Thoracic Spinal Deformities Affects Cardiopulmonary Function in Patients with Scoliosis

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Disclosure

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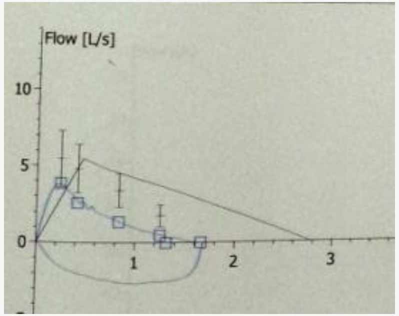
Background

Scoliosis

- Complex 3-D deformity of spine
- Associated with rib anomaly
- Thorax deformity

Restrictive pulmonary dysfunction

- Influence on pulmonary growth
- Limited motion of thoracic cage



Newton, P. O. et al. J Bone Joint Surg Am, 87(9): 1937-46, 2005.
Campbell, et al. JBJS, 2003;85-A:399-408.

Background

Previous studies revealed lower exercise capacity in scoliosis patients than normal control

Czaprowski et al. 70 patients with AIS V.S. 20 normal subjects

Results The maximal oxygen intake (l/min) and PWC170 (W; W/kg) values were considerably lower in girls with scoliosis of 25°–40° than in the control group. No signifi-

Sperandio et al. 29 patients with AIS V.S. 20 normal adolescents

RESULTS: Adolescent idiopathic scoliosis patients showed significant lower values of ISWD, VO_2, and ventilation at the end of the ISWT, as well as lower FEV_1 and FVC; they also presented

Alves et al. 86 patients with scoliosis V.S. 40 normal subjects

Results. Normal controls presented significantly lower mean heart rate and Borg scores, as well as higher oxygen saturation and walked longer distances on the 6MWT.

Shen et al. 40 patients with AIS

Conclusions: Overall exercise tolerance was not correlated with the magnitude of the thoracic curve and kyphosis. Some parameters of ventilatory function and pulmonary gas exchange worsened as thoracic curvature increased or kyphosis

Czaprowski, et al. Eur Spine J 2012;21:1099-105.
Sperandio, et al. Spine J 2014;14:2366-72.
Alves et al. Spine (Phila Pa 1976) 2009;34:E926-9.
Shen, et al. JBJS 2016; 98: 1618-20.

Hypothesis

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Severity and etiology of thoracic scoliosis affects exercise performance

Method

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- Patients with thoracic scoliosis
- Radiographic measurement
  - Thoracic curvature (Cobb angle)
  - Apical vertebral translation
- Static pulmonary function test
- Cardiopulmonary exercise test

Jan. 2014 to Dec. 2017

187 patients included

Excluded:

- Other cardiopulmonary diseases
- Other thorax deformities
- History of cardiothoracic surgery
- Intracanal anomaly

Correlation test：Pearson & Spearman correlation analysis

Intergroup comparison : Student t test

Method

Cardiopulmonary Exercise Test (CPET)

- Electrocardiogram
  — Heart rate
- Gas exchange
  — Oxygen uptake
  — Production of CO_2
  —Oxygen saturation
- Ventilation
  — Minute ventilation
  — Tidal volume
  — Respiratory rate
  — Breathing reserve
- Subjective feeling
  — Shortness of breath
  — Exhaustion of lower limbs

- Symptom limited load test
- Differential diagnosis of worsening exercise capacity
- Preoperative risk assessment

TABLE 18. USUAL CARDIOPULMONARY EXERCISE RESPONSE PATTERNS

Measurement	Heart Failure	COPD	ILD	Pulmonary Vascular Disease	Obesity	Deconditioned
$\dot{V}O_2$max or $\dot{V}O_2$peak	Decreased	Decreased	Decreased	Decreased	Decreased for actual, normal for ideal weight	Decreased
Anaerobic threshold	Decreased	Normal/decreased/ indeterminate	Normal or decreased	Decreased	Normal	Normal or decreased
Peak HR	Variable, usually normal in mild	Decreased, normal in mild	Decreased	Normal/slightly decreased	Normal/slightly decreased	Normal/slightly decreased
O_2 pulse	Decreased	Normal or decreased	Normal or decreased	Decreased	Normal	Decreased
($\dot{V}_E$/MVV) × 100	Normal or decreased	Increased	Normal or increased	Normal	Normal or increased	Normal
$\dot{V}_E/\dot{V}CO_2$ (at AT)	Increased	Increased	Increased	Increased	Normal	Normal
V_D/V_T	Increased	Increased	Increased	Increased	Normal	Normal
Pa_{O_2}	Normal	Variable	Decreased	Decreased	Normal/may increase	Normal
$P(A–a)O_2$	Usually normal	Variable, usually increased	Increased	Increased	May decrease	Normal

Definition of abbreviations: AT = Anaerobic threshold; COPD = chronic obstructive pulmonary disease; HR = heart rate; ILD = interstitial lung disease; MVV = maximal voluntary ventilation; $P(A–a)O_2$ = alveolar–arterial difference for oxygen pressure; V_D/V_T = ratio of physiologic dead space to tidal volume; $\dot{V}_E$ = minute ventilation; $\dot{V}CO_2$ = carbon dioxide output; $\dot{V}O_2$max = maximal oxygen uptake; $\dot{V}O_2$peak = peak oxygen uptake.

