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Comparative effects of aerobic exercise training and incentive spirometry on selected cardiopulmonary parameters in apparently healthy elderly

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Individuals that are above 60 years old have decreased functions of several organs, such that the lungs can lose greater than 40% of their capacity over time and a significant reduction in cardiopulmonary muscle strength and endurance. However, some of these changes can be negated by lifestyle modification. This study compared the effects of aerobic exercise training and incentive spirometry on selected cardiopulmonary parameters in apparently healthy elderly. Forty apparently healthy elderly aged 60 to 94 years were recruited from selected homes for the elderly in Lagos State through a purposive sampling for this study but 35 of them (17 males and 18 females) completed it. They were randomly assigned to 3 groups. Group A underwent Aerobic Exercise training, Group B underwent Incentive Spirometry and Group C was the Control. These interventions were done three days a week for four weeks. Selected cardiopulmonary parameters were assessed at baseline and at the end of 4 weeks. Data were analysed using SPSS version 17. Although there were positive changes in most of the cardiopulmonary parameters of groups A and B, paired *t*- test showed that they were not statistically significant except Forced Expiratory Volume in 1 second (FEV_1) (A: p=0.002; B: p=0.03). Comparison of the mean changes in all selected variables due to the two interventions showed no significant differences. There were no significant differences between the mean changes caused by Incentive Spirometry and Aerobic Exercise training in selected cardiopulmonary parameters in apparently healthy elderly, although incentive spirometry brought about better changes.

Key words: Aerobic exercise training, Incentive spirometry, cardiopulmonary parameters, elderly.

INTRODUCTION

Cardiopulmonary fitness requires an efficient heart, vascular and respiratory systems which are able to function effectively at rest and during emergencies (Pollock and Wilmore, 1990). Ageing which refers to a multidimensional process of physical, psychological, and social change causes structural changes in the body's systems that lead to decline in function (Birbrair et al., 2013; Abdullah et al., 2013). The prevalence of age related musculoskeletal disorders associated with sedentary lifestyle in the elderly is high and common in the lower limbs and back (Aweto et al., 2016). Cardiopulmonary system is one of the body's systems

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that decline in function with age and this causes a decrease in the cardiopulmonary fitness of the elderly people (Stratton et al., 1994). The mechanical pumping action of the heart can become less efficient due to muscle fibre changes. Systematically, blood vessels can lose elasticity which further decreases oxygen delivery to muscles for healthy sedentary elderly adults. The lungs mature by age 20-25 years and thereafter progressively decline in function such that they can lose greater than 40% of their capacity over time and a significant reduction in cardiorespiratory muscle strength and endurance (Sharma and James, 2006; El-Kader and Ashmawy, 2012; Richard, 2013). The elastic recoil of the lungs decreases owing to changes in elastin and collagen (Ruivo et al., 2009). The lung weight decreases by approximately one-fifth and the bronchial epithelium and mucous glands degenerate. The alveolar ducts and bronchioles enlarge, with an accompanying decrease in the depth of the alveolar sacs. The alveolar dead spaces increase with age, affecting arterial oxygen without impairing the carbon dioxide elimination (Sharma and James, 2006). There is hardening of the bronchi and narrowing of the bronchioles resulting to a greater resistance to airflow. The Vital Capacity (VC) and Forced Expiratory Volume in the first (FEV1), Maximum Ventilatory Ventilation (MVV) and Peak Expiratory Flow (PEF) decrease while the residual volume increases due to decrease in the elastic recoil of the lungs, air trapping, weakness of respiratory muscles, coastal cartilages calcification and reduced mobility of the ribs (Ruivo et al., 2009). Concerning the arterial blood gases, arterial oxygen saturation (SaO2) and partial pressure of arterial oxygen (PaO2) decrease with age (Michael, 2005). The value of PaO2 is got by subtracting half of a person’s age from 105; so that the PaO_2 of an 80 year old man is 65mmHg while that of a younger person of 50 years is 80 mmHg (Michael, 2005).

