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Breathing asymmetry in an adult idiopathic scoliosis patient assessed by optoelectronic plethysmography. A case report

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1. Introduction

Idiopathic scoliosis is the most common spinal deformity that directly affects the chest (Koumbourlis, 2006). Scoliosis-induced deformities reduce rib cage compliance which may influence breathing kinematics (Romberg et al., 2020). Scoliosis patients with a Cobb angle from 10° to 70° are considered having no functional respiratory dysfunction, according to respiratory volumes measured by conventional spirometry (Koumbourlis, 2006). However, this technique does not consider the mechanics behind gas flow generation. Optoelectronic plethysmography (OEP) is a non-invasive technique that records chest wall motion to assess both the respiratory volumes and the contribution of each part of the trunk to the total chest wall motion producing airflow (Cala et al., 1996). The chest wall is commonly divided into three compartments: the pulmonary rib cage (RCP), the abdominal rib cage (RCA) and the abdomen (ABD)(Aliverti et al., 2001). As suggested by Aliverti et al., OEP can differentiate between left and right chest wall expansion, which promised to be useful for assessing asymmetries (Aliverti et al., 2001). However, to our knowledge, this technique has never been used on idiopathic scoliosis patients.

The aim of this case report is to assess the relevance of OEP for measuring and understanding asymmetrical chest wall motions in an adult mild idiopathic scoliosis (Cobb angle <30°) before and after osteopathic manipulative treatment (OMT) and breathing exercises.

2. Methods

2.1 Case description

The patient was a 72-year-old woman (60.9 kg, 170 cm, 21.07 kg/m²), a retired human resources manager. Her physical activity is limited to active walking three times per week (about 9 km per week). The patient has been an active smoker for more than 50 years and currently smoking approximately 15 cigarettes per day.

The patient was diagnosed with adolescent idiopathic scoliosis in the 1960's. In the frontal plane, the patient has a lumbar deformity with left concavity, apex at L2 and Cobb angle of 19°. The thoracic spine showed a compensatory right curve with an apex at T9 and a Cobb angle of 19°.

2.2 Optoelectronic Plethysmography (OEP)

OEP is a non-invasive technique using 89 passive reflective markers placed on the patient's trunk. The patient was assessed before and after three sessions of OMT and breathing exercises. Each OEP measurement included three repetitions of the following tasks: one minute of quiet breathing followed by three vital capacity maneuvers. The 3D markers' coordinates were recorded with eight motion capture MX10 cameras (Vicon© Motion Systems Ltd, UK, sampling frequency 50 Hz). Volume variations over time of the 6 chest wall compartments were calculated using the Gauss theorem. Vital capacities were normalized using respiratory cycle percentage. The asymmetry score (AS) estimates the percentage of

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left and right contribution to the total motion of the compartment. AS was calculated for each compartment using the following equation:

$$AS_{RCP} = \left(\frac{V_{R,RCP}}{V_{RCP}} \times 100\right) - 50$$

where $V_{R,RCP}$ corresponds to the volume of the right side of the pulmonary rib cage, and V_{RCP} corresponds to the total volume of the pulmonary rib cage. Means and standard deviations over 9 vital capacities were calculated for each compartment's volume and AS. The sum of the compartmental volume equals the total chest wall volume, and the sum of the left and right part of each compartment is 100%.

3. Results and discussion

At D0, the mean AS_{RCP} reached -4 ± 1.61% at end-inspiratory volume, indicating a larger range of motion of the left side of the RCP. At D35, the mean AS_{RCP} is linear and centered around 0 ± 0.67% (fig.1). At D0, the mean AS_{RCA} reached +10% ± 4.25% at end-inspiratory volume indicating a larger range of motion of the right side of the RCA. At D35, the mean AS_{RCA} is linear and centered around 0 ± 1.91%. The ABD compartment did not present any significant asymmetrical motion from D0 to D35.

The patient described in this case report presented an asymmetrical motion during the respiratory cycle. The left RCP had a larger range of motion, whereas the RCA range of motion was larger on the right side which is consistent with the shape of the scoliosis deformity: the patient has lumbar scoliosis with left concavity involving the RCA compartment, and a thoracic compensatory right curvature involves the RCP compartment. We hypothesize that RCP and RCA each compensate the kinematics of the other compartment to optimize volume mobilization during breathing in scoliosis. The intra- and inter-rater variabilities is known to be low for the total chest wall volume (Vieira et al., 2013). Further studies are needed to assess this potential bias for compartmental analysis.

4. Conclusions

OEP was an effective method for assessing asymmetrical breathing patterns of a scoliosis patient. Spinal curvature and chest wall kinematics appear to be related. Our findings suggest that, in scoliosis, the chest wall compartments on the curvature side have impaired expansion during breathing. The kinematics of the upper and lower thorax appear to compensate each other with respect to the spinal deformity.

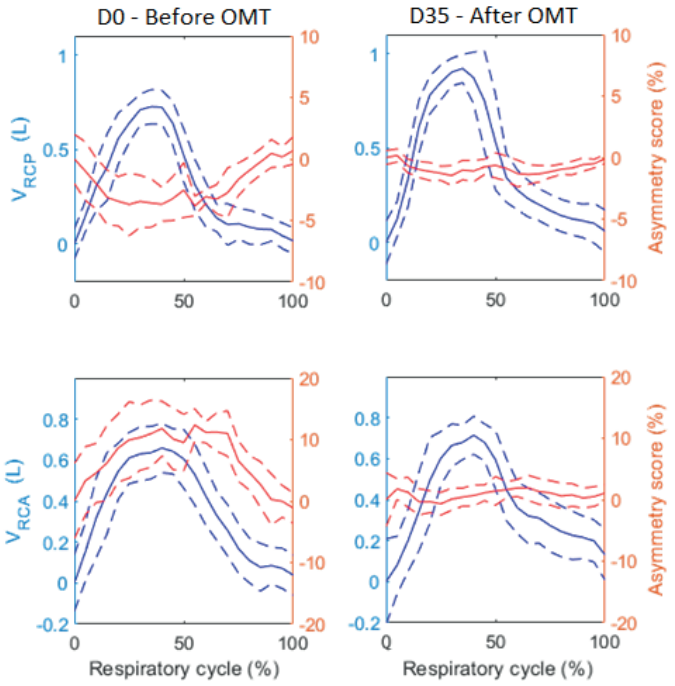

Figure 1. Volumes and asymmetry scores of RCP and RCA compartments as a function of the percentage of the respiratory cycle during vital capacity maneuvers, at day 0 and day 35 after 3 OMT sessions. Solid blue lines (dashed blue lines) represent the mean volume (±1 SD) of each compartment. Solid red lines (dashed red lines) represent the mean AS (±1 SD) of each compartment.

Conflict of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Contributor Roles

Concept/Idea/research design: L. Gaillard, D. Riquet, N. Houel, L. Stubbe; Writing: L. Gaillard, D. Riquet, N. Houel; Data collection: L. Gaillard, D. Riquet; Data analysis: L. Gaillard, N. Houel; Project management: N. Houel, L. Stubbe; Providing participants: L. Stubbe; Consultation (including review of manuscript before submitting): L. Gaillard, D. Riquet, N. Houel, L. Stubbe, T. Marin.

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