Original Article

Static standing posture and pulmonary function in moderate-persistent asthmatics following aerobic and diaphragmatic breathing training

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ABSTRACT

Objectives: The present study evaluated and compared the effects of aerobic and diaphragmatic breathing training on static standing posture and its relation to effort-dependant pulmonary function in moderate-persistent asthmatics.

Methodology: Sixty-six inactive, moderate-persistent asthmatics were matched and randomly assigned to an eight-week, three times weekly aerobic training (At), diaphragmatic breathing training (Db) or as part of a non-exercise control (No) group. At walked and jogged at 60%HR_{max}. Db performed diaphragmatic breathing combined with inspiratory resistive breathing at varying inspiration, expiration ratios while control group received no structured exercise.

Results: Following At and Db, significant improvement were found in FVC (At:p=0.001;Db:p=0.000), FEV_1 (At:p=0.000;Db:p=0.000), PEF (At:p=0.012; Db: p=0.000) and IVC (At:p=0.006;Db:p=0.000). Only At improved MVV (p=0.000). At and Db did not significantly change the position of their knee (At:p=0.296;Db:p=0.247), hip (At:p=0.236;Db:p=0.383), shoulder (At:p=0.289;Db:p=0.509) and anterior auditory meatus (At:p=0.207;Db:p=0.198).

Conclusion: Both At and Db improved pulmonary function in asthmatics despite no changes in posture suggesting that both modes may be a useful adjuvant therapy in moderate-persistent asthmatics for optimized asthma management.

KEY WORDS: Body position; Breathing training, Endurance training; Spirometry.

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INTRODUCTION

Excessive use of accessory respiratory muscles and the mouth breathing observed with asthma may lead to the development of alterations in posture.[1] Asthmatics tend to have a typical 'tight' posture characterised by a forward slumping of the upper back (thoracic kyphosis) and flattening of the sacrolumbar area ("flat-back" posture), adversely impacting pulmonary function. Postural deviations can lead to overuse of accessory respiratory muscles and underuse of the diaphragm, decreased endurance and strength, mechanical shortening or imbalance of the respiratory muscles.[2] Loss of midcervical lordosis associated with asthma increases the weight and tension exerted at the cervical-thoracic junction leading to abduction of the scapulae, shortening the

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pectoralis major and minor, serratus anterior, latissimus dorsi, subscapularis and teres major, lengthening the rhomboids and lowering the trapezius, all of which affect normal breathing.[3]

Asthmatics typically suffer from thoracoabdominal dyssynchrony as a result of the reduced activity of the respiratory muscles induced by poor posture impeding the actions of the diaphragm and creating further imbalances in the respiratory muscles worsened by the dysfunction of lung mechanics.[4]

No definitive exercise regime has been identified for the effective management of asthma and specifically for improving asthma-posture and expectantly pulmonary function. When the asthma-posture is investigated, studies focus on the effect of sleeping position on nocturnal asthma[5], despite persistent poor posture and pulmonary function in asthmatics during waking hours. As such, the purpose of this study was to compare the effects of aerobic and diaphragmatic breathing training on static standing posture and its concomitant effort-dependent pulmonary function in inactive moderate-persistent asthmatics.

METHODOLOGY

Subjects and Protocol: Sixty-six inactive Caucasian subjects were matched, by age and gender, and randomly assigned to an aerobic training (At) (mean age: 21.95±3.87) group, diaphragmatic breathing training (Db) (mean age: 21.93±3.95) group or non-exercise control (No) (mean age: 21.90±3.89) group after completing a written informed consent form. The study was approved by the Institutional Review Boards at the University of Johannesburg.

Subjects were inactive, weight stable six months prior to the commencement of the study, non-smokers, had moderate-persistent asthma, no influenza-like or respiratory infection symptoms two weeks prior to the evaluations, exhibited daily asthmatic symptoms, exhibited nocturnal asthmatic symptoms more than one night weekly and had peak flow variability of more than 30%.

Anthropometric Measurements: Anthropometric measurements were taken at baseline for descriptive purposes. Body mass was measured in kilogrammes (kg) on a calibrated digital medical scale (Seca 843, Switzerland) with the subjects wearing minimal clothing. Stature was measured in centimeters (cm) using a standard wall-mounted stadiometer without shoes.

Pulmonary Function Measurements: Effort-dependent forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), peak expiratory flow (PEF), maximal voluntary ventilation (MVV) and inspiratory vital capacity (IVC) were evaluated at pre- and post-training using a calibrated Cosmed® FX System spirometer (Pavona di Albano, Rome). FVC, FEV_1 and PEF were measured during the FVC maneuver requiring each subject to expire as hard and as fast as possible, then completing the cycle by inspiring as hard and rapidly as possible. MVV was measured following 12 seconds of forceful maximal inspirations and expirations while IVC was measured during a slow forceful and maximal inspiration followed by a forceful maximal expiration. Each test was performed at least three times, without differing by more than 5% or 100 millilitres. The largest value obtained from the three executions was used in the final analysis.

