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Short term effects of pranayama on reaction time, agility and cardiorespiratory functions in community dwelling elderly

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Abstract
The purpose of this study was to know the effect of 4 weeks of pranayama on reaction time (auditory and visual), agility and the cardiorespiratory functions *viz*. heart rate (HR), respiratory rate (RR), systolic blood pressure (SBP), diastolic blood pressure (DBP), rate pressure product (RPP), maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), peak expiratory flow rate (PEFR) and two minute step test (2MST) in community dwelling elderly. After obtaining Institutional Ethics Committee and written informed consent, 38 healthy community-dwelling individuals above 60 years of age were recruited in the study. The individuals performing pranayama on a daily basis were excluded from this study as well as those with a history of any recent hospitalization, acute illness, visual or auditory impairments or with clinical diagnosed case of neurological disorders, musculoskeletal or cardiorespiratory disorders, impaired cognition that made them unable to perform the proposed functional tests. They were assessed for reaction time, agility and cardiorespiratory parameters before the intervention. The intervention included anulom-vilom, kapalbhati, ujjayi pranayama, shitkari & sheetali pranayama, bhramari and bhastrika pranayama. After a period of 4 weeks, the individuals were reassessed for all parameters. Data was analysed using SPSS 24 software.p value of less than 0.05 was accepted as indicating significant difference between the compared parameters.There was a statistically significant change in HR (p=0.000), SBP (p =0.002), RPP (p =0.000), Respiratory Pressures [MIP (p=0.000), MEP (p=0.002)], PEFR (p=0.000), agility (p=0.007), cardiorespiratory endurance (p=0.000) & Reaction Time (p=0.000). However, RR (p=0.071) and DBP (p=0.057) did not show a statistically significant change post intervention. The study shows that short term practice of pranayama is beneficial in improving reaction time, agility and cardiorespiratory functions in community dwelling elderly.

Keywords: pranayama, community dwelling elderly, reaction time, agility

1. Introduction
Aging is a universal phenomenon associated with deteriorating health status and is regarded as an inevitable biological phenomenon. Aging results in the overall impairment of homeostasis and therefore, reduction in the ability to respond to external or internal stresses and increased risk of diseases [1]. Its characterised by a decline in one's physical performance, slower speed of reaction and inadequate working of various systems with poor motor and sensory conduction [2]. According to Population Census 2011, there has been an increase in the geriatric population from 5.6 % in 1961 to 8.6% in 2011 [3]. Community-dwelling older adults are defined as individuals over the age of 60 years who live independently in the community. According to studies, one third of these individuals experience fall at least once per year [4, 5]. Falls can cause injuries that can be serious or fatal such as fractures, joint dislocation or head trauma or can have significant effects on psychosocial health, including greater fear of falling that can lead to social isolation [6, 7]. Reaction time could be an interesting predictor of falls in the elderly, due to the sensory and motor components associated with it [8]. The reduction in reaction time as well as agility is regarded as an important factor for falls in the elderly. The decrease in agility is known to have accelerated after the age of 50–60 years that is, nearing the geriatric community [9].
With aging, there are changes that occur in the cardiovascular as well as respiratory system, which result in alterations in cardio-respiratory physiology. Many recent researches have shown the benefits of physical exercise in improving the functional capacity of elderly. Various therapies such as resistance training, balance training, endurance training, coordination training, multicomponent exercises and Tai Chi, have proven to have favourable effects on certain functional parameters in the older adults [10-16]. Yoga is another intervention that can be used in the geriatric population, since it is known to be effective and beneficial in improving mental/emotional health, exhaustion levels and perceived stress levels in elderly [17]. Pranayama is part of yoga that focuses on the regulating one's breath.There is some evidence of specific types of pranayama techniques showing an improvement in reaction time and cardiorespiratory functions. [2, 18, 19] Though potential health benefits have been postulated, further clinical research is required to prove the effects of pranayama on reaction time, agility and cardiorespiratory parameters together, especially in a geriatric population. With the above in mind, this study planned to evaluate the short-term effects of pranayama on reaction time, agility and cardiorespiratory parameters in community dwelling elderly.

