TOLERANCE OF PHYSICAL EFFORT IN PATIENTS WITH SURGICALLY TREATED SCOLIOSIS

Maciej Glowacki[1], Przemyslaw Lubiatowski[1], Maria Laurentowska[2], Andrzej Szulc[1]
[1]Department of Pediatric Orthopaedics, University of Medical Sciences, Poznan, Poland
[2]University School of Physical Sciences, Poznan, Poland

Fourty-eight patients were treated operatively for idiopathic scoliosis by means of Cotrel-Dubousset technique heaving pre-operative angle values of 50°-70°. Exercise test was performed using cycle ergometer both in pre- and postoperative period. Cardiorespiratory parameters were constantly measured throughout the test to estimate ventilation threshold. Following parameters were included: heart rate, oxygen intake, lung ventilation per minute, rate and volume of ventilation, as well as power and work performed. Test was terminated when ventilation threshold was achieved. This is considered noninvasive method to calculate threshold of anaerobic metabolism. Maximal oxygen intake was indicated by means of Astrand-Ryhming nomogram. Body weight and height were also measured. Operative treatment of scoliosis using Cotrel-Dubousset method enhances physical efficiency moderately most probably due to improvement of respiratory mechanics, increase in ventilation per minute during exercise test through deepening of breaths rather than increase in ventilation rate.

KEY WORDS: idiopathic scoliosis, physical efficiency, Cotrel-Dubousset method

INTRODUCTION: Decrease in vital capacity and respiratory efficiency due to scoliosis of high angular values is considered to be well known risk factor especially in long term observation (Chong, Letts, & Cumming, 1981; Freidel et al., 2002; Kearon, Viviani, & Killian, 1993; Weinstein, Zavala, & Ponseti, 1981). Deterioration of respiratory efficiency resulting in decreased physical efficiency (Ferrari et al., 1997) may be associated with decreased thoracic kyphosis as shown by Winter, Lovell, & Moe (1975) or increased values of Cobb angle (Sakic, Pecina, & Pavicic, 1992). Current studies on respiratory mechanics in scoliosis patients indicate some other explanations for decreased respiratory function, e.g. limited respiratory motion of upper chest (Leong, Lu, Luk, & Karlberg, 1999) confirmed in MRI studies by Kotani et al., (2004).
The aim of the study was to analyse the impact of operative correction of scoliosis with Cotrel-Dubousset technique (resulting in altered shape and function of chest) on physical efficiency in patients with idiopathic scoliosis.

METHODS: Physical efficiency was evaluated based on ventilation threshold using cycle ergometer in 48 patients with idiopathic scoliosis with the preoperative Cobb angle range of 50°-70°. Measurements were performed preoperatively and one year after the operative treatment with Cotrel-Dubousset technique. Cardiorespiratory parameters were constantly measured through the test to estimate ventilation threshold. Following parameters were included: heart rate (HR), oxygen intake (VO_2/KG, VO_2max, VO_2max/KG), lung ventilation per minute (VE), rate and volume of ventilation (f, V_T), as well as power and work performed. Test was terminated when ventilation threshold was achieved. This is considered noninvasive method to calculate threshold of anaerobic metabolism. Maximal oxygen intake was indicated by means of Astrand-Ryhming nomogram. Body weight and height were also measured. Patients did not use any braces after operation as well as no sport activities were allowed.

RESULTS: The results of anthropometric parameters are listed in the Table 1.

Table 1 Results of anthropometric parameters measured at the ventilation threshold in patients both preoperatively and after operative correction of scoliosis

Parameter	Group				Significance level
	patients before operation		patients 1 year after operation		
	mean	SD	mean	SD	
Age [years]	14.40	1.41	15.65	1.41	<0.001
Weight [kg]	47.71	5.74	53.07	6.45	<0.001
Height [cm]	161.71	6.39	165.42	6.08	<0.001
Power [W]	79.23	15.26	90.71	14.92	<0.001
HR [rate/min]	172.85	8.30	172.31	13.28	NS
VO_2/KG [ml/kg/min]	20.01	4.60	20.85	4.84	NS
VE [l/min]	30.48	8.45	35.26	8.84	<0.001
F [breath/min]	34.29	7.20	33.25	6.29	NS
V_T [ml]	930.92	199.19	1100.88	224.78	<0.001
VO_2max/KG [l/kg/min]	41.79	6.84	40.43	7.04	NS
VO_2max [l/min]	1.96	0.25	2.13	0.35	0.003
Work [kJ]	27.59	8.05	34.53	9.78	<0.001
Power/KG [W/kg]	1.68	0.34	1.72	0.28	NS

DISCUSSION: Operative treatment of scoliosis improves patients' results of cardiorespiratory parameters at the level of ventilation threshold as shown by significant change in the measured values at follow-up. In the study group ventilation threshold before operation was achieved at lower loads then in the follow-up examination. Heart rate at the ventilation threshold was similar in both pre- and postoperative measurements. Whereas ventilation per minute was significantly higher 1 year after operation. Ventilation rate was similar, but the volume of breath increased postoperatively. Maximal oxygen intake was lower before operation but no significant difference was found when the measure was related to body weight. Operated patients were able to perform increased work having similar power values related to body weight.

