Selected Ventilatory Functions Response to Closed and Open Kinematic Chain training of the arm in elderly

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Abstract: Aging is associated with pulmonary alterations; these changes culminate in a decrease in muscle strength, lower level of endurance and impairment of mobility. Fortunately, increasing the level of physical activity may affect the declines of these parameters. The present work aimed to investigate the effect of closed vs. open kinematic chain exercises on ventilatory functions in elderly subjects. Thirty elderly subjects (13 female and 17 male) participated in the study their age ranged from 60 to 75 years. They were divided into two study groups equal in number. Group I comprised of 15 subjects received a training program of closed kinematic chain "supported arm exercise" and group Π received a training program of open kinematic chain "unsupported arm exercise". Hand held Spirometer was used for measuring ventilatory functions. Arm ergometer, was used for closed kinematic chain (supported arm exercise group). Both groups were trained for 8 weeks, three times a week. The results showed that the vital capacity, the forced expiratory volume in 1st second, and the maximum voluntary ventilation were significantly improved in both groups but the percentage of improvement was significantly higher in group I of closed kinematic chain training. It is concluded that the outcomes of this study may help to outline the most effective, curative and safety type of arm exercise to be included in training programs for pulmonary and orthopaedic problems in elderly.

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1. Introduction

Aging is associated with diminished physical ability as a result of a decrease in muscle strength, endurance, flexibility and neuromuscular coordination. In addition, aging is accompanied by the development of many disabling diseases. Although the chronological criterion that is presently used for identifying the old has been set at 65 years, yet the onset of some of the health problems of elders may occur as soon as they enter their early 50. (Guccione, 2000)

As aging progress, the respiratory system undergoes a measurable decline in the physiologic function. The thoracic cage stiffens with advancing age; with the increased possibility for increased kyphosis coupled with increased work demand of the respiratory muscles thus increases the work of breathing. There are significant changes in the functions of the pulmonary system including: decreased FEV1, FVC and VC, increased RV, and increased FRC. The most important consequence of age-related changes that occur is the reduction in the physiologic reserve of the respiratory system (Robergs and Roberts, 2000).

Previous studies have showed that scalenes are not accessory respiratory muscles as commonly considered, but are active during quiet inspiration. On the other hand , the accessory muscles which are silent in normal breathing are recruited as the ventilation increases. The accessory muscles include: - sternocleidomastoid, extensors of the vertebral column, pectoralis minor, trapezius and serratus muscles. Many of these muscles reverse their usual origin/insertion and help to expand the chest, provided the arms and shoulder girdle are fixed by grasping a suitable support; closed chain (Lumb, 2000).

The performance of many everyday tasks requires use of not only the hands, but also other muscle groups that are used in upper torso and arm positioning. Some of these muscle groups serve respiratory as well as postural functions, so arm exercise can improve ventilation. If the arms are trained to perform more work, or if the ventilatory requirement for the same work is decreased. Moreover, the capacity to perform activities of daily living could improve with parallel increase in strength and endurance of respiratory muscles and so decreased oxygen uptake at the same workload (Celli, 1998).

Although it is possible that arm activities are limited by weak shoulder and arm muscles, it is likely that the ability of patients with chronic obstructive arm diseases to sustain arm exercises is determined not only by the strength & endurance of arm muscles, but also by the influence of the arm position itself on ventilatory mechanics (Dolmage *et al.,* 1993). The circulation of blood to the tendon also depends on muscle tension. In the tendon, circulation will be inversely proportional to the tension. At very high tension levels, circulation may cease completely. Recent studies have shown that the intramuscular pressure in the supraspinous muscle can exceed 30 mm Hg at 30 degrees of forward flexion or abduction in the shoulder joint. Impairment of blood circulation occurs at this pressure level. Since the major blood vessel supplying the supraspinous tendon runs through the supraspinous muscle, it is likely that the circulation of the tendon may even be disturbed at 30 degrees of forward flexion or abduction in the shoulder joint. Moreover, Arm exercises includes motor control hypothesis that varies according to testing or training conditions (Brindle *et al*., 2006)

Closed kinematic chain training such as lifting free weights or dowels and stretching elastic "Thera" bands, in contrast to open kinematic chain exercise such as arm ergometer and shoulder wheel results in improved upper extremity function. As improvement in unsupported arm activity is likely of greater clinical significance. A program of simple unsupported arm training is the ideal format to achieve this. (Martinez *et al.,* 1993; Lareau *et al.,* 1999).

