Effect of Exercise at the AT Point for Children with Cerebral Palsy

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Abstract

Eleven children with spastic cerebral palsy (CP) who could walk underwent exercise at the anaerobic threshold (AT) point. The subjects exercised for 20 minutes per session, twice a week for a period ranging from 6 to 20 weeks. The subjects were divided into two groups. The leg exercise group contained six CP children who exercised on a cycle ergometer with average attendance of 1.8 days a week. The other five CP children constituted the arm exercise group and exercised using an arm cranking ergometer with average attendance of 1.5 days per week. After the exercise period, the oxygen uptake (VO₂) at the AT point increased significantly in the children in the leg exercise group. On the other hand, the VO₂ at the AT point did not change in children in the arm exercise group. These results demonstrate that cycle ergometer exercise at the AT point is effective in improving the physical endurance of children with CP. In contrast, arm exercises for children with CP seem to have little effect on increasing physical endurance.

The heart rate of children with spastic cerebral palsy (CP) while walking markedly increased compared to normal children even at the same walking speed.¹ From those results, we think that physical endurance must be decreased in children with CP. Decrease of physical endurance in children in this population is a result of engaging in fewer physical activities than normal children. Although walking may be an effective exercise to improve physical endurance in some cases, it may be rather harmful to individuals who show extremely high heart rates while walking.² Since many children with CP are not good at self-regulating their walking speed, they cannot reduce their walking speed as their heart rate increases. In other words, they cannot regulate the intensity of exercise while walking. In addition, there are children with CP whose heart rates continue to increase even when their walking speed was kept very slow.³ In these cases, oxygen uptake (VO₂) will raise over the anaerobic threshold (AT) point.⁴ In such cases walking itself seems to be a rather risky form of exercise. For these patients, rather than walking, another form of exercise at a lower intensity should be recommended.

The AT point can be detected under submaximal exercise, and exercise at the AT point has been thought to be effective in improving the physical endurance of children and adults, both with and without physical disabilities and diseases.⁵⁻¹² However, trainability of exercise, that is whether exercise at the AT point improves physical endurance or not, has been illusive in children with CP. We tried to reveal the trainability of exercise at the AT point in children with CP.

Subjects and Methods

Subjects

Eleven children with CP were involved in this study and divided into two groups. The leg exercise group contained six children who could pedal on a cycle ergometer; they ranged in age from 13.3 to 15.8 (14.6 ± 0.9) years old. The arm exercise group contained five children who were not able to pedal the cycle ergometer but could crank an arm cranking ergometer; they ranged in
age from 11.8 to 16.3 (14.2 ± 1.7) years old. Informed consent was obtained for each subject.

**Ergometer Test**
Before, during, and after the period of exercise, the CP children were tested. After a four minute warm-up period of pedaling a cycle or cranking an arm ergometer without load, the work rate was increased by 7 or 10 W per minute to the limit of the childrens' tolerance. Oxygen (O₂) uptake (VO₂), carbon dioxide (CO₂), output (VCO₂), and minute ventilation (VE) were measured breath by breath using a respirometer equipped with a gasometer (Model RM300 and Model MG360, Minato Medical Co.,) through the facemask. On the basis of these data, VO₂ at the AT point were determined according to the V-slope method.4,13

**The Program of Exercise at the AT Point**
The program of exercise at the AT point was designed so that the children would exercise using a cycle ergometer or an arm cranking ergometer at AT point for 20 minutes per session.

**Interview of the Children**
Interviews with the children were attempted in order to ascertain whether they were able to detect improvement in their physical endurance as a result of the exercise program.

**Test-Retest Reliability**
Three children were tested three times on separate days in the same week. The standard deviation of VO₂ at the AT point measured were 0.17, 0.47, and 0.73 ml/kg/min.

**Statistical Analysis**
Statistical differences in the data between the groups were tested using analysis of variance (ANOVA). The significance level was set at 0.05.

**Results**

**Overall Period and Frequency of Attendance**
The overall period and frequency of attendance were distributed among the children. The total period of exercise ranged from 8.0 to 20.6 (16.7 ± 4.7) weeks in the leg exercise group. The frequency of attendance per week ranged from 1.1 to 2.3 (1.8 ± 0.4) times in the leg exercise group. In the arm exercise group, the total period of exercise ranged from 5.0 to 19.3 (12.7 ± 6.3) weeks and the frequency of attendance per week ranged from 1.0 to 2.3 (1.5 ± 0.5) times. No significant difference was observed in the total period of exercise and frequency of attendance among the two groups.

**VO₂ at the AT Point Before and After the Exercise Period**
In the leg exercise group the VO₂ at the AT point before and after the exercise period ranged from 13.0 to 27.5 (22.0 ± 5.2) ml/kg/min and from 14.6 to 33.5 (27.4 ± 7.1) ml/kg/min, respectively. VO₂ at the AT point after the exercise period were significantly increased (Fig. 1).

In the arm exercise group, however, the VO₂ at the AT point before and after the exercise period ranged from 10.2 to 15.2 (12.5 ± 2.3) ml/kg/min and from 12.8 to 15.6 (14.0

**Figure 1** Change of VO₂ during exercise period in subjects in the leg exercise group.

**Figure 2** Change of VO₂ during exercise period in subjects in the arm exercise group.
± 1.0) ml/kg/min, respectively. Significant changes were not observed between VO₂ at the AT point before and after the exercise period (Fig. 2).

**VO₂ at the AT Point vs. Frequency of Attendance**

No significant difference was found in the frequency of attendance between those in the leg and arm exercise groups. Five of the six children in the leg exercise group could attend more than one time per four days (more than 1.8 times a week). The increment of VO₂ at the AT point was the lowest in the children whose frequency of attendance was the lowest (Fig. 3). Significant correlation between the frequency of attendance and the increase in VO₂ at the AT point was found in a leg exercise group.