There is increasing evidence that by modifying one’s lifestyle (increasing exercise and changing diet) some of these changes can be reduced (Larsen, 2009). The benefits of participation in regular activities and exercises in alleviating a number of functional declines associated with ageing have been demonstrated in healthy and chronically ill elderly subjects while the risks of such activities and exercises have been found to be minimal (Cherubini et al., 1998). Participation in regular aerobic and strength exercise elicits a number of favourable responses that contribute to healthy ageing (Mazzeo et al., 1998). Weight resistance training for the elderly has also been shown to produce significant increases in strength (Mayer et al., 2011). The goal of training is to reduce the rate of muscle mass atrophy that results from loss of function (Mayer et al., 2011). There is strong evidence that regular physical activity reduces the risk of cardiovascular disease in the lives of people who engage in it regularly while lack of exercise training is directly associated with increased mortality from cardiovascular diseases (Pollock and Wilmore, 1990; Buchner, 2009).

Incentive Spirometery (IS) is a mechanical assistive aid and mainstay of lung expansion therapy. It is equipment-assisted approach that enhances pulmonary hygiene by encouraging patients to simulate natural sighing or yawning, in a pattern described as sustained maximal inspiration through visual and/or auditory feedback (Warren, 2000). Incentive spirometry is a clinical technique that is commonly used in patients who are at high risk of developing airway or breathing problems while hospitalized (Leader, 2008). It has been used in disease conditions such as atelectasis, pneumonia, respiratory failure and postoperative pulmonary complications (Restrepo et al., 2011). It has also been shown that consistency in the practice of Incentive Spirometry brings about improvements in PEF and FEV1 (Adeniyi and Saminu, 2011). In addition, use of IS results in a prolonged phase of effective inspiration, more controlled flow and greater enthusiasm to practice (Restrepo et al., 2011). Little is known about the comparative effects of aerobic exercise training and incentive spirometry on the cardiopulmonary functions of apparently healthy elderly; hence the reason for this study.

MATERIALS AND METHODS

Forty apparently healthy elderly were recruited for this study from two old people’s homes in Lagos (The Holy Family Elderly’s Home of Regina Mundi Catholic Church, Mushin, Lagos and the Lagos State Old People’s Home, Lancaster Avenue, Sabo – Yaba, Lagos) through a purposive sampling technique. Their ages ranged from 60 to 94 years. Elderly people suffering from diabetes, cardio-pulmonary diseases and orthopaedic challenges were excluded from the study. The subjects who met the inclusion criteria gave their written informed consent and were randomly assigned to three groups (A, B and C) using a fish bowl technique where the number the subjects picked determined their group. Two subjects dropped out due to ill health, one opted out due to loss of interest in the research, and two were not available for the post assessment. This left the number at 35 (17 males and 18 females) that completed the study. Group A (Aerobic group) was made up of 10 males and 6 females, Group B (Incentive spirometry group) was made up of 3 males and 7 females while Group C (Control group) was made of 4 males and 5 females. Ethical approval was obtained prior to the study from the Health Research and Ethics Committee of the Lagos University Teaching Hospital.

Procedure for data collection

Pre-intervention assessment

The subjects were evaluated at their residing Old People’s Homes. Their meal time and resting periods were also obtained to prevent clashes with the time of the experimental procedures. The medical records of all the subjects were sought to ascertain their current health status and certify them fit for the experimental procedure. The baseline measurements of all the selected cardiopulmonary outcome parameters were taken for the subjects after a rest period of 15 min prior to the intervention (Aweto et al., 2015). Systolic blood pressure (SBP) in mmHg and Diastolic blood pressure (DBP) in mmHg were measured with a mercury sphygmomanometer and a stethoscope in sitting position. Heart rate (HR) in beats/min was measured with a stethoscope. Respiratory rate in beats/min was taken in sitting position just after the blood pressure was measured. Forced vital capacity (FVC) and FEV_1 in litres were measured with a hand-held medical spirometer in sitting position. Height and weight of each subject were also measured at baseline using height meter and weighing scale respectively and the values were used to determine the Body Mass Index (BMI) using the formular:

$$BMI = Weight / Height^2$$

The vital signs of all subjects were taken at all times of visits before the start of the procedure to ensure that the subjects were fit enough to participate in the study. These selected cardiopulmonary parameters were also measured post-intervention at the end of the 4^{th} week of the study.