2. Material and Methods
Clearance was obtained from the Institutional Ethics Committee and written informed consent was taken. 42 healthy community-dwelling individuals above 60 years of age were recruited in this study. Out of the 42 subjects, three subjects dropped out in the 2nd week and one in the 3rd week of intervention. The individuals performing pranayama on a

daily basis were excluded from this study as well as those with a history of any recent hospitalization, acute illness, visual or auditory impairments or with clinical diagnosed case of neurological disorders, musculoskeletal or cardiorespiratory disorders, impaired cognition that made them unable to perform the proposed functional tests. The subjects were familiarized with the study procedure.

The individuals were assessed for the following

1. Cardiorespiratory Parameters- Heart rate (HR), Respiratory Rate (RR), Blood Pressure (BP), Rate Pressure Product (RPP), Maximum Inspiratory Pressure (MIP), Maximum Expiratory Pressure (MEP), Peak Expiratory Flow Rate (PEFR) and the 2-Minute Step Test (2MST)
2. Agility- using the 8 Foot Up and Go Test
3. Auditory and Visual Reaction Time

2.1 Assessment

The assessment was done at the beginning of the course of intervention.

The subject was made to sit for 5-10 minutes and his/ her resting heart rate (HR) was assessed manually as number of beats per minute. In a similar way, the number of breaths per minute were counted that determined the respiratory rate (RR). The systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured in mm Hg with the help of a Sphygmomanometer – Diamond Mercurial Blood Pressure Apparatus. Rate Pressure Product (RPP) was measured as a product of systolic blood pressure and heart rate.

$$RPP = SBP \times HR$$

Respiratory muscle strength was assessed using Care Fusion Vyaire Medical Respiratory Pressure Meter (Micro RPM). To measure Maximal Inspiratory Pressure (MIP), the subject was asked to remain seated for the test and instructed to exhale slowly and completely to residual volume and then seal the lips firmly around the mouthpiece to inhale with as much effort as possible. The largest negative pressure sustained for at least one- two seconds was noted. It was attempted 5 times and the highest value was selected. The Maximal Expiratory Pressure (MEP) was measured in a similar way. The subject was asked to inhale to total lung capacity and then exhale as strongly as possible against the mouthpiece for at least two seconds. The values were noted in a manner similar to MIP. Both MIP & MEP is measured in cmH_2O.

PEFR was measured with Wrights Standard Peak Flow Meter. It is a small handheld device used to monitor a person's ability to breathe out air. The subject was asked to breathe in deeply and blow into the mouthpiece as quickly and as hard as possible. The test was done three times and the highest of the three speeds was noted. PEFR is measured in L/min.

Then the 8 Foot up and go test was performed which is used to test agility of the elderly. A chair was placed and 8 foot was marked in front of it. The path was cleared between the chair and the marker. The subject had to be fully seated, hands resting on the knees and feet flat on the ground. On the command, "Go," timing was started and the subject had to stand and then walk (no running) as quickly as possible (and safely) to and around the point marked 8 feet away, returning to the chair to sit down. Timer was stopped once the subject sat down on the chair. Two trials were performed. Best of the 2 trials nearest to $1/10^{th}$ second was selected [20].

The two-minute step test was performed and the number of steps were calculated. The subject was made to stand near a wall after taking his/ her resting vitals. The height of the iliac crest and patella was measured and half the distance between the two points was marked. On starting the timer, the subject had to raise his/her knee to the level of mark on the wall that is, the subject began stepping. This was done for 2 minutes. The number of times the right knee reached the required height was the score. The subject was asked to slow down or stop to regain proper form if the height could not be reached, but the stopwatch was kept running. A chair was kept aside just in case the subject loses his/ her balance [20].