Adapted by permission from References 3, 49, and 72.

* *Decreased*, *normal*, and *increased* are with respect to the normal response.

ATS/ACCP Statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med 2003;167:211-77.

Results

- 113 females and 74 males
- Mean age 19.0 years (10-36)
- Average thoracic curve 58.9° (25-157°)

	Mean ± SD
Anthropometric data	
Age(yr)	19.0 ± 6.73
Height(cm)	152.7 ± 10.2
Weight(kg)	49.5 ± 9.38
Body Mass Index(kg/m²)	20.6 ± 3.14
Radiographic data	
MTC (degrees)	58.9 ± 38.3
TK (deg)	42.3 ± 45.4

Results

Correlation of severity of major thoracic curve with PFT

r value	Thoracic curvature	Apical vertebral translation
FEV_1(%)	-0.483	-0.476
FVC(%)	-0.592	-0.513
TLC(%)	-0.616	-0.601
FEV_1/FVC	0.174	0.219

P value	Thoracic curvature	Apical vertebral translation
FEV_1(%)	0.014	0.019
FVC(%)	0.001	0.004
TLC(%)	<0.001	<0.001
FEV_1/FVC	0.731	0.633

- Restrictive ventilation dysfunction
- Significantly correlated to severity of thoracic deformity

Results

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Correlation of severity of major thoracic curve with ventilation

r value	thoracic curvature	apical vertebral translation
VE(%)	-0.122	0.076
Vt(%)	-0.586	-0.570
RR(/min)	0.610	0.564
BR(%)	-0.429	-0.449

P value	thoracic curvature	apical vertebral translation
VE(%)	0.757	0.894
Vt(%)	0.002	0.005
RR(/min)	<0.001	0.005
BR(%)	0.017	0.014

- Correlation of lower tidal volume, faster respiratory rate, worse breathing reserve

Results

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Correlation with gas exchange & cardiac function

P value	Thoracic curvature	Apical vertebral translation
SpO_2 at rest (%)	0.003	0.019
SpO_2 at max exercise (%)	0.001	0.001
drop of SpO_2(%)	<0.001	0.006

- Oxygen saturation (both at rest and max. exercise) was lower in patients with severe scoliosis, and the drop was more obvious

P value	Thoracic curvature	Apical vertebral translation
VO_2 (mL/kg/min)	0.794	0.644
HR (%)	0.223	0.240
O_2/pulse(%)	0.796	0.756

- Maximal exercise capacity that patients could reach was not related to severity of deformity

Results

Comparison between IS and CS

	Idiopathic N=126	Congenital N=61	P value
FEV1(%)	70.6 ± 17.4	67.6 ± 20.2	0.284
FVC(%)	72.5 ± 16.3	66.9 ± 18.5	0.303
TLC(%)	71.0 ± 16.9	70.7 ± 16.7	0.599
FEV1/FVC	83.1 ± 6.44	86.2 ± 5.08	0.865

- No significant difference was discovered in PFT

Results

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Comparison in ventilation, gas exchange & cardiac function

	Idiopathic N=126	**Congenital N=61**	**P value**
VE(%)	56.6 ± 14.6	49.5 ± 10.6	0.126
Vt(%)	60.9 ± 11.9	45.7 ± 13.9	0.002
RR(/min)	41.6 ± 8.76	52.9 ± 10.6	0.007
BR(%)	38.2 ± 17.5	34.5 ± 17.0	0.750

- Lower tidal volume, faster respiratory rate in CS patients

	Idiopathic N=126	**Congenital N=61**	**P value**
VO2 (mL/kg/min)	67.9 ± 12.5	65.7 ± 16.0	0.814
HR (%)	90.8 ± 8.54	94.8 ± 6.32	0.773
O2/pulse(%)	75.4 ± 13.6	75.0 ± 18.5	0.905
drop of SpO2(%)	2.75 ± 3.41	5.40 ± 5.17	0.032

- Reduced oxygen saturation in CS patients

Conclusions

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- Thoracic scoliosis negatively influences pulmonary function
- In an exercise test, patients accelerate respiratory rate to compensate the smaller tidal volume
- Abnormal breathing pattern is more obvious in CS patients