Interventions for the study groups

Study Group A

Therapeutic exercise mode: Aerobic exercise (Brisk walking)

Therapeutic exercise procedure: Therapeutic exercise intervention for subjects in this group was done in 3 phases namely Phase 1, 2 and 3. Phase 1 consisted of 5 min warm-up exercises which involved body movements and stretching while slow music was being played (Aweto et al., 2012). In phase 2, the subjects walked briskly to and fro the walk ways marked out in the large spaced balconies at the two locations for 10 min. It was promptly followed by a 5 min cool down session (Phase 3) in which the subjects were asked to walk at a slower pace and then performed breathing exercises (Aweto et al., 2015).

Therapeutic exercise frequency: The subjects underwent the exercise training for a period of 4 weeks at a frequency of three times a week (Lee, 2014).

Study Group B

Therapeutic intervention mode: A modified Incentive Spirometer.

Therapeutic intervention procedure: A modified incentive spirometer was made using the tube of a syringe, gloves and a masking tape with the names of the subjects written on them. The subjects were asked to blow into their individual incentive Spirometers every 2 h for at least 10-20 times per time and the care givers at the two locations were indulged to monitor their progress (Restrepo et al., 2011).

Therapeutic Intervention Frequency: The procedure was carried out for the same period of 4 weeks at a frequency of at least 10-20 times per time, every 2 h during the day, three days a week (Restrepo et al., 2011).

Study group C

This is the control group. They did not carry out any of the procedures of the other groups but were given advice on good lifestyle at the time of their baseline evaluation and were also asked to continue with their normal activities of daily living.

Data analysis

All statistical tests were done using Statistical Package for Social Sciences (SPSS) version 17 (Chicago, IL, USA). All demographic and quantitative data were expressed as mean $\pm$ standard deviation. The data obtained were represented in tables. Paired *t* -tests were used to determine the significance of the differences between the mean values and changes of cardiopulmonary variables within each group and between intervention groups. Significant level was $p \leq 0.05$.

RESULTS

The mean age, height, weight and BMI of all subjects that participated in this study were 78.16± 10.215 years, 1.57± 9.603 m, 54.74 ±9.603 kg and 22.00 ± 3.817 kg/m^2 respectively (Table 1). Following 4 weeks of study, paired *t*-test comparison of pre and post intervention cardiovascular mean scores showed no significant changes in the SBP ($p > 0.05$), DBP ($p > 0.05$) and HR ($p > 0.05$) of subjects in groups A, B and C (Table 2). Paired *t*-test comparison of pre and post intervention pulmonary mean scores showed significant changes in FEV_1 for subjects in groups A and B (A: p=0.002; B: p=0.03) and FVC for subjects in group C (p=0.004) (Table 3). Table 4 shows a comparison of the mean changes in the cardio-pulmonary parameters between groups A and B. Paired *t* test analysis showed that there were no significant differences in any of the parameters [SBP: p=0.67, DBP: p=0.76, HR: p=0.58; RR: p=0.11, FEV_1: p=0.79, FVC: p=0.65].

DISCUSSION

The aim of this study was to compare the effects of aerobic exercise training and incentive spirometry on selected cardiopulmonary parameters in apparently healthy elderly. The result showed that after 4 weeks of the study, there were positive changes in most of the cardiopulmonary parameters of both aerobic and incentive spirometry groups which were not statistically significant except forced expiratory volume in 1 second (FEV_1) of both groups. There were no significant differences between the mean changes in selected cardiopulmonary parameters (SBP, DBP, HR, RR, FEV_1, and FVC) brought about by aerobic exercise training and incentive spirometry training. However, the incentive spirometry training brought about better changes than aerobic exercise training in most of the selected cardio-pulmonary parameters after 4 weeks of intervention.

