significant improvement in any component (p>.05).

Conclusion: Alternate nostril breathing can be used as a maneuver to improve age related lung function decrement.

Keywords: Adults, breathing exercise, lung function, peak expiratory flow rate

1. INTRODUCTION

The physiological functions of human body are examined to diagnose the development of disease or prognosis of individuals (1). Pulmonary function tests (PFTS) are an investigative procedure that measure the function, capacity and condition of lung (2).

Both the physical and psychological health depend on cardiopulmonary endurance (3). But factors including poor diet, sedentary lifestyle, rapid industrialization, stress, environment pollution, overcrowding can influence the normal health (4). Improper lifestyle has an impact on cardiopulmonary functions. Reduction of cardiopulmonary function progressively result in reduced functional capacity (5). Moreover, the normal function of lung changes minimally from 20 to 35 years of age but thereafter starts declining gradually due to various anatomical and physiological changes with aging (6,7).

Breathing can be regulated voluntarily among all other autonomic functions of human body (3). Voluntary control of breathing can assist in functions of autonomic nervous system to provide a harmonic state (8). Regular practice of specific techniques can also improve physical, as well as, psychological health of individual in everyday life (9). Alternate nostril breathing (ANB) is a type of slow, deep breathing techniques that allows voluntary regulation of breath through the alternate use of right and left nostrils (10). During breathing exercise, the heart and the lungs come into their action. The lungs involve in bringing of oxygen into the body, providing energy, and also removal of carbon dioxide (11).

Authors from previous reports suggested that practice of ANB breathing can enhance psychological health by relieving stress (12). It has also been proved to modulate sympatho-vagal activity with improved lung functions (8). Breathing exercises are very common step in different exercise forms (9). This is also beneficial for maintaining health status of individual among all age groups (13). Diaphragmatic breathing, deep breathing, paced breathing, buteyko breathing, ANB were used in different experimental studies (14-16). Among them, ANB is a simple voluntary breathing

DOI: 10.33808/clinexphealthsci.1337686

technique that can be easily performed at home. So, it is important to understand the effect of ANB exercise among population of young, as well as old age groups.

Slow and deep breathing with alternate nose consists of inhalation, retention and exhalation phases (17). Different types of breathing exercises are included in yogic practice which can be done either fast or slow manner (18). But the physiological effects of slow and fast breathing can vary among individual. Fast, deep breathing replenishes air in each part of lung, whereas, slow, deep breathing is effective in reducing ventilation in dead spaces of lung (19). Recently, Leelarungrayub J et al. conducted a study that compared the effect of slow and fast breathing technique using volume-oriented incentive spirometer and found that slow deep breathing is more effective in improving functional capacity, whereas fast deep breathing is effective in improving both pulmonary function and functional capacity in patients with mild to moderate chronic obstructive pulmonary disease (20). Rapid reduction of FEV_1 is an important marker of COPD as it directly explains about the progression of disease. It is observed that FEV_1 declines at a rate of 25–30 ml/year at 35–40 years of age and 60ml/year after the age of 70 years in normal adults (6). It can be inferred that the use of ANB may have similar effects on healthy asymptomatic individuals.

To the best of our knowledge, the effect of ANB exercise on physical functional capacity had not been studied yet. This study is aimed to find out the efficacy of ANB on pulmonary function and functional capacities in adults across different age groups.

2. METHODS

2.1. Study Design

This is a pretest posttest, randomized experimental study.

2.2. Ethical Statement

The study obtained the ethical clearance from Institutional Ethics Committee and had been registered in the Clinical Trials Registry-India with universal trial number CTRI/2019/06/01976. The study was performed under Indian Council of Medical Research (2017) National Ethical Guidelines for biomedical and health research involving human participants and the ethical principles for medical research involving human subjects stated in the Declaration of Helsinki (revised 2013).