Simple open kinematic chain arm elevation like a trivial task result in significant increase in the metabolic and ventilatory demands in normal subjects' .This is associated with an increased contribution of the diaphragm to ventilation (Couser *et al.,* 1993). Open and closed kinetic chain exercises appear to be equally effective in improving shoulder joint reposition sense which suggest that shoulder joint reposition sense can be enhanced with training in healthy subjects (Rogol *et al.,* 1998).

Concerning the possible difference between training of the arm and leg on pulmonary functions , results varies .Minute ventilation at peak leg exercise was significantly higher than at peak arm exercise in normal subjects and in mild and moderate cystic fibrosis patients, as well as at peak exercise, the workload for leg exercise were significantly higher than for arm exercise (Alison *et al.,*1998).

Musculoskeletal changes with aging result in common problems such as degenerative changes in intervertebral disk (cervical spondylosis) and frozen shoulder (due to stiffness in peri-articular connective tissue). For which upper limb exercises are commonly considered for inclusion as a main part in many physical therapy programs for those persons (Guccione, 2000).

Previous authors demonstrated a variable difference in the ventilatory response to supported and unsupported arm exercises in patients with chronic obstructive pulmonary disease. It was found that within COPD group, peak work level, peak VO2 and VE were significantly lower for unsupported arm exercise than for both leg and supported arm exercise (Mckeough *et al.,* 2003a).

In a study conducted by Morrissey *et al.* (2000) comparing the open kinematic and closed kinematic chain in knee surgery. The authors concluded that there are no clinically differences in the functional improvement resulting from the choice of OKC and CKC exercises in the early period of rehabilitation. The findings were delimited because of the short period of supervised rehabilitation (2-6 weeks)

This study might be the first one applied to investigate the effect of open and closed kinematic chain arm exercises on the ventilatory function in healthy elderly subjects.

Hypothesis:

It was hypothesized that there were non statistical significant differences in ventilatory response for closed vs. open kinematic chain arm exercises in elderly subjects.

2. Subjects, Materials, and Procedures

Subjects:

Inclusion criteria:

- Thirty elderly right handed subjects (13 female and 17 male) participated in the study.
- Anthropometric measurement: Their ages ranged between (60-75) years with a mean of 65.83 ± 5.08 years. Their weight ranged between (57- 95) Kg with a mean of 81.2 ± 9.14 Kg. While their height ranged between (155-180) cm with a mean of 168.47 ± 6.19 cm.. Body mass index mean is 22.46 ± 4.28
- Subjects selected, with mild to moderate level of activity as most of them were employee; some were teachers while most of females were house wives.
- All of the elderly did not receive any physical therapy programs related to respiratory training before they were participating in the study.

Exclusion criteria:

All non smokers' participants were examined by the responsible physician to exclude sever renal disease, liver disorders, obese and diabetic or sever hypertensive subjects, neurological dysfunction as cerebral stroke, parkinsonism, neuropathy or psychological or mental impairments. In addition severe chronic cardiac problems as heart failure, ischemic heart disease, and coronary artery by pass graft. Chronic chest disease as chronic obstructive lung disease, restrictive lung disease or chronic chest infection, fibrosis or suppuration or other problems that may interfere with movement as musculoskeletal deformities as scoliosis, kyphosis and kyphoscoliosis, chronic inflammatory orthopedic disorders and rheumatoid arthritis were also excluded.