The finding that both aerobic exercise and incentive spirometry brought about positive changes that were not statistically significant in all of the selected cardiopulmonary parameters in apparently healthy elderly except FEV_1 after 4 weeks of study may imply that both interventions can significantly improve these parameters in apparently healthy elderly if they train in them for longer time than 4 weeks and more frequently than three times a week. Aerobic exercise improves myocardial circulation and metabolism which improves the heart oxygen supply and its contractility during a specific challenge (Pollock et al., 2000). This causes the heart

Table 1. Physical characteristics of the subjects in all the groups.

Physical characteristics	Group A (n=16) Mean + SD	Group B (n=10) Mean + SD	Group C (n=9) Mean + SD	All subjects (n=35) Mean + SD
Age (years)	78.06± 8.062	79.20 ± 12.647	77.22± 9.935	78.16 ± 10.215
Height (meters)	1.59 ± 8.739	1.53± 9.673	1.56 ± 10.747	1.57± 9.603
Weight (kg)	56.31 ± 11.831	49.90 ± 7.54978	57.33 ± 18.276	54.74 ± 9.603
Body mass index (BMI) (kg/m^2)	21.98 ± 3.910	21.23 ± 3.554	22.90 ± 4.173	22.00 ± 3.817

Table 2. Comparison of pre-test and post-test of cardiovascular mean scores in each of the 3 groups.

Cardiovascular Variables	Pre-test Mean ± SD	Pre-test Mean ± SD	t-value	p-value
Group A				
Systolic blood pressure (mmHg)	138.69 ± 23.125	132.94 ± 16.631	1.80	0.09
Diastolic blood pressure (mmHg)	74.94 ± 13.087	71.00 ± 9.099	1.47	0.16
Heart rate (beats/min)	72.73 ± 10.787	76.93 ± 11.835	-1.70	0.11
Group B				
Systolic blood pressure (mmHg)	145.5 ± 22.016	137 ± 18.469	1.53	0.21
Diastolic blood pressure (mmHg)	78.70 ± 17.101	73.10 ± 11.628	1.08	0.31
Heart rate (beats/min)	76.50 ± 12.358	80.50 ± 13.746	-0.76	0.47
Group C				
Systolic blood pressure (mmHg)	148 ± 26.661	143.67 ± 22.252	1.60	0.15
Diastolic blood pressure (mmHg)	77.89 ± 14.743	75.89 ± 14.173	1.33	0.25
Heart rate (beats/min)	73.67 ±8.846	72.33 ± 9.631	0.70	0.50

SD= Standard Deviation.

Table 3. Comparison of pre-test and post-test of pulmonary mean scores in each of the 3 group.

Pulmonary variable	Pre-test Mean ± SD	Pre-test Mean ± SD	t-value	p-value
Group A				
Respiratory rate (breaths/min)	21.38 ± 3.481	22.50 ± 2.129	-1.28	0.22
Forced expiratory flow in one sec (L)	0.97 ± 0.442	1.24 ± 0.463	-3.76	0.002*
Forced vital capacity ((L)	1.38 ± 1.548	1.55 ± 0.530	-1.62	0.13
Group B				
Respiratory rate (breaths/min)	23.00 ± 2.708	21.60 ± 3.864	1.08	0.31
Forced expiratory flow in one sec (L)	0.62 ± 0.246	0.93 ± 0.552	-2.58	0.030*
Forced vital capacity ((L)	1.12 ± 0.594	1.12 ± 0.551	-0.89	0.40
Group C				
Respiratory rate (breaths/min)	22.67 ± 2.828	22.44 ± 2.186	0.36	0.73
Forced expiratory flow in one sec (L)	0.55 ± 0.301	0.62 ± 0.356	-1.81	0.11
Forced vital capacity ((L)	0.76 ± 0.473	0.88 ± 0.505	-4.08	0.004*

*Level of Significance ($p \leq 0.05$)
SD= Standard deviation.

the work of myocardium. Wilmore and Costill (2005) reported that the long term effect of aerobic exercise rate and blood pressure to be favourably reduced at rest and during exercise leading to a significant reduction of

Table 4. Comparison of the mean changes in selected cardiopulmonary parameters brought about by Aerobic exercise training and Incentive spirometry training.