2.3. Eligibility Criteria

Asymptomatic male and female participants of aged 20-50 years with body mass index 18.5-24.9 kg/m², and stable vitals were included in the study. Volunteers were nonsmokers and had no acute disease 6 weeks preceding the study. Any documented conditions (cardiopulmonary disease, musculoskeletal disorders, neuromuscular diseases, kidney disease, metabolic diseases, blood diseases, any recent surgery, cancer etc.), use of any medications, participants who perform regular exercises or sports and any "YES" on PAR-Q Scale were excluded from the study.

2.4. Sample Size Estimation

The sample size was estimated by G*Power software, version 3.1.9.2.21, based on the effect size of FVC values from a previous study (22). The parameters include: assuming tests with family distribution means: difference between two independent means (two groups) with effect size 1.61,22 a type I error of 0.05, a power equal to 0.95. The sample size is 12 in each group. The total sample size considering 4 groups was 48. Considering 10% drop out, the total sample size was 52.

2.5. Study Participants

The researchers orally communicated and distributed information sheet about the study in brief to the students and staff of the institute and nearby community dwellings. People who were interested reported to the primary and secondary researchers within the due date. Normal adults were recruited among them. Prior to the intervention, all participants were asked to sign the informed consent.

2.6. Procedure

Individuals who voluntarily wanted to participate were recruited and explained about the research. Informed consent forms were taken from those who were agreed to participate. The samples were taken by stratified random sampling and divided into two strata of different age groups: Young group (20-35 years of age) and old group (36-50 years of age) (6). Then randomization was done for both the strata's. Block randomization was done by sequentially numbered opaque sealed envelope method for dividing them into experimental and control group (23). A total of four blocks with six rows had been created for 24 samples in young strata, whereas, four blocks with seven rows had been designed for old strata with sample size (28). Sequentially numbered opaque sealed envelope was applied to perform random allocation sequence (24). The data was collected in between 12th May 2019 to 21st January, 2020.

The samples of young group strata were allocated into young experimental group (YEG) and young control group (YCG). Participants of old group strata were allocated into old experimental group (OEG) and old control group (OCG).

Measurement of force vital capacity (FVC), force expiratory volume in one second (FEV_1), ratio of FEV_1 and FVC (FEV_1/FVC), peak inspiratory flow rate (PIFR), peak expiratory flow rate (PEFR) and distance covered during six minutes' walk test (6MWD) were recorded before starting the experiment.

Pulmonary function test was measured by using RMS Helios 401 – computerized spirometer as per standardized guidelines (25). Before performing the test, all the participants were allowed to take rest period of 30 minutes to prevent measurement error. Participants were performed the test for at least three times to obtain the best value. The participants were asked to sit comfortably in erect position with feet firmly rest on floor. The lips of participant were sealed around a disposable mouth piece, and a nose clip was attached to the nose of subject to ensure that there was no chance breathing through the nose. Then they were instructed to breathe in fully through the mouth and then blast out air through the mouth piece.

The 6MWT was performed according to the guidelines of ATS (25). Before doing the test, the participants were allowed to sit in a chair at rest for at least 10 minutes.

BP of participants was recorded using sphygmomanometer. The participants were instructed to stay and quite during measurement. Systolic and diastolic BP was taken and noted (26). Then the rate of perceived exertion of participants was assed using the Borg scale.

The primary researcher asked the participants to walk along a 30 m straight, long track of corridor of hospital at their own pace for 6 minutes. The participants were instructed to walk to cover as much distance as possible, in the duration of 6 minutes. Participants were encouraged continuously during the test. In case participants developing any symptoms like severe breathlessness, pain in chest, dizziness, pain in leg, or diaphoresis during the 6 minutes' walk test, the patients were allowed to stop. But during the test, none of the participants experienced any such symptoms. After 6 minutes, the participants were asked to stop at the point, they were at that time. Before and after completion of 6 minutes, PR, SpO2, and BP were assessed and RPE is recorded (27).

Experimental groups of both strata performed ANB exercise for 15 minutes per day for 4 weeks (six days in a week) under face-to-face supervision of primary researcher, while the control groups did not perform any exercise. After completion of 4 weeks, again the measurements of FVC, FEV_1, FEV_1/FVC, PIFR, PEFR and 6MWD were taken in both the groups.