Materials:

A. Evaluation Equipment:

Electronic Spirometer:

Futuremed Discovery Hand held Spirometer made in Germany fig(1) used for measuring ventilatory functions with disposable mouth piece and nasal clips. It is a computerized apparatus with an electronic memory allowing on a single forced exhalation, the forced vital capacity & the maximum voluntary ventilation values.

Body weight and height scale:

Health made in china, used to measure the subject's weight and height & calculate the body mass index (BMI) according to the formula:

BMI = body weight in kilograms/ height in meter squared (**Barreto *et al.,* 2003**)

Mercury sphygnomanometer & pulsoxemeter:

Speidel, used to measure blood pressure before and after each session.

Fig. (1) Futuremed Discovery Hand held Spirometer

B. Training Equipment:

Arm Ergometer:

Monark Rehab Trainer, Model 881E, made in Sweden, used for closed kinematic chain training (supported arm exercise group). It has the ability for individual calibration according to each subject. Crank arms are individually adjustable both horizontally and vertically according to the subject height in order to be comfortable starting at horizontal level arm position 90 degrees shoulder elevation. It's graduated scale in Watts, showing the workload in 50 r/min & its electronic readouts showing; pedal r/min, total pedal revolutions and time.

Wooden Bars of different weights that were designed with hand grip in the middle third of the bar were used for comfortable grasping during the exercise (Mckeough *et al*., 2003a).

Procedures:

The subjects were assigned into two groups equal in number:

The first group trained in a closed kinematic chain "supported arm exercise group" SAE group: trained with the ergometer. The second group trained as open kinematic chain "unsupported arm exercise group" UAE: include subjects who received a training program with wooden bars.

Participants of both groups received a thorough explanation of the procedures and duration before starting the study. A written consent form was obtained from each subject before participating in the study. Both groups were trained for 8 weeks, three times a week

The study procedures were carried out at Outpatient Clinic of the Faculty of Physical Therapy, Cairo University.

A. Evaluation procedures:

After the subjects were carefully chosen by physician, all of the subjects underwent several evaluation steps including the following:

1) Preliminary assessment:

It was undertaken by a physical therapist. Careful history was taken for any pervious chest diseases, smoking, any old fractures or traumatic insults to upper limbs and any neurological problem that may hinder the movements of the arm or cause pain during the exercise. Postural examination while the subject was in standing position (Thomas and Strandberg, 2004). Range of motion examination & gross muscle testing for all the joints & muscles of the upper limb of both sides were examined to insure comfortable and complete joint motion during exercises & insure normal muscle strength and endurance (Kinser and Colby, 1990; Bickley, 2003). Vital signs ;Blood pressure, respiratory rate and heart rate were measured and recorded initially then before and after each session through the training program, to insure stable hemodynamic condition. Then BMI was calculated to insure normal average.

2) Ventilatory functions test:

Subject preparation:

- The subjects were required to:
  1) Avoid eating a heavy meal just before the test
  2) Avoid performing any excess effort for 6 hours before the test.
  3) Wear loose clothes that don't restrict breathing in any way.
- While the subject was sitting on stool with trunk unsupported, he was asked to place the nasal clip around the nose. Then the mouth piece was firmly put into his mouth. The subject was asked to breathe few times before starting procedures. After that he was asked to inhale fully and exhale as slowly and as completely as possible, then breath normally again till test ends to examine the VC. For MVV manoeuvre, the subject was asked to put a disposable mouth piece in his mouth tightly, inhale and exhale fully as completely, as fast as possible for 12 seconds. Each manoeuvre was repeated for three successive times and the greatest reading was obtained and recorded. All the previous measures have been recorded and stored then repeated again at the end of the study period (eight weeks).

3) Determination of Target Heart Rate:

Target heart rate (THR) was calculated using Karvonen formula (Quoted and adopted from Sullivan and Schmitz, 1994).

4) Determination of Exercise intensity for closed kinematic chain "SAE "group:

Subject preparation:

The subject was seated with back completely supported and his feet rested on the ground for 10 min to gain homodynamic stabilization. The resting pulse rate, respiratory rate and blood pressure were then measured and recorded. Then the probe of the pulse meter was applied to the subject's ear to measure the heart rate during the exercise.