Posture Measurement: Posture was analysed using the Dartfish 3.0 Advanced Video Analysis Software (Atlanta, Georgia, United States of America) with subjects wearing minimal clothing. The postural analysis was performed in a static, standing position with hands at the subjects' sides and the bare feet about 20-30cm apart in a typical and comfortable stance. The standard procedures of Kendall *et al*.[6] were followed to assess posture in the lateral view.

Periodised Exercise Programmes: Subjects performed a five-minute warm-up consisting of walking at <100 beats per minute (bpm) and concluded with stretching and a five-minute cool-down consisting of walking at <100bpm. The At group walked and jogged for 30 minutes at 60% of their individual age-predicted maximum heart rate (HR_{max}). Intensity was readjusted at week four with a 5% increase in heart rate.[7]

The Db group performed diaphragmatic breathing combined with inspiratory resistive breathing in the semi-recumbent position. Subjects inspired and expired maximally through a 10 by 1cm tube principally using abdominal motion, while reducing upper rib cage motion. One hand of the subject stabilised a 2.5kg (weeks 1-4) or a 5kg weight (weeks 5-8) onto the abdominal cavity. Subjects completed three sets of 5-10 repetitions using one second of inspiration and two seconds of expiration (1:2 inspiration to expiration ratio), three sets of 10-15 repetitions of a 2:4 inspiration to expiration ratio and three sets of 15-20 repetitions of a 3:6 inspiration to expiration ratio.[7,8] The control group followed no structured exercise programme.

Statistical Analysis: Data was analysed using the Statistical Package of Social Sciences (SPSS) Version 14 (Chicago, IL). Statistical analysis consisted of basic statistics. Levene's Test was applied to the data at baseline to determine homo-/heterogeneity. A two-way analysis of variance (ANOVA) for repeated measures was performed on the data. Scheffe and Dunnett T3 tests were used to determine which of the programmes was the most effective. Pearson's Correlation coefficient was used to assess relationships between posture and pulmonary function variables. Alpha levels were set at $p < 0.05$ for establishing statistical significance.

RESULTS

When the groups were compared, no significant differences ($p>0.05$) were found at baseline for age (p=0.901), stature (p=0.832), body mass (p=0.882), FVC (p=0.544), FEV_1 (p=0.609), PEF (p=0.999), IVC (p=0.765), MVV (p=0.900) and position of the knee joint (p=0.112), hip joint (p=0.796), shoulder joint (p=0.699) and anterior auditory meatus (p=0.091). FVC significantly ($p <0.05$) improved following At (p=0.001) and Db (p=0.000) (Table-I). Significant improvements were found in FEV_1 (At:p=0.000; Db:p=0.000), PEF (At:p=0.012; Db:p=0.000) and IVC (At:p=0.006;Db:p=0.000). However, only At improved MVV (p=0.000). *Post-hoc* analysis showed that At and Db were equally effective at improving FVC (p=0.504), FEV_1 (p=0.582), PEF (p=0.960) and IVC (p=0.084).

At and Db did not significantly change the position of their knee joint (p=0.296 and p=0.247, respectively), hip joint (At:p=0.236:Db:p=0.383), shoulder joint (At:p=0.289:Db:p=0.509) and anterior auditory meatus (At:p=0.207;Db:p=0.198). No significant changes were found in any of the measured pulmonary function and static posture variables in the No group.

DISCUSSION

Eight weeks of aerobic and diaphragmatic breathing training significantly improved the effort-dependent pulmonary function variables despite no changes in the static standing posture of either group. Exercise training may induce changes in posture in relation to disease severity since severe asthma has a decidedly more pronounced asthma-posture.[2] Further, individuals with a reduced pulmonary function often have greater upper body limitations[9], therefore requiring specific upper-body exercises and not lower-body exercises as used in this study.

Table-I: Pulmonary function and static standing posture following aerobic and diaphragmatic breathing training.

