Respiratory Physiology & Neurobiology 227 (2016) 27–33

Contents lists available at ScienceDirect

Respiratory Physiology & Neurobiology

journal homepage: www.elsevier.com/locate/resphysiol

Acute effects of different inspiratory efforts on ventilatory pattern and chest wall compartmental distribution in elderly women

Helga Muniz de Souza[a], Taciano Rocha[a,*], Shirley Lima Campos[a], Daniella Cunha Brandão[a], James B. Fink[b], Andrea Aliverti[c], Armele Dornelas de Andrade[a,**]

[a] Department of Physical Therapy, Universidade Federal de Pernambuco—UFPE, Recife, Brazil
[b] Department of Respiratory Therapy Lewis School of Nursing and Health Professions, Georgia State University, Atlanta, GA, USA
[c] Dipartimento di Elettronica, Informazione e Bioingegneria Politecnico di Milano, Milan, Italy

A R T I C L E I N F O

Article history:
Received 2 April 2015
Received in revised form
18 December 2015
Accepted 11 February 2016
Available online 18 February 2016

Keywords:
Breathing pattern
Opto-electronic plethysmography
Aging
Respiratory mechanics

A B S T R A C T

It is not completely described how aging affect ventilatory kinematics and what are the mechanisms adopted by the elderly population to overcome these structural modifications. Given this, the aim was to evaluate the acute effects of different inspiratory efforts on ventilatory pattern and chest wall compartmental distribution in elderly women. Variables assessed included: tidal volume (Vt), total chest wall volume (Vcw), pulmonary rib cage (Vrcp%), abdominal rib cage (Vrca%) and abdominal compartment (Vab%) relative contributions to tidal volume. These variables were assessed during quiet breathing, maximal inspiratory pressure maneuver (MIP), and moderate inspiratory resistance (MIR; i.e., 40% of MIP). 22 young women (age: 23.9 ± 2.5 years) and 22 elderly women (age: 68.2 ± 5.0 years) participated to this study. It was possible to show that during quiet breathing, Vab% was predominant in elderly ($p < 0.001$), in young, however, Vab% was similar to Vrcp% ($p = 0.095$). During MIR, Vrcp% was predominant in young ($p < 0.001$) and comparable to Vab% in elderly ($p = 0.249$). When MIP was imposed, both groups presented a predominance of Vrcp%. In conclusion, there are differences in abdominal kinematics between young and elderly women during different inspiratory efforts. In elderly, during moderate inspiratory resistance, the pattern is beneficial, deep, and slow. Although, during maximal inspiratory resistance, the ventilatory pattern seems to predict imminent muscle fatigue.

1. Introduction

With aging respiratory muscles performance decreases due to sarcopenia and changes in muscle fibers (Lalley, 2013) decreasing maximal strength development (Williams et al., 2002). Additionally, as a consequence of the calcification of costovertebral cartilages and joints, intercostal spaces and thoracic compliance are reduced (Rossi et al., 2008).

All these changes might affect ventilatory kinematics; however, the adaptive mechanisms adopted to overcome these structural changes in the elderly population are still not completely understood. Itís mandatory to differentiate the physiological changes induced by age from pathological changes.

The chest wall kinematics evaluation using opto-electronic plethysmography (OEP) has emerged as a useful method to evaluate the changes generated in different situations (Paisani et al., 2013; Wilkens et al., 2010). The OEP records each respiratory cycle in real time making it possible to evaluate the ventilatory pattern and the chest wall volume with its compartmental distribution (pulmonary rib cage, abdominal rib cage and abdomen) (Parreira et al., 2012). However, studies that observed the effects of senescence over chest wall kinematics using the OEP (Britto et al., 2009) are still scarce. Moreover, the changes generated in different inspiratory efforts have not been evaluated yet.

We hypothesized that elderly develop different chest wall kinematic and ventilatory patterns, compared to young, when they are submitted to different inspiratory loads. In the elderly population, this difference would be more noticeable in the abdominal volume contribution since, due to senile sarcopenia, the decrease in respiratory muscle strength would impair the capacity to overcome upper chest wall restrictive forces. Considering that after

* Corresponding author. Fax: +55 81 21268491.
** Corresponding author.
E-mail addresses: helgamuniz@yahoo.com.br (H. Muniz de Souza), taciano_rocha@hotmail.com (T. Rocha), shirleylcampos@uol.com.br (S.L. Campos), daniellacunha@hotmail.com (D.C. Brandão), fink.jim@gmail.com (J.B. Fink), andrea.aliverti@polimi.it (A. Aliverti), armeledornelas@hotmail.com (A.D. de Andrade).