Instrument preparation:

The arm ergometer machine was placed on an adjustable table so that the fulcrum of the handle was at the level of the subject's shoulder. The cycling speed was adjusted at 50 revolutions per minute (Martin *et al.,* 1991; Regnis *et al.,* 1997; Alison *et al.,* 1998).

Exercise test protocol for group I:

The exercise started by warming up for 10 min with no resistance (0 watt) & terminated with cooling done for 10 min. During the conditioning phase the resistance was increased by 5 watts every one minute until the subject reached calculated target heart rate (THR) this level of resistance obtained is recorded for analysis (Martinez *et al.,* 1993; Mcardle *et al.,* 2001).

The exercise test was repeated after four weeks in the same steps to readjust the intensity of exercise.

5) Determination of Exercise intensity for open kinematic chain " UAE" group:

Subject preparation:

The same preparation steps as closed kinematic chain SAE group. The different sizes wooden bars were put on the table near to the subject.

Exercise test protocol:

The subject started the exercise test with warming up for 10 minutes, using 300g bar, and flex his shoulders as high as he can without moving trunk forward from his waist to the horizontal arm position (with extended elbows) and back to the waist. After the warming up the subject lifted the different sized bars and moved each one from the waist to the 90 degrees shoulder flexion for 10 repetitions while notice the respiratory rate, heart rate, breathing pattern and the possibility for dyspnoea.

This procedure was repeated using bars with different weights, until the subject reached the maximum weight, according to his calculated target heart rate. This maximum obtained weight is recorded for analysis. After that the subject performed cooling down for 10 minutes exactly like warming up procedure using 300g bar(Mckeough *et al.,* 2003a).

The exercise test was repeated after four weeks in the same steps to readjust the intensity of exercise.

B. Training procedures:

1. Exercise session for SAE group:

After warming up exercise for 10 minutes with no resistance (0 watts), the subject started pedaling at the level of resistance obtained from exercise test (60% of THR) for 15 minutes. Then ,the resistance is decreased to 0 watt and he terminated the session with cooling down for 10 min (Martin *et al.,* 1991; Martinez *et al.,* 1993; Regnis *et al.,* 1997; Alison *et al.,* 1998; Mcardle *et al.,* 2001).

2. Exercise session for UAE group "open kinematic chain":

After warming up using 300g bar for 10 min in the same pattern as he previously trained. Then he was trained with the 60% of the weight recorded from exercise test for 15 min. At the end he performed cooling down by using 300g bar for 10 min (Mckeough *et al.,* 2003a).

3. Results:

Concerning the subject characteristics

This study compromised 30 healthy elderly subjects who were selected from Dar Hediet Barakat in Giza for nursing home. Their age ranged from 60 to 75 years, their height ranged from 155 to 180 cm and their weight ranged from 57 to 95 Kg (Table 1).

Table (1): Anthropometric characteristics of all subjects.

Item	Mean ± SD
Age(year)	65.83±5.08
Weight(Kg)	81.2±9.14
Height(cm)	168.47±6.19
BMI	22.46 ± 4.28

Kg: kilogram. Cm: centimeter. BMI body mass index. SD: standard deviation.

Anthropometric Data in both Groups:

From table (2): we can notice that there was no significant statistical difference between groups in Age, Height, Weight and Body mass index as P. value > 0.05.

Table (2): Comparison between the two Study Groups in Age, Height, Weight and BMI.

Item	Group I	Group Π	t-value	Level of significance
Age(year)	67.47 ± 4.49	64.2 ± 5.25	1.83	P. value >0.05
Height(cm)	170.33 ± 5.46	166.6 ± 6.48	1.71	P. value >0.05
Weight(kg)	79.47 ± 11.09	82.93 ± 6.58	1.04	P. value >0.05
BMI	22.46 ± 4.28	23.97 ± 2.9	1.87	P. value >0.05

BMI: body mass index P.value > 0.05 is non significant.