	No (n =22)		*At (n = 22)*		*Db (n = 22)*	
	Pre-Test(±SD)	*Post-Test(±SD)*	*Pre-Test(±SD)*	*Post-Test(±SD)*	*Pre-Test(±SD)*	*Post-Test(±SD)*
Pulmonary Function Variables						
Forced vital capacity (FVC) (ℓ)	2.82(±0.57)	2.93(±0.57)	2.77(±0.48)	3.11(±0.71)*	3.01(±0.58)	3.52(±0.74)*
Forced expiratory volume in one second (FEV_1) (ℓ)	2.62(±0.53)	2.70(±0.5)	2.72(±0.53)	2.97(±0.65)*	2.85(±0.57)	3.22(±0.63)*
Peak expiratory flow (PEF) (ℓ)	7.09(±1.97)	7.04(±1.65)	7.15(±1.45)	7.57(±1.47)*	7.10(±1.57)	7.68(±1.26)*
Inspiratory vital capacity (IVC) (ℓ)	3.13(±0.76)	3.02(±0.64)	3.03(±0.71)	3.17(±0.68)*	3.24(±0.86)	3.67(±0.73)*
Maximal voluntary ventilation (MVV) ($ℓ.min^{-1}$)	106.41(±37.85)	106.94(±37.32)	103.65(±27.86)	128.97(±27.56)*	107.43(±34.65)	109.62(±38.91)
Static Standing Posture Variables						
Position of the Knee Joint (°)	1.99 (±1.22)	2.39 (±1.27)	2.25 (±1.39)	2.60 (±0.96)	2.99 (±1.45)	2.68 (±1.64)
Position of the Hip Joint (°)	2.28 (±1.76)	2.18 (±1.64)	2.67 (±2.24)	2.03 (±2.09)	2.38 (±1.89)	2.04 (±1.96)
Position of the Shoulder Joint (°)	12.12 (±6.56)	11.80 (±7.52)	10.55 (±7.81)	11.93 (±7.55)	12.44 (±6.92)	11.80 (±7.29)
Position of the Anterior Auditory Meatus (°)	2.51 (±1.30)	2.74 (±1.20)	2.77 (±1.18)	3.15 (±1.09)	3.37 (±1.42)	3.10 (±1.49)
Position of the Anterior Superior Iliac Spines in the Transverse Plane (°)	2.43 (±1.41)	2.60 (±1.51)	2.87 (±2.03)	2.13 (±1.78)	2.24 (±2.13)	2.29 (±2.22)
Position of the Shoulders in the Transverse Plane (°)	2.77 (±1.06)	2.61 (±1.07)	3.17 (±2.11)	2.69 (±1.84)	2.44 (±1.52)	1.98 (±1.58)
Position of the Shoulders in the Transverse Plane (°)	3.56 (±3.27)	5.45 (±2.92)	2.83 (±3.64)	4.03 (±4.10)	2.60 (±4.06)	2.76 (±3.68)
Position of the Scapulae in the Transverse Plane (°)	4.51 (±2.52)	3.35 (±2.71)	4.95 (±3.36)	3.95 (±3.77)	4.03 (±3.08)	2.41 (±2.42)

*: Statistically significant ($p < 0.05$)

The detrimental effects of the postural deviations on pulmonary function in this study were likely nullified by the improvements in pulmonary function following At and Db. The study of Fluge *et al*.[10] corroborated the improvements in FVC following Db in asthmatics. This improvement may have been as a result of an increased inspiratory force, possibly occurring from lengthened intercostals and accessory muscles and a trained diaphragm being elongated and placed at a mechanical advantage. The improvement in FVC in this study is of clinical importance in that it could signify a diminution in small airway obstruction.[11]

The results of Fluge *et al*.[10] support the present study's findings in that both studies demonstrated improvements in FEV_1 following Db in asthmatics. Since FEV_1 provides a clear idea of the severity and change of pulmonary disease, including asthma, improvements in FEV_1 demonstrates the effectiveness of At and Db in avoiding further and rapid decline in pulmonary function.

The improvements in PEF could signify a decrease in the obstruction of the large airways and thus an increased bronchodilation[12] due to an increased number of motor unit recruitment during forced inspiration and expiration, increasing power and in effect the rate of muscle shortening.[13]

The improvement in MVV following At may suggest the need for an aerobic-type exercise being required to improve MVV due to the MVV manoeuvre requiring a simulated "heavy-breathing" effect.[14] Notably, the improvements in MVV following At indicate a reduction in airflow obstruction, airway hyperresponsiveness and fatigue during activities of daily living.[15]

The improvements in IVC following Db and At are noteworthy since IVC is the maximum amount of air that can be inhaled from forced maximal expiration and as such improvements in this spirometry value are essential to asthmatics.

CONCLUSIONS

Our results show that eight weeks of aerobic and diaphragmatic breathing training improved effort-dependent pulmonary function variables without clinical complications and that the improvements were not related to concomitant improvements in static standing posture. Research examining the effect of additional modes of exercise training on static standing posture is needed to confirm these findings and to assess how posture in other asthmatics (i.e. severe asthmatics) respond to different modes of exercise therapy.

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