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THE EFFECT OF PHYSICAL TRAINING ON EXERCISE ABILITY IN ADOLESCENT IDIOPATHIC SCOLIOSIS

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Twenty subjects with adolescent idiopathic scoliosis, aged 11–17 years, were studied before spinal fusion. Half the patients underwent a programme of daily physical exercises for 6–10 weeks. Before and after this period all the patients carried out a range of lung function tests and a progressive exercise test. There were no significant differences in any of the results between the control group and the training group. The cardiac and respiratory complications of spinal fusion are therefore unlikely to be lessened by preoperative physical training, except in selected subjects.

Key words: exercise testing; physical training; scoliosis; spinal fusion

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Although physical exercises have been used in an attempt to correct spinal curvatures there have been no reports of their use to improve cardiac and respiratory performance preoperatively. This is surprising in view of the well-established diminution in lung volumes (Schaub et al. 1954) and the hyperventilation, and reduced maximal ventilation and maximal oxygen uptake during exercise in adult scoliotics (Shneerson 1978a). In this study half the patients carried out a programme of daily exercises to see whether their cardiorespiratory function could be improved preoperatively and the complications of surgery thereby minimized.

PATIENTS AND METHODS

Twenty successive subjects with adolescent idiopathic scoliosis in which the primary curve affected the thoracic spine were studied. None of the subjects had any cardiac or respiratory disease complicating the scoliosis. All the patients performed a range of lung function tests and an exercise test and were then randomly allocated to the control or the training groups. The latter were instructed to carry out a daily regime of physical exercises, including repeated step-ups, hopping, jumping, and reaching up above their head. The exercises were performed initially in the presence of the authors and in each patient the heart rate rose above 160/minute. The exercises were supervised by their parents and records kept of their performance. After 6–10 weeks both the control and the training groups were recalled and the lung function and exercise tests were repeated.

The angle of scoliosis was determined by the method of Cobb (1948). The vital capacity (VC) was measured with a dry spirometer (Vitalograph) and the maximum voluntary ventilation with a wet spirometer (P. K. Morgan).

Exercise was performed while sitting on an electrically-braked bicycle ergometer (Lode). The inspiratory minute volume was measured by a dry gas meter. The gas meter was connected to a low resistance two-way respiratory valve (P. K. Morgan 71522) with a dead space of 60 ml. The expired gas passed to a mixing chamber containing a fan. A sample of the mixed expired gas was dried with magnesium perchlorate and passed through a paramagnetic Servomex OA 150 oxygen analyser, and an infra-red absorption CO_2 analyser (URAS 4). Both machines were connected electrically to a direct writing ink jet recorder (Mingograf 81).

The patients rested on the ergometer until their

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inspired ventilation, mixed expired gas composition and heart rate were steady. They then began pedalling, initially at a work rate of 15 watts. The work rate was increased by 15 watts each minute and the patients were encouraged to keep exercising for as long as possible, which was usually 6–10 minutes. There were no complications of the procedure.

The slope of the relationship between the minute ventilation ($\dot{V}_E$) and heart rate (HR) and the oxygen uptake ($\dot{V}_{O_2}$) was calculated by the least squares method. The $\dot{V}_E$ and HR responses were expressed as maximal values ($\dot{V}_{E\,max}$) and at interpolated values of $\dot{V}_{O_2}$ of 0.75 L, 1.0 L and 1.5 L ($\dot{V}_{E0.75}$, $\dot{V}_{E1.0}$, $\dot{V}_{E1.5}$; $HR_{0.75}$, $HR_{1.0}$, $HR_{1.5}$) (Cotes 1969, Spiro et al. 1974).

RESULTS

Personal details

Both the control and training groups included nine girls and one boy. The mean age of the controls was 14.1 years (s.d. 1.7) and of the training group was 13.9 years (s.d. 0.9). The two groups had similar weights (control group: mean 50.4 kg, s.d. 7.4; training group: 48.9 kg, s.d. 7.0) and angles of scoliosis (control group: mean 62.2°, s.d. 10.5; training group: 61.4°, s.d. 11.1).

Resting lung function tests

There was no significant difference between the mean VC or MVV of the two groups at their first attendance. Both VC and MVV were slightly improved when tested a second time, but there was no difference between the two groups (Table 1).

Progressive exercise tests

No significant changes in the submaximal values of ventilation or heart rate were observed between the control and training groups initially or after 6–10 weeks (Figure 1). The dyspnoeic index and the maximal values of minute ventilation, tidal volume and oxygen uptake were not affected by the training programme (Table 1).