Concerning the gender distribution of both groups there was no significant statistical difference in gender distribution in the studied groups as P. value >0.05, as shown in table (3).

Table (3): Comparison between the Percentages of Male to Female subjects in both groups.

Item	Group 1	Group 2
Male	10 66.7 %	7 46.7 %
Female	5 33.3 %	8 53.3 %
x^2 value	1.18	
Level of significance	P. value >0.05	

X^2: Chi-squared test P.value > 0.05 is non significant

Comparison between the Pre& Post Study mean of Forced Expiratory volume in 1st second values in both Groups:

As shown in table (4) the pre-study mean values of FEV1 was 1.77 ± 0.63 L/S in group I and 1.45 ± 0.54 L/S in group Π. This indicated a non-significant statistical difference of FEV1 between group I and group Π before closed & open KC arm exercise with P. value >0.05 L/S. While the post-study mean values of FEV1 2.56 ± 0.44 L/S in group I and 1.83 ± 0.55 L/S in group Π. This indicated highly significant increase of FEV1 after supported arm exercise (CKC) than unsupported (OKC) arm exercise with P-value <0.01 L/S.

Table (4): Comparison between the Pre& Post Study mean values of Forced Expiratory volume in 1st second values in both Groups.

Item	Pre-study		Post-study	
	Group I	Group Π	Group I	Group Π
Mean	1.77	1.45	2.56	1.83
± SD	0.63	0.54	0.44	0.55
t value	1.54		3.98	
Level of significance	P. value >0.05		P. value <0.01	

SD: Standard Deviation -value >0.05 is non-significant t: paired t-test P-value <0.01 is highly significant.

Comparison between the Pre & Post Study mean values of Vital Capacity in both Groups:

As shown in table (5), the pre-study mean values of VC was 2.12 ± 0.29 L in group I and 1.88 ± 0.38 L in group Π. This represented a non-significant difference between the both groups in VC before the study with P. value >0.05 L. While the post-study mean values of VC was 2.85 ± 0.36 L in group I and 2.29 ± 0.55 L in group Π. This showed a highly significant improvement of VC with favour for supported arm exercise group with P. value <0.01.

Table (5): Comparison between the Pre & Post-study mean values of Vital Capacity in both groups.

Item	Pre—study		Post-study	
	Group I	Group Π	Group I	Group Π
Mean	2.12	1.88	2.85	2.29
± SD	0.29	0.38	0.36	0.55
t value	1.94		3.29	
Level of significance	P. value >0.05		P. value <0.01	

SD: Standard Deviation P-value >0.05 is non-significant tp: paired t-testP-value <0.01 is highly significant

As illustrated in table (6) the pre-study mean values of MVV was 56.67 ± 18.02 L/min in group I and 50.43 ± 13.35 L/min in group Π. This indicated a non-significant difference of MVV between both groups before the study with P. value >0.05 L/min. On the other hand the post-study mean values of MVV were 97.11 ± 16.07 L/min in group I and 64.69 ± 16.06 L/min in group Π. This revealed a highly significant increase of MVV after CKC than OKC arm exercise with P. value <0.01 L/min.

Table (6): Comparison between the Pre-study mean values of Maximum Voluntary Ventilation in both groups.

Item	Pre-study		Post-study	
	Group I	Group Π	Group I	Group Π
Mean	56.67	50.43	97.11	64.69
± SD	18.02	13.35	16.07	16.06
T value	1.08		5.53	
Level of significance	P- value >0.05		P- value <0.01	

SD: Standard Deviation P-value >0.05 is non-significant tp: paired t-test P-value <0.01 is highly significant

From table (7) it can be noticed that the mean difference of VC between both groups shown a non-significant statistical difference as P. value > 0.05.

Table (7): Comparison of the mean difference between ventilatory function readings in both groups.