Most of the parameters indicate improved physical efficiency following operation. Some of the results are improved when unrelated. However when related to body weight no significant differences were recorded. Considering increase in weight (ca. 5 kg), overall improvement in

efficiency occurred during limited mobility in postoperative treatment (period of spinal fusion) and was proportional to increasing body weight.
Positive impact of operative treatment was also seen as making the respiratory function more economic. Ventilation per minute was increased through deepening of breath rather then increased rate of ventilation. This is probably the most crucial effect of correction of idiopathic scoliosis on posture and physical efficiency.
One of the most important factors decreasing vital volume in scoliosis patients are localization of apical vertebra at Th5-Th8 in combination with Cobb angle exciding 70° (Sakic et al., 1992). Winter et al. (1975) noted postoperative improvement of respiratory function when treated patients with Harrington method despite using only distractive instruments.
Some of the authors (Kennedy, Robertson, Hudson, & Phelan, 1989) attribute decreased respiratory function to application of braces (Milwaukee, Boston) in preoperative period. Others (Ferrari et al., 1997), deny that observation and consider low physical activity level as main deteriorating factor. In this point of view improved respiratory parameters in our study may be surprising. We hypothesize that this may be associated with improved economics of respiration. We know from other studies that the chest volume is not increased in Cotrel-Dubousset method as shown by computed tomography (Wood, Schendel, Dekutoski, Boachie-Adjei, & Heithoff, 1996). Postoperative change in shape of the spine as well as proportion of the chest have the positive impact on respiratory mechanics (Leong et al., 1999). Similar observation were made in magnetic resonance imaging by Kotani et al. (2004). They assume that limited motion of chest is significant factor disturbing the respiratory mechanics. Correlation has been found between limited chest motion and results of exercise tests.

CONCLUSION: Operative treatment of scoliosis using Cotrel-Dubousset method enhances physical efficiency moderately most probably due to improvement of respiratory mechanics, increase in ventilation per minute during exercise test through deepening of breaths rather than increase in ventilation rate.

REFERENCES:

Chong, K.C., Letts, R.M. & Cumming, G.R. (1981). Influence of spinal curvature on exercise capacity. *J Pediatr Orthop,* 1(3), 251-4.
Ferrari, K., Goti, P., Sanna, A., Misuri, G., Gigliotti, F., Duranti, R., Iandelli, I., Ceppatelli, S. & Scano, G. (1997). Short-term effects of bracing on exercise performance in mild idiopathic thoracic scoliosis. *Lung,* 175(5), 299-310.
Freidel, K., Petermann, F., Reichel, D., Steiner, A., Warschburger, P. & Weiss, H.R. (2002). Quality of life in women with idiopathic scoliosis. *Spine,* 15, 27(4), 87-91.
Kearon, C., Viviani, G.R. & Killian, K.J. (1993). Factors influencing work capacity in adolescent idiopathic thoracic scoliosis. *Am Rev Respir Dis,* 148(2), 295-303.
Kennedy, J.D., Robertson, C.F., Hudson, I. & Phelan, P.D. (1989). Effect of bracing on respiratory mechanics in mild idiopathic scoliosis. *Thorax,* 44(7), 548-53.
Kotani, T., Minami, S., Takahashi, K., Isobe, K., Nakata, Y., Takaso, M., Inoue, M., Maruta, T., Akazawa, T., Ueda, T. & Moriya, H. (2004). An analysis of chest wall and diaphragm motions in patients with idiopathic scoliosis using dynamic breathing MRI. *Spine,* 1, 29(3), 298-302.
Leong, J.C., Lu, W.W., Luk, K.D. & Karlberg, E.M. (1999). Kinematics of the chest cage and spine during breathing in healthy individuals and in patients with adolescent idiopathic scoliosis. *Spine,* 1, 24(13), 1310-5.
Sakic, K., Pecina, M. & Pavicic, F. (1992). Cardiorespiratory function in surgically treated thoracic scoliosis with respect to degree and apex of scoliotic curve. *Respiration,* 59(6), 327-331.
Weinstein, S.L., Zavala, D.C., & Ponseti, I.V. (1981). Idiopathic scoliosis: long-term follow-up and prognosis in untreated patients. *J Bone Joint Surg Am,* 63(5), 702-12.
Winter, R.B., Lovell, W.W. & Moe, J.H. (1975). Excessive thoracic lordosis and loss of pulmonary function in patients with idiopathic scoliosis. *J Bone Joint Surg Am,* 57(7), 972-7.

Wood, K.B., Schendel, M.J., Dekutoski, M.B., Boachie-Adjei, O. & Heithoff, K.H. (1996). Thoracic volume changes in scoliosis surgery. *Spine,* 15, 21(6), 718-23.