Visual and auditory reaction time was measured in milliseconds with the help of Inquisit 4.0 computer software released in 2013 by Millisecond Software in Seattle, Washington. [21] In the Auditory Reaction Time (ART) task, after variable time intervals, a beep is heard which lasts for 30 seconds. The subject had to press the spacebar as soon as the sound was presented. During the Visual Reaction Time (VRT) task, in the centre of the white screen background, the subject gets presented a black 'plus' (+) sign that is followed after variable time intervals by a target stimulus that is, red circle. The subjects were asked to press the 'space bar' key on the keyboard as soon as possible once the red circle (target stimulus) appeared on the screen. Allthe subjects were thoroughly acquainted with the procedure and practice trial was given before taking the test. Five readings for each stimulus were taken and the fastest reaction time for the respective tasks was noted.

2.2 Intervention

The intervention of 4 weeks included 3 supervised sessions per week lasting for 30 minutes each. The sessions were conducted in the following manner-The subjects had to sit on the mat in sukhasana – sitting erect with legs crossed such that the outer edges of the feet rest on the floor and inner edges arch on the shin. Subjects unable to sit on the mat could sit on a chair. The subjects were told to keep their back erect while performing the pranayama. 3 sets of Omkara were performed at the beginning and end of each session. To perform Omkara the subjects had to sit in a comfortable position, with back erect. They were then asked to inhale up to a maximum. After inhalation, the sound of OM (AUM) had to be vocalised. Half of the exhalation is spent on O (AU) and the other half on M. The M is pronounced with mouth closed. The last part has to be lengthened. This exercise was repeated thrice. After performing Omkaras, the subject had to remain still for a few seconds. Then, the following pranayama techniques were given:

1. **Anulom-vilom:** The subjects had to place their thumb over the right nostril. Palm of the other hand is kept on the knee and eyes remain closed. The subjects were then instructed to inhale slowly up to maximum through the left nostril. Then they were asked to close the left nostril with the ring finger while releasing the thumb from the right nostril and thereby exhale slowly up to maximum. After exhalation, the subject was asked to inhale through the right nostril itself. The air entered is then exhaled through the left nostril by releasing the finger placed on it and thereby placing the thumb on the right nostril.

Inhalation from the left nostril until its exhalation from the same nostril consists of one cycle of anulom-vilom. 5 to 10 cycles of this pranayama were performed.

2. **Kapalbhati Pranayama:** In this type of pranayama, both the nostrils function like the blacksmith's bellows. Palms should be kept on the knees and eyes should be closed. This type of pranayama can be done by both nostrils together or also by slightly lifting the nostril that works less. The subjects were instructed to exhale to a maximum followed by inhalation to half capacity and then slightly lift the nostril that works less. They were then instructed to breathe in and out at a brisk rate like the blacksmith's bellows with a slight friction at the nostril. The inhalation and exhalation have to be only half breaths. They were asked to attempt 10-15 rhythmic breathing counts and the counts were increased gradually according to one's capacity. On stopping, the subjects were asked to do a prolonged exhalation. 2 sets were performed with a gap of half a minute
3. **Ujjayi Pranayama:** In this type of pranayama, breathing is done through the nostrils but friction is to be felt in the throat. The sound produced is similar to that of snoring. The subjects were instructed to do a forceful exhalation in the beginning. Then deep inhalations and exhalations with friction in the throat were to be repeated. While doing inhalation, the chest should expand and the stomach should contract. The subjects were asked not to expand the chest purposely. The palms were to be rested on the knees or on the upper thigh. It was done 5 times and later extended up to 10 to 15 times.
4. **Shitkari Pranayama:** The subjects were asked to sit straight with palms on their knees, eyes closed and to hold their teeth together with lips apart so that the teeth were exposed. They were instructed to inhale slowly and deeply through the teeth. A hissing sound is produced at the time of inhalation. They were then instructed to exhale through the nose. 2 sets were given with half minute intervals and 5-10 repetitions per set.
5. **Sheetali Pranayama:** The subjects were asked to sit straight with palms on their knees and eyes closed. They were then asked to stick their tongues out and roll the lateral edges upward such that the tongue forms a tube. They were instructed to inhale deeply through the rolled tongue and then exhale through the nose. 2 sets were given, 5-10 repetitions each. Each set was performed after half minute intervals.
6. **Bhramhari Pranayama:** The subjects were asked to place their index finger on their ears while the remaining fingers formed a fist. The subjects had to inhale deeply and slowly. On exhalation, the sound made was supposed to resemble the humming sound of a bee. 2 sets were given, 5-10 repetitions each. Each set was performed after half minute intervals.
7. **Bhastrika Pranayama:** The subjects had to sit straight with palms on knees and eyes closed. They were asked to inhale and exhale repeatedly, deeply using the abdominal muscles. The abdomen moves out during inhalation and inwards on exhalation. The movements had to be slightly exaggerated and rhythmic. 2 sets were given 5 repetitions each. Each set was performed after half minute intervals.