Item	Mean Difference		t-value	Level of significance
	Group 1	Group 2		
FEV1	0.782	0.383	2.86	P. value < 0.01
VC	0.731	0.504	1.66	P. value >0.05
MVV	40.44	14.26	6.24	P. value < 0.001

FEV1: forced expiratory volume in 1st second
VC: vital capacity
MVV: maximum voluntary ventilation
t-value: student t-test
P. value > 0.05 is non-significant
P. value < 0.01 or < 0.001 is highly significant
P. value <0.05 is significant

From table (8) one can notice that in both groups there was a high significant improvement in all ventilatory functions

Table (8): Comparison between the percentages of improvement of ventilatory function readings in both groups:

Item	Group I	Group Π	Level of significance
FEV1	55.39 %	30.53 %	P. value < 0.01
VC	36.14 %	36.01 %	P. value >0.05
MVV	83.11 %	29.46 %	P. value < 0.001

FEV1: forced expiratory volume in 1st second
VC: vital capacity MVV: maximum voluntary ventilation
P. value > 0.05 is non-significant. P. value < 0.01 or < 0.001 is highly significant
P. value <0.05 is significant

Correlation between the percentage of improvement and Age in group I:

As shown in table (9), the correlation coefficient value between the percentage of improvement of, FEV1, MVV and age were 0.14 & 0.06 respectively, which means non-significant positive correlation as p-value >0.05. While the correlation coefficient value between the percentage of improvement of VC and age was -0.18, that means non-significant negative correlation as p-value >0.05.

Table (9): Correlation between the percentage of improvement of all variables and Age in group I.

Relative variable	r-value	P-value	Level of significance
FEV1 & age	0.14	p-value >0.05	r-value <0.48
VC & age	-0.18	p-value >0.05	r-value <0.48
MVV & age	0.06	p-value >0.05	r-value <0.48

r-value: Correlation coefficient value.
FEV1: forced expiratory volume in 1st second
VC: vital capacity MVV: maximum voluntary ventilation
r-value <0.48 is non-significant

Correlation between the percentage of improvement and Age in group Π:

As illustrated in table (10), the correlation coefficient value between the percentage of improvement of FEV1, MVV and age were 0.01 and 0.36 respectively, which means non-significant positive correlation as p-value >0.05. While the correlation coefficient value between the percentage of improvement of VC and age was -0.19, that means non-significant negative correlation as p-value >0.05.

Table (10): Correlation between the percentage of improvement of all variables and Age in group Π.

Relative variable	r-value	P-value	Level of significance
FEV1 & age	0.01	p-value >0.05	r-value <0.48
VC & age	-0.19	p-value >0.05	r-value <0.48
MVV & age	0.36	p-value >0.05	r-value <0.48

r-value: Correlation coefficient value. r-value <0.48 is non-significant FEV1: forced expiratory volume in 1st second
VC:vital capacity MVV:maximum voluntary ventilation

4. Discussion

This study measured the effect of different types of arm exercises on the ventilatory functions in the elderly subjects. Arm exercises include two types; closed kinematic chain "supported" arm exercise like using arm ergometer and pen kinematic chain "unsupported" arm exercise using free weights as a modern basis

Thirty healthy elderly subjects (13 female and 17 male) enrolled in this study. The evaluation of ventilatory functions including VC, FEV1 & MVV were recorded before the training program & repeated at the end of the 8th week of training program for each subject. The selected measurements used in this study are considered as indicators for the integrity of respiratory system, elastic recoil of the lung and airway resistance as well as strength and endurance of the respiratory muscles (Talavera *et al.,* 1998).

All the participants were assigned into two studied groups. The first group "SAE" group has performed supported arm exercise using arm ergometer at 60% of THR. While the second group "UAE" group has performed unsupported arm exercise using wooden bars with 60% of the weight at THR weights (Mcardle *et al.,* 2001; Mckeough *et al.*, 2003a).