Variable	Group A Mean change	Group B Mean change	t-value	p-value
Cardiovascular				
Systolic blood pressure (mmHg)	-5.75	-8.50	0.43	0.67
Diastolic blood pressure (mmHg)	-3.94	-5.60	0.32	0.76
Heart rate (beats/min)	-0.25	4.00	-0.56	0.58
Pulmonary				
Respiratory rate (breaths/min)	1.13	-1.40	1.67	0.11
Forced expiratory flow in one sec (L)	0.27	0.30	-2.60	0.79
Forced vital capacity ((L)	0.16	0.09	0.46	0.65

leads to an expansion of the oxygen transport system, which is reflected by the augmented capacity for maximal work. There is larger lung size and vital capacity, higher blood volume and total haemoglobin, larger stroke volume, maximal oxygen uptake and arterio-venous oxygen difference. For aerobic exercise to be beneficial to health, the American College of Sports Medicine (American College of Sports Medicine, 2006) has recommended that it should be moderate to vigorous intensity performed for 30 to 60 min per day preferably daily or at least 3 to 5 times a week. The longer the duration and frequency of aerobic exercise training, the more beneficial it becomes to health. Similar studies by Ohkubo et al. (2001) and El-Kader and Ashmawy (2012) showed that exercise training programme performed for longer duration of 3 months and 6 months brought about significant improvements in blood pressure. Hassan et al. (2011) reported that eight weeks of aerobic exercise training significantly enhanced airway trachea indexes. The benefits of participating in regular physical activities and exercises in alleviating a number of functional declines associated with ageing have been demonstrated in healthy and chronically ill elderly subjects while the risks of such activities and exercises have been found to be minimal (Cherubini et al., 1998).

Incentive spirometry is well known to improve the pulmonary functions of individuals but not the cardiovascular parameters (Adeniyi and Saminu, 2011; Amonette and Terry, 2002; Maureen et al., 2008). This improvement in pulmonary functions is partly as a result of an increase in the strength of the respiratory muscles (diaphragm, external and internal intercostals, scalene and abdominal muscles)(Amonette and Terry, 2002). Maureen et al. (2008) reported that using incentive spirometry with expiratory positive airway pressure reduces pulmonary complications, improves lung functions and functional capacity. Adeniyi and Saminu (2011) reported that using incentive spirometer consistently brings about improvements in PEF and FEV1. Incentive spirometry is clinically used as an adjunct to chest physiotherapy and it enhances lung expansion and inspiratory muscle strength in chronic obstructive pulmonary disease (Weiner et al., 2000). It has proven to have a positive effect on FEV1 in both healthy subjects and patients recovering from various surgeries (Davis, 2012; Alfred et al., 2013).

The finding that there were no significant differences between the mean changes in selected cardiopulmonary parameters brought about by aerobic exercise training and incentive spirometry training imply that none of the interventions was superior to the other in improving the selected cardiopulmonary parameters in apparently healthy elderly. More so, both interventions brought about significant improvement in FEV1 in apparently healthy elderly.

Conclusion

Although incentive spirometry training brought about better changes than aerobic exercise training in most of the selected cardiopulmonary parameters in apparently healthy elderly, these mean changes caused by the two interventions were not significantly different.

Relevance of the study

The elderly should be encouraged to engage in either aerobic exercise training or incentive spirometry training in order to improve their declining cardiopulmonary functions.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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