   After completing the intervention of 4 weeks, post assessment was done.

2.3 Data Analysis

Data was analysed using SPSS 24 Software. Normality of the data was analysed using the Shapiro-wilk test following which paired t Test was done for the data that was normally distributed and Wilcoxon Test was done for the data that was not normally distributed. p Value ≤ 0.05 was accepted as indicating significant difference between the compared parameters.

3. Results

The current study included 42 community dwelling elderly population, out of which 38 subjects completed4 weeks of intervention. Four individuals dropped out during 2nd and 3rd week of intervention, so their data couldn't be used for analysis. Study population included 32 males and 6 females having a mean age of 66.97 (5.42) years.

The results of effect of Pranayama on different outcome measures are presented in Table 1.

There was a statistically significant decline in Heart Rate (p = 0.000), Systolic Blood Pressure (p = 0.002) and Rate pressure product (p = 0.000) post intervention. There was a statistically significant improvement in respiratory muscle strength [MIP (p = 0.000), MIP (p = 0.002)], Peak Expiratory Flow Rate (p = 0.000), cardiorespiratory endurance (p = 0.000) and agility (p=0.006)after 4 weeks of Pranayama intervention. Both Auditory and Visual Reaction Time [ART (p = 0.000), VRT (p = 0.000)] decreased post intervention. However, Respiratory Rate (p = 0.071) and Diastolic Blood Pressure (p = 0.057) did not show a statistically significant change though their mean values decreased post intervention.

Table 1: Intra-group comparison of cardiorespiratory functions, agility and reaction time in the subjects

	Outcome Variables	Pre Values	Post Values	pvalue
		MEAN ± SD		
Cardiorespiratory Functions	HR (beats per min)	69.55±9.58	65.53±6.51	0.000*
	SBP (mm Hg)	125.21±8.32	123.05±7.58	0.002*
	DBP (mm Hg)	80.79±6.14	80.26±5.34	0.057
	RR (breaths per min)	20.68±3.26	19.89±2.24	0.071
	RPP	8695.84±1215.43	8062.32±931.86	0.000*
	MIP (cm H_2O)	27.58±10.01	31.47±10.05	0.000*
	MEP (cm H_2O)	48.95±20.29	55.16±20.35	0.002*
	PEFR (Litres per min)	338.95±63.57	360.26±59.66	0.000*
	2MST (no of steps)	66.71±18.91	70.50±19.40	0.000*
Agility	8 Foot Up & Go Test (seconds)	6.87±0.75	6.75±0.79	0.007*
Reaction Time	ART (milliseconds)	359.92±104.04	311.27±83.91	0.000*
	VRT (milliseconds)	326.84±61.64	282.27±55.86	0.000*

* Level of Significance ≤ 0.0

4. Discussion

The present study showed a significant improvement in the reaction time, agility and cardiorespiratory functions in community dwelling elderly after four weeks of pranayama. The HR, SBP, RPP, MIP, MEP PEFR, 8 Foot Up & Go Test, 2MST shows a statistical significance. However, the RR and DBP was not statistically significant even though there has been an appreciable decrease in their values post intervention.