On the other hand, only one child in the arm exercise group could attend more than one time per four days (more than 1.8 times a week). The other children in the arm exercise group attended less than 1.8 times a week. In this group, no correlation was found between the frequency of attendance and a change in VO₂ at the AT point (Fig. 4).

**VO₂ at the AT Point vs. Total Period of Exercise**

It was observed that the VO₂ at the AT point began to increase at one to three months after the initiation of the exercise program for those in the leg exercise group (Fig. 1). However, no change in the VO₂ at the AT point was apparent over the course of the entire period of the exercise program in the arm exercise group (Fig. 2).

**Self-Assessment of Endurance**

Five of six children in a leg exercise group subjectively realized improvement in their physical endurance. One child in the leg exercise group whose increase in VO₂ at the AT point was the lowest did not realize any improvement in physical endurance. However, in the arm exercise group, four of five children did not realize improvement in their physical endurance (Table 1).

**Discussion**

**VO₂ at the AT Point as an Index of Physical Endurance**

Although maximal oxygen uptake (VO₂max) is a reliable index of physical endurance, it is often difficult to measure VO₂max directly. It is possible to predict VO₂max from the linear increase in the heart rate during work. Predicted VO₂max may be as good an index of physical endurance as VO₂ at the AT point. However, we think VO₂ at the AT point is a rather reliable index of physical endurance and intensity of exercise because VO₂ at the AT point is achieved by direct measurement. The concept of the AT point was proposed by Wasserman and colleagues. Although there is controversy concerning the concept of AT point, it is very convenient to use VO₂ at the AT point as an index of physical endurance and intensity of exercise for clinical investigations because it is a safer measurement to

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Self Assessment of Physical Endurance</th>
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<tr>
<td></td>
<td>Leg Exercise Group</td>
</tr>
<tr>
<td>Getting Better</td>
<td>5</td>
</tr>
<tr>
<td>No change</td>
<td>1</td>
</tr>
<tr>
<td>Getting Worse</td>
<td>0</td>
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Figure 3 Relationship between change of VO₂ at the AT point and frequency of attendance in the leg exercise group.

Figure 4 Relationship between change of VO₂ at the AT point and frequency of attendance in the arm exercise group.
assess in subjects who suffer from cardiac diseases and or motor dysfunction.

Our great concern is reliability of VO$_2$ at the AT point as an index of physical endurance and intensity of exercise in children with CP. In this study, the standard deviation of VO$_2$ at the AT point as a test-to-test reliability was less than 1 ml/kg/min in three children with CP. Abnormal muscle contraction such as muscle spasticity, which can be influenced easily by mental excitement, may influence VO$_2$ at the AT point. It is very important to repeat rehearsals until children become accustomed to wearing the face mask, the staff conducting the experiment, the equipment, as well as their surroundings. We think it is very important to assure that the subjects are relaxed during the measurement process. Repeating rehearsal may help produce good results during the ergometer tests. If we acquired odd data on a given day from a specific participant, we tended to doubt the data and, instead, tried to acquire the measurement on another test day; the anomalous data may have been caused by something new in experimental environment which influenced the participant and, therefore, caused the odd data in the measurement.

**Trainability of Exercise at the AT Point in CP Children**

Trainability of exercise at the AT point in children with CP has been illusive. This study revealed that exercise with a cycle ergometer was effective in improving physical endurance in children with CP. From this result, exercise at the AT point using a cycle ergometer is reasonable and safe for this patient population (especially when considering that their heart rate can become highly increased during walking exercise). From our results, it can be seen that little or no change in endurance can be expected in the first one to three months of a cycling exercise program. However, a positive affect can be shown when the subjects continue the program for three months.

On the other hand, no effect was observed in the subjects that participated in the arm exercise program. When considering the frequency of attendance, although there was no statistical difference among the two groups, five of six children in the leg exercise group attended exercise sessions more than 1.8 times a week whereas only one child in the arm exercise group could attend with this level of frequency. Bar-Or proposed an exercise program to improve the physical endurance of normal children; he suggested that children exercise at the intensity of 60% to 70% of VO$_2$max more than twice a week. This supports the idea that perhaps the frequency of attendance for those in the arm exercise group might have been insufficient to manifest a result. In other words, exercising at least 1.8 times per week (about twice a week) may be necessary for increasing physical endurance in children. The VO$_2$ at the AT point may increase if the frequency of attendance is increased, even in children with CP in an arm exercise program. But it is also true that no correlation was found between the change of the VO$_2$ at the AT point and the frequency of attendance in the arm exercise group. The VO$_2$ at the AT point did not increase even in the child in the arm exercise group who did attend over 1.8 times a week. The children in the arm exercise group could walk (with varying ability). The muscle volume of the lower limbs is usually larger than the muscle volume of upper limbs in patients who can walk. This means that arm exercise may be an insufficient form of exercise for improving physical endurance in children with CP who are ambulatory. In children that have CP but cannot walk, an arm exercise program may be an effective method for improving their physical endurance. If it is true that arm exercise is an insufficient means for improving the physical endurance of children with CP who can walk, hydrotherapy gait, which can also control exercise intensity, might be a good choice for improving their endurance.

This study presented a small sample of children with cerebral palsy. Furthermore, as mentioned above, the frequency of attendance was somewhat lower in the arm exercise group. We could not decide whether exercise at the AT point using an arm cranking ergometer for children with CP would help increase endurance.

**Conclusion**

We concluded that exercise on a cycle ergometer at the AT point for 20 minutes per exercise session at a frequency of two to three times a week is a good method for increasing the physical endurance of most children with CP who are ambulatory.

**Acknowledgments**

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**References**