http://dx.doi.org/10.1016/j.resp.2016.02.004
1569-9048/

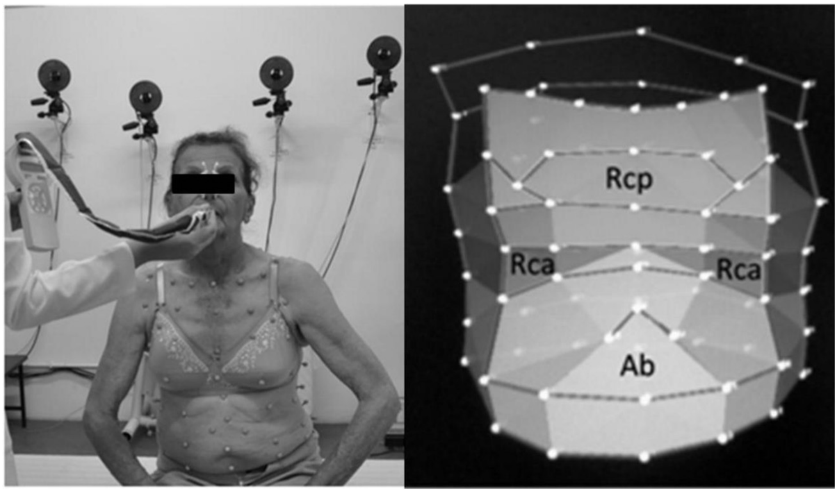

Fig. 1. Maximal inspiratory pressure assessment during opto-electronic plethysmography evaluation (left) and three-dimensional model of rib cage compartments. Pulmonary rib cage (Rcp), abdominal rib cage (Rca), and abdomen (Ab) (right).

menopause women have lower levels of estrogen and that this intensifies the senile sarcopenia (Kenny et al., 2003), the aging related changes in chest wall kinematics might be more evident in this gender. Given this, we decided to test our hypothesis in a group formed exclusively by women. Therefore, the aim was to evaluate the acute effects of different inspiratory efforts on ventilatory pattern and chest wall compartmental distribution in elderly women.

2. Methods

2.1. Study design

This was a cross-sectional study approved by the Research Ethics Committee of the Center for Health Sciences at the Federal University of Pernambuco (CEP/CCS/UFPE No 457/11). The research was conducted in the Laboratory of Cardiopulmonary Physiotherapy, Department Physiotherapy, Federal University of Pernambuco (UFPE) from August to December 2014. All volunteers signed a free and informed consent form.

2.2. Participants

The sample was formed by 22 elderly women and 22 young women. A pilot study was made with five individuals in each group to calculate the sample. A total of 34 participants would provide 95% power and alpha level of 0.05 to detect difference between groups in the pulmonary rib cage contribution. The following inclusion criteria were adopted: age between 20 to 80 years; to be able to walk without assistance; to have cognitive integrity in the elderly group, assessed by the Mini-Mental State Examination (MMSE). The exclusion criteria were: contraindication or difficulty to perform the evaluation procedures; respiratory muscle strength lower than 70% of the predict (Neder et al., 1999); smoking; hemodynamic instability; neuromuscular degenerative diseases; pulmonary comorbidities; heart disease and users of medications that change the bone metabolism or the muscle strength.

2.3. Data collection

All volunteers were initially submitted to an anthropometric, clinical, and demographic evaluation. The level of physical activity was evaluated through a self-reported instrument adapted to the Brazilian population, the Profile of Human Activity (PHA) (Souza et al., 2006). This instrument quantifies the level of physical activity through the adjusted activity score (AAS) sorting the individual into three categories: inactive (AAS < 53), moderately active (53 ≤ AAS ≤ 74), and active (AAS > 74). Afterwards, the volunteers were instructed to breathe with a moderate inspiratory resistance, to ensure the correct performance of the technique several days before the measurements. The evaluation was conducted in two stages. In the first, we assessed pulmonary function and maximal respiratory pressures. In the second, ventilatory pattern and chest wall compartmental distribution were assessed by the OEP.

2.3.1. Pulmonary function tests

Tests were performed using a portable spirometer (Micro Medical, Microloop, MK8, England). The highest value in forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), forced expiratory flow 25–75% (FEF25–75%), and the FEV1/FVC ratio was used, after three acceptable maneuvers. Reference values for Brazilian adult population were considered (Pereira et al., 2007).

2.3.2. Maximal respiratory pressures

The measurement of the maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) was performed using a digital manometer (MVD300, Globalmed, Brazil) from residual volume and total lung capacity, respectively (Neder et al., 1999). At least five measurements were carried out until three acceptable and reproducible measurements were obtained, i.e., without air leakage and with less than 10% difference among them, with the highest value obtained being registered (Evans and Whitelaw, 2009).

2.3.3. Breathing with moderate inspiratory resistance (MIR)

The moderate inspiratory resistance was performed with an inspiratory muscle training device, the Threshold®IMT (Respironics, NJ, USA), commonly used to train healthy people (Downey et al., 2007; Enright and Unnithan, 2011) as well as others populations (Gosselink et al., 2011; Plentz et al., 2012). The volunteers performed the MIR in a seated position and were oriented to breathe quietly and keep a regular respiratory rate prior to the test. During the evaluation, there was no incentive or verbal instructions to the volunteers. The device was coupled to the volunteer through a mouthpiece that provides a linear resistive load (De Andrade et al., 2005) established at 40% of the previously obtained MIP. Nasal clips were also used during MIR. The duration of the MIR session was three minutes (Souza et al., 2014). During expiration, there was no resistance and no respiratory rate was imposed.