2.7. Intervention Description

Instruction was given by the primary researcher. Participants were asked to sit crossed leg, with erect spine. With the help of right thumb, they were instructed to block the nostril of right side, and then to inhale slowly and deeply through the left nostril for 6 seconds. Then they were asked to block the left nostril with right index finger (both the nostrils were closed), and to hold the breath for 6 seconds. After 6 second, they were advised to release the right thumb from the right nostril to exhale for the same time with right nostril.

Air was then again breathed in through the right nostril for 6 seconds that was still opened. Then, with the right thumb, right nostril was also blocked (closed both nostrils) for the same time. Then, the left nostril was opened to exhale for 6 seconds, thus completing one cycle (28). The cycle was repeated for 15 minutes per day for 4 weeks (six days in a week). No external stimuli, such as music or meditative sounds were used during the ANB exercise. The participants were instructed to concentrate solely on their breathing.

Control group did not perform any exercises.

2.8. Outcome Measures

Our outcomes measures were pulmonary function parameters: force vital capacity (FVC), force expiratory volume in one second (FEV1), ratio of FEV1 and FVC (FEV1/FVC), peak inspiratory flow rate (PIFR), peak expiratory flow rate (PEFR) and physical functional capacity: distance covered during six minutes' walk test (6MWD). Pulmonary function was measured by using RMS Helios Spirometer, while, functional capacity was measured by calculating the distance covered during six minutes' walk test. All outcomes were assessed at baseline and 4 weeks after the intervention.

2.9. Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 21.0. Shapiro Wilk test was used to analyze normality of the data. The data were not normally distributed and represented as median and inter quartile range in Table 1. Mann Whitney U test was used to compare experimental with control group. Wilcoxon signed rank test were used to compare within groups. Level of significance, i.e. p value, was set as < .05; p value > .05 was considered as statistically insignificant.

Table 1. *Baseline characteristics of the experimental group and no-treatment control group.*

Variables	Total sample		p-value for normality test
	Experimental group	Control group	
	Median (IQR)	Median (IQR)	
Age (years)	30 (21-56)	30 (21-49)	.0001
Height (meter)	1.61 (1.52-1.87)	1.59 (1.50-1.74)	.04
Weight (Kg)	56 (48-86)	56.50 (45-68)	.0001
BMI (Kg/m²)	22.55 (18.70-24.80)	21.10 (19.50-24.80)	.002

Shapiro Wilk test was employed to check normality distribution of the data.
n: Number of subjects, IQR: Inter Quartile Range
BMI=Body Mass Index.

3. RESULTS

Total 58 individuals expressed interest in this study and were assessed for eligibility. Total 48 participants of 20-50 years of age recruited for analysis. Subjects' recruitment flow diagram was represented in Figure 1. Demographic data of the participants is reported in Table 1. Significant improvement was found in experimental groups of both strata in comparison with control groups (YEG vs YCG) (OEG vs OCG) in the domain of pulmonary function parameters ($FEV_{1,}$ FVC, and PEFR) as shown in Table 2.