Analysis of the result of the present study indicated that supported arm exercise in the form of arm ergometer can increase VC. This improvement of VC may be due to improvement of the mechanical behaviour of thoracopulmonary system. The arm exercises result in mobility of rib cage in addition to change and improvement of posture of head, neck and shoulders thus increasing chest wall compliance (Plekonen *et al.,* 2003)

Concerning the dynamic lung volumes and flow rates recorded in this study; forced expiratory volume at first second and maximal voluntary ventilation showed significant improvement after closed kinematic chain training "supported arm exercise". The increment of MVV may be referred to the improvement in the respiratory muscles strength and endurance as well as improved co-ordination. In supported arm exercise, the arms are supported thus increasing the ventilatory contribution of the inspiratory muscles of the neck and rib cage decreasing the contribution by the diaphragm thus decreasing the ventilatory demand as well as oxygen demands allowing longer time for exercise (Martinez *et al.,* 1993).

Since the subjects in the present study didn't suffer from any respiratory illness except the normal physiological changes of aging. The resultant improvement in FEV1 may be referred to increased respiratory muscle strength and better coordinated use of all musculature in expelling the air with greater response to closed kinematic chain in supported arm exercise indicating better response to this type.

With regard to the open kinematic chain "UAE" group by using wooden bars the results demonstrate increased VC as well. This improvement of VC may be due to increase in thoracic expansion during the exercise as when the arms are elevated the chest is placed in an inflated position in addition to improvement of thoracic mobility. When the arms are elevated above 90 degrees, some muscles as pectoralis will expand the rib cage by passive stretching, whereas others, such as serratus anterior will do so by active contraction (Mckeough *et al.,* 2003b).

The dynamic lung volumes including FEV1 and MVV have showed a significant improvement after unsupported arm exercise. The improvement of MVV may be referred to increase in inspiratory and expiratory muscles power and endurance capabilities as well as improved compliance of the lung-thorax system and so the ability of respiratory muscles to contract and relax rapidly and deeply is enhanced (Plekonen *et al.,* 2003).

The FEV1 is increased as a consequence of enhancement of strength and endurance of respiratory muscles, in particular the diaphragm, which is reflected on the increase in the lung volumes and leads consequently to increase in the flow air out of the lung.

Although the statistical analysis between the pre and post study values in both groups showed significant improvement in most of variables, on comparing the result of both groups regarding the percentage of improvement one can notice some difference between both groups.

In the open kinematic chain "UAE" group, the performance of such training may displace the respiratory functions of the scapular belt muscles to a more antigravity function, thus increasing the work done by the diaphragm and the ventilatory demand. In addition, exercises with the arms elevated and unsupported keeps the arm muscles under high tension and decrease the arm blood flow due to the increase in adrenergic vasomotor tone. This response seems to be more pronounced in small muscle groups, thus causing early muscle fatigue and shortening the length of time for any arm activity. These in turn explain the more improvement in the respiratory muscles strength and endurance and improved coordination in "SAE" group (Velloso *et al.,* 2003).

However, in closed kinematic chain training "SAE" group, the arms are supported thus decreasing load on muscles of shoulders and upper torso and so increasing their contribution to the ventilatory demand. These explain increased respiratory muscles strength and endurance and improved coordination in the "SAE" group.

In a comparison between these two modes , Electromyographic activities of infraspinatus, posterior deltoid, anterior deltoid, pectoralis major, and supraspinatus muscles are reported to be reduced during supported than unsupported training of shoulder joint. This reduction was probably due to an unloading effect as supporting the limb helps to diminish the weight of the arm, thereby decreasing the demand on the shoulder musculature so decreasing oxygen consumption and improving muscle efficiency (Wise *et al.,* 2004).

It is important to understand possible CNS control strategies behind movements with various types of peripheral feedback and under a variety of conditions. The addition of an external load in a closed or open chain is typical examples. The shoulder including scapular movement together with the knee joint reflect the change in mechanics with the shift from open to closed kinematic chain including forces (Dillman *et al.,* 1994).

It has been reported that, to establish equilibrium at the glenohumeral joint at any position, a minimum of three forces is required: (1) the weight of the arm, (2) the working musculature, and (3) the resultant of the former forces. Thus, by decreasing one component, for example, the weight of the arm, the other two components must decrease to maintain equilibrium that occurred during "SAE, in which part of the arm weight was carried or supported by the handles of the arm ergometer (Apreleva *et al.,* 2000).