Table 1. Physiological data

Group		VC (L)		MVV (L/min)		$\dot{V}_{E\,max}$ (L/min)		Dyspnoeic index (%)		$V_{T\,max}$ (L)		$\dot{V}_{O_2\,max}$/(L/min)	
		Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Control	Before	2.93	0.91	101.1	6.7	62.1	12.9	67.3	20.7	1.48	0.46	1.83	0.50
	After	3.02	0.87	105.8	6.1	64.3	18.0	63.4	16.1	1.52	0.52	1.95	0.52
Training	Before	2.66	0.81	91.6	5.0	54.0	10.0	61.7	15.0	1.31	0.30	1.58	0.26
	After	2.67	0.70	97.4	4.7	61.8	11.9	66.6	19.2	1.38	0.32	1.70	0.30

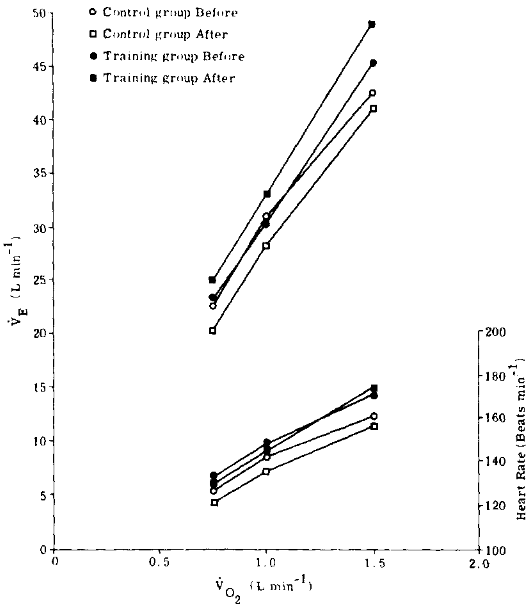

Figure 1. Minute ventilation and heart rate responses during exercise tests.

DISCUSSION

This study was carried out to determine whether the exercise capacity of patients with adolescent idiopathic scoliosis could be improved by a course of physical training. Scoliotics develop a variety of cardiac and respiratory abnormalities (Bergofsky et al. 1959) and it is therefore important that they are as fit as possible, especially prior to surgery such as spinal fusion. The exercises chosen were simple and practicable and utilized all the main muscle groups. More intensive and supervised exercises could have been designed if the subjects had been admitted to hospital for the period of training. However, hospitalization for several weeks is undesirable and unacceptable to many patients and it was thought preferable to use a simple regime. The effectiveness of a training programme depends on the severity of the physiological stress it presents. Exercise which induces a rise in heart rate above 150 beats/minute is sufficient to produce measurable improvement (Saltin et al. 1969). The heart rate rose above 160 beats/minute in all the subjects of this study. A significant increase in $\dot{V}_{O_2}$ max can be produced by an exercise course of 8 weeks (Saltin et al. 1968), which was the approximate duration of this training course.

The group of control patients who did not undergo physical training was comparable with the training group in age, sex, weight, and angle and level of scoliosis. The previous studies of the effects of exercise in scoliotics (Bjure et al. 1969, Götze et al. 1974, Stoboy & Speierer, 1975) have not included a control group, but instead have studied the same patients on two or more occasions. The improvements they have observed could therefore be due to lessening of anxiety on the later occasions, familiarity with the apparatus (McHardy 1978), or to the physiological consequences of growth of the subjects. For instance, the FEV_1 and VC are related to height and arm span (Godfrey et al. 1970), the heart rate response during exercise is inversely proportional to lean body mass (Cotes et al. 1973), and $\dot{V}_{O_2}$ max varies with body weight (Davies et al. 1972).

An improvement in physical fitness due to the exercise course should result in a higher dyspnoeic index with an unchanged MVV, a slower heart rate at any given $\dot{V}_{O_2}$, and a greater $\dot{V}_{O_2}$ max. Both the trained and untrained subjects improved slightly at their second attendance in several ways, but the trained group did not show any significant benefit compared with the control group. There was no difference in response between the milder and more severe subjects within the trained group. Even a slight improvement in the most severely affected subjects might be of symptomatic benefit, but Shneerson (1978b) has shown that severe pulmonary hypertension can develop during and after exercise in scoliotics with a vital capacity less than 1.0–1.5 litres. Physical training should, therefore, not be advised for these subjects. The best results from a course of training would probably be achieved by selecting those who are habitually the least active. A high proportion of active subjects in the present study may have obscured the benefit that more sedentary adolescents would achieve from a course of training similar to the present one.

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