Table 2. *Between and within group comparison of young strata*

Variables	Young experimental group				Young Control group				z-value	p-value
	Pre test	Post test			Pre test	Post test				
	Median (IQR)	Median (IQR)	z-value	p-value	Median (IQR)	Median (IQR)	z-value	p-value		
FEV_1 (l)	2.19 (1.93-3.77)	2.66 (2.14-4.19)	-3.05	.002*	2.29 (2.02-4.35)	2.24 (2.02-4.00)	-1.059	0.28	-2.16	.03†
FVC (l)	2.26 (1.91-4.61)	2.87 (2.20-4.83)	-3.05	.002*	2.45 (2.26-3.75)	2.47 (2.13-3.73)	-0.589	0.55	-2.33	.01†
FEV_1/ FVC (%)	92.67 (81.78-98.11	95.18 (81.78-100)	-1.86	.06	93.59 (81.00-97.82)	91.94 (81.25-99.45)	-1.647	0.09	-0.80	.41
PEFR (l)	5.27 (4.68-8.77)	6.54 (5.33-9.31)	-3.05	.002*	5.67 (4.77-7.75)	5.23 (4.46-8.18)	-1.156	0.24	-2.13	.03†
PIFR (l)	3.78 (2.94-8.18)	4.51 (3.37-8.57)	-3.07	.002*	4.36 (2.31-6.57)	4.20 (1.63-6.76)	-2.354	0.01	-1.27	.20
6MWD (m)	444.50 (432.60-510.00)	446.87 (434.00-512.00)	-3.07	.002*	438.82 (420.00-500.83)	439.25 (419.75-502.00)	-0.432	0.66	-1.81	.06

*Between groups' comparison: Mann Whitney U test., Within group comparison: Wilcoxon signed rank test., FEV_1: Force expiratory volume in 1 second, FVC: Force vital capacity, PEFR: Peak expiratory flow rate, PIFR: Peak inspiratory flow rate, 6MWD: 6-minutes walk distance, IQR: Inter Quartile Range, *: Statistically significant for within group comparison., †: Statistically significant for between group comparison.*

Table 3. *Between and within group comparison of old strata*

Variables	Old experimental group				Old control group				z-value	p-value
	Pre test	Post test			Pre test	Post test				
	Median (IQR)	Median (IQR)	z-value	p-value	Median (IQR)	Median (IQR)	z-value	p-value		
FEV_1 (liter)	2.23 (1.77-2.90)	2.43 (1.96-3.19)	-2.82	.005*	2.14 (1.87-2.58)	2.17 (1.89-2.56)	-1.181	.238	-2.34	.01†
FVC (liter)	2.46 (2.18-3.51)	2.56 (2.21-4.00)	-2.23	.025*	2.32 (1.96-3.08)	2.38 (2.08-3.09)	-0.550	.582	-1.93	.05†
FEV_1/ FVC (%)	90.59 (78.63-98.03)	93.09 (79.75-96.49)	-1.17	.239	89.42 (79.46-95.95)	92.76 (81.00-96.37)	-1.413	.158	-0.14	.88
PEFR (liter)	5.30 (4.35-6.61)	6.41 (4.53-7.79)	-3.06	.002*	5.54 (4.76-6.43)	5.56 (4.40-6.60)	-1.173	.241	-2.34	.01†
PIFR (liter)	3.87 (1.02-5.43)	3.94 (1.84-5.56)	-1.88	.06*	3.60 (2.76-5.14)	3.31 (2.74-5.16)	-0.235	.814	-1.12	.26
6MWD (meter)	419.3 (408.80-442.73)	420.50 (429.00-444.00)	-2.98	.003*	422.00 (410.00-448.00)	423.00 (408.69-449.00)	-1.339	.210	-0.86	.37

*Between groups' comparison: Mann Whitney U test., ithin group comparison: Wilcoxon signed rank test., FEV_1: Force expiratory volume in 1 second, FVC: Force vital capacity, PEFR: Peak expiratory flow rate, PIFR: Peak inspiratory flow rate, 6MWD: 6-minutes' walk distance., IQR: Inter Quartile Range, *: Statistically significant for within group comparison., †: Statistically significant for between group comparison*