In the present study, during closed kinematic chain "SAE", the subject performs forward elevation of the arms from 70-75 degrees to about 90-100 degrees as the fulcrum is positioned at shoulder level. While during open kinematic chain "UAE", the subject perform flexion from 0-10 degrees to about 130-140 degrees. So the difference between both groups can be explained on biomechanical basis as during each exercise several muscles are working with different levels of activity according to degree of arm elevation.

Studying the electrical activities of shoulder girdle and trunk muscles during varying level of shoulder elevation showed difference in activities. It has been found that EMG activity of deltoid (anterior, middle, posterior) increases throughout elevation to about 100 degrees with the greatest amplitude occurring for anterior deltoid and then plateaus. The same occurs for supraspinatus, but its activity reaches peak at 80-100 degrees and then decreases. The pectoralis major assists anterior deltoid in elevation with the calvicular portion being the more active. While for trapezius muscle; the upper fibers in addition to serratus anterior are active throughout arm elevation with gradual increasing activity, reaching peak at maximal elevation. Secondly; little activity was observed in the lower trapezius until after 90 degrees of elevation, with sharp rise in activity thereafter, reaching peak at latter stages. (Gray *et al.,* 1989; Diver, 2000)

From the above, it is clear that the activity of trapezius (upper, middle, lower), serratus anterior, rhomboids, subscapularis, and teres minor muscles were higher in unsupported than supported arm exercise while for deltoid and supraspinatus muscles, the activity was the same in both modes of exercise.

On studying FEV1, which reflect a volume-time relationship measured from the FVC, depending on both diaphragmatic force and upper airway flow showed increase in response to open kinematic chain in the "SAE" group by about 55.39% while in the "UAE" group it increased by about 30.53% as a response to closed kinematic chain training.

In agreement with other previous studies, Dolmage *et al.*(1993) have reported that oxygen consumption, carbon dioxide production and minute ventilation were significantly greater during unsupported arm elevation than during supported arm elevation by a customized sling. These changes are attributed to the increase in metabolic activity of the active arm muscles that maintain this position.

One of the recent studies that support our results was applied by Mckeough *et al.*(2003b) who concluded that, unsupported arm position affect static lung function and altered lung mechanics in chronic obstructive lung pulmonary disease and healthy subject. Functional residual capacity is (FRC) significantly increased while inspiratory capacity (IC) and total lung capacity (TLC) are significantly decreased with arms above 90 degrees shoulder flexion when compared with both arms below 90 degrees shoulder flexion. With the arms above 90 degree, the chest wall is already in an inspiratory position so that relatively less chest wall expansion. In addition the stretch on latissimus dorsi muscle causes it to act like a tight band around the rib cage restricting complete expansion.

These findings and explanation was confirmed also by Mckeough *et al.*(2003a), who found that peak Vo2 and peak VE were significantly lower for the unsupported arm exercise test than for both leg exercise and the supported arm exercise tests. Mechanical constraint to ventilation during unsupported arm exercise test would have resulted from restriction to chest wall expansion when arms were positioned above head in addition the chest wall muscles act to position and stabilize the arms and torso.

On the other hand, the results of this study contradict the early study of Couser *et al.*(1992) who investigated the respiratory response to unsupported arm elevation for 2 minutes and down at the sides. They showed no significant change of FEV1 and FVC. The difference of the results between the present study and that study may be due to different protocol they studied as they applied a test to specific position for two minutes and wide age group ranged from 22 to 72 year.

Some of the findings of Lake *et al.*(1990), and Couser *et al.*(1993) , were contradicted with the results of the current study as they found that the VC decreases significantly during arm elevation with no change in the pulmonary functions including FEV1,. This may be due to different sample characteristics & differences in the exercise protocol concerning the weight used and duration of the training.

In conclusion it was recommended that close kinematic chain mode of exercise "SAE" is the exercise of choose for training elderly with any musculoskeletal or pulmonary problems considering efficiency and safety.

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