The decrease in Reaction Time, both ART and VRT indicates an improved sensorimotor performance. Reaction Time is an indirect indicator of the processing ability of central nervous system and determines sensorimotor performance. The effect of pranayama on central nervous system is due to, greater arousal and faster rate of information processing of the CNS. Shortening of VRT as well as ART after pranayama training signifies greater arousal, improved concentration power and ability to ignore or inhibit extraneous stimuli and faster responsiveness [21, 22]. The changes in breathing pattern occurring due to the voluntary control of inspiration have been reported to be significantly correlated to changes in RT [23, 24].

The shortening of RT after pranayama and hence an improved sensorimotor function may be attributed to enhance the agility in elderly population. Furthermore, studies show that a shorter agility time is related to a better RT [25]. There have been studies showing increase in agility due to an increase in the oxygen carrying capacity, which in this case has increased due to the effects of pranayama [26].

There have been previous studies reporting the effects of pranayama on cardio respiratory parameters in elderly [2, 27, 28]. In the geriatric population, pranayama works in tandem to increase lung capacity by developing better lung function and increase the concentration of oxygen in the lungs. It also improves the circulation of blood and the lymphatic system, helping to eliminate toxins and strengthen the immune system. This helps in enhancing physical fitness. The significant reduction in HR, SBP, DBP and hence RPP can be attributed to modulate the autonomic activity with an increase in parasympathetic activity and relatively reduced sympathetic tone. This autonomic modulation in pranayama is due to the change in of breathing patterns which activates various central and autonomic mechanisms and hemodynamic adjustments thus causing changes in cardiovascular functioning [29, 30]. Pranayama is known to increase the frequency and duration of inhibitory neural impulses by activating pulmonary stretch receptors during above tidal volume inhalation, which brings about a reduction of sympathetic tone in skeletal muscle blood vessels, which leads to generalized vasodilation, and hence decreasing the peripheral resistance and as a result the DBP. [31] It is also probable that with longer duration of pranayama training there may be a further and statistically significant decrease in RR and DBP. Bhramhari Pranayama has been reported to influence parasympathetic dominance on cardiovascular system due to its effects in reducing SBP, DBP, mean arterial BP and HR [32].

The reduction in HR and SBP automatically reduces RPP, which is a product of systolic BP and HR and is a better index of MVO_2. RPP is especially important in patient care as this is an indirect indicator of myocardial oxygen consumption and load on the heart, thereby signifying a lowering of strain on the heart [27]. The significant reduction in RPP therefore denotes a reduction in the myocardial workload and as a result reduces the energy consumption of the heart.

The increase in MIP and MEP indicates that pranayama improves the strength of the inspiratory as well as expiratory muscles respectively. It is known to be due to Bhastrika Pranayama which involves powerful strokes of inhalation and exhalation, which helps the subject in making full use of diaphragm and abdominal muscles [33]. Increase in respiratory pressures suggests that pranayama training strengthens of muscles of respiration. Stimulation of pulmonary stretch receptors due to maximum inflation of the lungs relaxes smooth muscles of larynx and tracheo-bronchial tree which modulates the distensibility of airways and reduces airway resistance. Thus, opening of small airway and reduced airway resistance increases PEFR [34]. During yoga practice, one consciously and consistently overrides the stimuli to the respiratory centers, thus acquiring some degree of control over the respiration. This results in an improved cardiorespiratory endurance [12]. Thus by improving the strength and endurance of respiratory muscles through yoga, onset of respiratory muscles fatigue could be delayed, which could then lead to improvement of physical performance [33].

The study was conducted on the healthy individuals, hence limiting the application of its findings to elderly with pathological conditions. The long-term effects of pranayama on reaction time, agility and cardiorespiratory functions were not examined in this study.

A larger sample size taking place over a greater period will prove helpful to evaluate the precise physiological effects and underlying mechanisms taking place in pranayama on reaction time, agility and cardiorespiratory functions in community dwelling elderly.

5. Conclusion

This study proves that a short-term practice of pranayama resulted in improved reaction time, agility and cardiorespiratory functions in community dwelling elderly.

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