Table 4. *Between and within group comparison of total sample*

Variables	Total experimental group				Total control group				z-value	p-value
	Pre test	Post test			Pre test	Post test				
	Median (IQR)	Median (IQR)	z-value	p-value	Median (IQR)	Median (IQR)	z-value	p-value		
FEV_1 (liter)	2.21 (1,77-3.77)	2.47 (1.96-4.19)	-4.20	.0001*	2.26 (1.87-4.35)	2.19 (1.89-4.00)	-0.15	.87	-3.08	.002†
FVC (liter)	2.39 (1.91-4.61)	2.77 (2.20-4.83)	-3.92	.0001*	2.39 (1.96-3.75)	2.42 (2.08-3.73)	-0.22	.81	-2.96	.003†
FEV_1/ FVC (%)	89.67 (86.33-93.02)	91.34 (88.18-94.49)	-0.33	.738	91.37 (79.46-97.82)	91.70 (81.00-99.45)	-0.11	.90	-0.52	.59
PEFR (liter)	5.30 (4.35-8.77)	6.45 (4.53-9.31)	-4.28	.0001*	5.60 (4.76-7.75)	5.54 (4.40-8.18)	-1.66	.09	-3.10	.002†
PIFR (liter)	3.85 (1.02-8.57)	4.22 (1.84-8.18)	-3.14	.002*	3.96 (2.31-6.57)	3.53 (1.63-6.76)	-2.01	.04*	-1.94	.05†
6MWD (meter)	437.50 (408.80-510.00)	439.25 (409.00-512.00)	-4.26	.0001*	428.50 (410.00-500.83)	429 (408.69-502.00)	-1.13	.25	− 0.88	.37

Between groups' comparison: Mann Whitney U test., Within group comparison: Wilcoxon signed rank test., FEV_1: Force expiratory volume in 1 second, FVC: Force vital capacity, PEFR: Peak expiratory flow rate, PIFR: Peak inspiratory flow rate, 6MWD: 6-minutes' walk distance., IQR: Inter Quartile Range
**: Statistically significant for within group comparison., †: Statistically significant for between group comparison*

Within group comparison showed significant improvement in FEV_1, FVC, PEFR, PIFR and 6MWD in both young experimental group and old experimental group after practicing ANB for 4 weeks (Table 3). Significant difference was observed in between group analysis of total sample in FEV_1, FVC, and PEFR. Significant improvement was observed in combine sample of total experimental group (Table 4). In addition, inter group analysis was also mentioned in Table 5 between YEG and. OEG, YCG and OCG. But no significant difference was found.

Table 5. *Inter-group analysis: Young experimental vs old experimental group and young control vs old control group*

Variables	Young experimental group vs Old experimental group		Young Control group vs Old Control group	
	z-value	p-value	z-value	p-value
FEV_1 (liter)	-1.41	.15	-0.98	.42
FVC (liter)	-2.28	.22	-0.66	.86
FEV_1/ FVC (%)	-2.25	.24	-2.02	.40
PEFR (liter)	-0.28	.79	-0.14	1.00
PIFR (liter)	-0.98	.34	-1.38	.50
6MWD (meter)	-1.70	.08	-0.34	.82

Between groups' comparison: Mann Whitney U test.FEV1: Force expiratory volume in 1 second, FVC: Force vital capacity, PEFR: Peak expiratory flow rate, PIFR: Peak inspiratory flow rate, 6MWD: 6-minutes' walk distance

4. DISCUSSION

ANB is a simple voluntary breath regulation technique that is commonly performed to relieve stress and improve physical and physiological functions (24). Regulation of breath voluntarily is usually performed with the aim to make rhythmic respiration and to provide calming effect of the mind (29). The main finding of our study was an improvement in several components of lung functions after performing ANB exercise by both the age groups.

FEV1 denotes the highest amount of expelling rate of breath in one second after maximal inhalation (30). Age can affect the average FEV1 value even in healthy subjects (30). Regular practice of ANB stimulates the stretch receptors of lung which helps to relax laryngeal smooth muscles and trachea bronchial tree. This probably helps to modulate the caliber of airways and reduction of resistance of airways and smooth exhalation (29). FEV1 depends upon the resistance of airway (31). Improvement in FEV1 may be due to the result of reduction of airway resistance after ANB exercise.

Secondly, the present study considered that practice of ANB irrespective of age also showed significant improvement in FVC. FVC is an indicator of the state of lung's elastic property (31). The component is considered as a measure of health for the evaluation of the normal individual and patients with pulmonary conditions (31). Regular practice of a slow deep breathing causes recruitment of muscles of respiration. Recruitment of these muscles results in strengthening of respiratory muscles that might have improved the lung's elastic property (31). Regular practice of ANB by slow and deep inspiration and expiration for a prolonged time, leads to strengthening of the respiratory muscles (32). Hence improvement in FVC could be due to strengthening of muscles of respiration.

Similar result was observed in a study conducted by Chetan K et. al. where the authors concluded that daily practice of ANB for 3 months provide significant improvement on FEV1 and FVC among college students of 17 and 21 years (32).

PEFR, which is an indicator of variation of elastic recoil pressure or of the distal airways resistance had also been improved in this study (33). Improvement in PEFR is mostly depend on volume of lungs and pulmonary airway mechanics (31). Slow deep breathing exercises have been considered to expand the lungs more than the normal breathing. This may recruit opening of alveoli that may be closed previously, result in increasing surface area of pulmonary membrane and diffusion of air across this membrane (34). This may lead to improve alveolar perfusion through widening of the pulmonary bronchioles (31). ANB is one of the self-regulated slow, deep breathing exercise that may raise the depth of breathing by using the spaces of lung, which are inert in normal breathing (35). So the increase in PEFR after practicing of ANB may the result of small airway opening of lung and lowering the resistance of distal airways. This result is in line with the study that was conducted by Garg S et al. in 2016 to identify effect of 6 weeks of nadi shodhan pranayama on PEFR (35).

No significant difference was observed in FEV1/FVC in line previous reports (36,37). Result of the present study showed no significant difference in PIFR.

Physical functional capacity is capacity of individual to perform activities of sub maximal level, which is assessed by variety of tests. One of the useful tests to measure functional capacity is 6-minute walk test. (38). 6MWD was statistically improved within YEG and OEG, as well as total experimental group. But no significant improvement had shown in YCG, OCG and total control group. Analysis between YEG and YCG found no significant difference in 6MWD. No significant difference was also observed between OEG and OCG group in terms of 6MWD. Result of previous study conducted by Kaminsky DA et. al. on yogic breathing in COPD showed significant difference in 6MWD after practicing long 12 weeks of breathing exercise (39).

This was the first study that evaluated the efficacy of ANB on pulmonary function on people of different age groups. ANB exercise is a simple and cost-effective technique that can be practiced in home by the participants themselves.

The study had few limitations: The present study was not being able to measure the level of physical activity of the subjects. Also, we were not able to examine the effect of ANB on other important parameters of PFT like maximum voluntary ventilation (MVV) and slow vital capacity (SVC).

5. CONCLUSION

The study concluded that regular practice of Alternate nostril breathing for 4 weeks produces a significant effect on FEV1, FVC, and PEFR. Practice of this breathing exercise has been proven to improve pulmonary function of young as well as older adults. So ANB exercise can be used as a maneuver to improve age related lung function decrement.

Acknowledgements: *We greatly acknowledge the support from all participants and sincerely thank all the subjects for taking part in the study.*
Funding: *The author(s) received no financial support for the research.*
Conflicts of interest: *The authors declare that they have no conflict of interest.*
Ethics Committee Approval: *This study was approved by Ethics Committee of Maharishi Markandeshwar Mullana, Haryana, India with ethical number IEC-1365 on 15/03/2019*
Peer-review: *Externally peer-reviewed.*
Author Contributions:
Research idea: SS, MV
Design of the study: SS, HV, MV
Acquisition of data for the study: SS, MV
Analysis of data for the study: SS, HV
Interpretation of data for the study: SS, HV
Drafting the manuscript: SS, HV
Revising it critically for important intellectual content: SS, HV
Final approval of the version to be published: SS, HV, MV

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How to cite this article: Saha S, Vaish H, Verma M. Efficacy of Alternate Nostril Breathing on Pulmonary Function and Physical Functional Capacity in Healthy Adults Across Different Age Groups: Randomized Control Trial. Clin Exp Health Sci 2024; 14: 967-973. DOI: 10.33808/clinexphealthsci.1337686