Nagoya J. Health, physical Fitness, Sports Vol. 10, No. 1 (March 1987)

Short Communication

# Physiological Cost Index of Exercises in Cerebral Palsy Children

YABE, K.[*1], K. MITA[*2], T. MIYAGAWA[*2] and N. ISHIDA[*3]

## INTRODUCTION

It is well established that paraplegia and tetraplegia result in a decrement in physical work capacity. Due to the handicap of the subjects, their physical activity is restricted to a degree determined by the severeness and type of the disability. Many of the previous studies have investigated the effect of a training program on sedentary disabled, while other studies looked at physiological changes that occur during maximum exercise in highly trained subject, but no physiological data have been gathered on cerebral palsy child.

The heart rate can be used as an indirect measurement of oxygen intake and energy needs, for instance when testing the physical working capacity (Coutts et al, 1985). Since the heart rate can be recorded continuously with telemetric equipment, with little or no discomfort to the subjects, such recordings were made on a group of children with cerebral palsy to establish the pattern of the heart rate variations in severely handicapped subjects during different physical activities. The purpose of the present study was to investigate the estimation of the physiological intensities in the cerebral palsy children during the physical activities. Part of the work described here has been reported in abstract somewhere.

## Methods

The experiments were conducted on two phases of physical activity. The first concerned swimming (Exp. 1) and second walking (Exp. 2). The methods in both experiments were very similar.

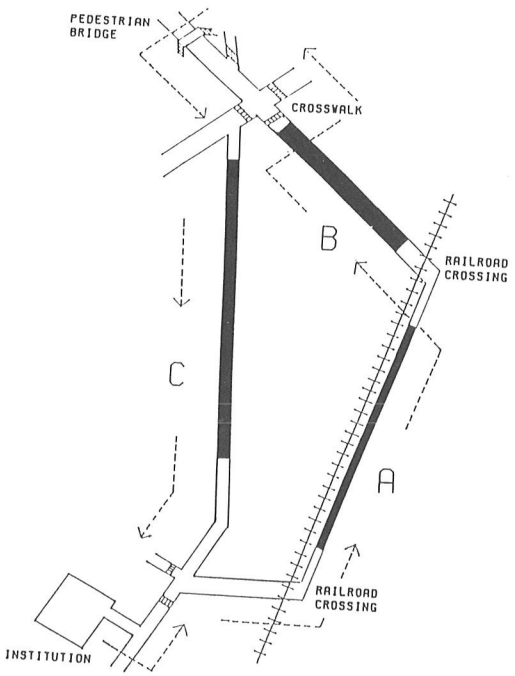
In Exp. 1, heart rate response (HR) during swimming was monitored by ECG radio telemetry. A small radio transmitter was carried on a waist-belt. The leads from the transmitter were connected to two electrodes, one of which was affixed over the manubrium sterni, and the other over the fifth left intercostal space, in the mid-clavicular line, following skin preparation.

The output from the radio receiver was stored permanently on magnetic tape for later analysis. The first experiment was performed on 8 cerebral palsy children (CP) of 7–11 years of age. Two CP subjects were studied with energy expenditure during swimming exercise by means of Douglas bag method. Maximum oxygen intake of a mild CP was obtained from treadmill walk.

In Exp. 2, HR responses during outdoor walk were obtained from 8 physically handicapped children (6 CP, 2 brain injury) between 11 and 18 years old and non-handicapped subjects (3 children, 4 adults). The subjects were instructed to walk distance of 1 or 2 km at their own speeds (Fig. 1). HR responses were recorded every ten seconds with portable size VINE heart rate measuring

*1 Research Center of Health, Physical Fitness and Sports, Nagoya University
*2 Institute for Developmental Research, Aichi Prefectural Colony
*3 Nagoya Jiyugakuin Junior College

**Fig. 1** Schematic illustration of walking course.




equipment, which allowed the subject to walk as naturally as possible. Simultaneously, the gait of the subjects and the changes in environment were recorded on the tape recorder. The walking speed was calculated from its observational records and the walking distance. As an indication of locomotor efficiency, a modified physiological cost index based on method described by Butler et al (1984) was calculated. This states that:

$$\text{Modified physiological cost index (PCI)} = \frac{S}{Hw - Hr} \text{ (m/beats)}$$

where S; average walking speed (m/min)
Hw; heart rate while walking (beats/min)
Hr; heart rate at rest (beats/min)

## Results and Discussion

EXP. 1;

Water as a medium for physical activity has both recreational and therapeutic aspects. Swimming of child with cerebral palsy is an excellent physical activity that facilitates coordination, provides strong muscle work and large range of joint movement for the whole body, and is valuable for training of circulation and respiration (Yabe et al, 1982). Swimming allows freedom of movement which denied on land. Water offers the experience of finding out ones body acted on by two forces; gravity and buoyancy. It provides the potential of physical exercise in three dimensions which cannot be achieved on land.

**Table 1.** Heart rate responses in cerebral palsy children during swimming program.

| Subject | Max. HR | mean ± SD |
|---|---|---|
| TMZ (sp) | 128 | 99 ± 10 |
| TMK (sp) | 140 | 119 ± 15 |
| SIT (sp) | 144 | 121 ± 10 |
| YDK (sp) | 147 | 119 ± 16 |
| YMD (sp) | 164 | 105 ± 14 |
| ONK (at) | 178 | 149 ± 13 |
| SMT (at) | 180 | 146 ± 21 |
| ADC (at) | 198 | 163 ± 20 |

sp: spastic at: athetotic

Maximum HRs during swimmig program ranged from 128–198 beats/min. Mean HRs in the water were 99, 119, 121, 119 and 105 beats/min in the spastic subjects, and 149, 146 and 163 beats/min in the athetotic subjects (Table 1). It was found that HR of the athetotic were more increased than that of spastic children.

Oxygen intake $\dot{V}O2$ during swimming program was obtained from two CP children (Table 2). A severe CP who was unable to walk showed 0.298 l/min of $\dot{V}O2$ at the end o f the program. The $\dot{V}O2$ of a mild spastic child who was unable to running was 0.753 l/min during crawl stroke. There was significant correlation between $\dot{V}O2$ and HR during swimming exercise. $\dot{V}O2$ max measured during treadmill walk (0.998 l/min) was about 25% higher than the $\dot{V}O2$ determined when the same

**Table 2.** Maximum oxygen intake of cerebral palsy children during physical activities.

| Subject | Swimming | Walking & Bicycling |
|---|---|---|
| CP (severe, 6yrs) | 0.298 l/min | |
| CP (mild, 8yrs) | 0.753 l/min | 0.998 l/min |
| | | 45.3 ml/kg min (treadmill walk) |
| NRM (8yrs from H. Matsui et al, 1974) | | 0.99 l/min |
| | | 39.4 ml/kg min (bicycle) |

CP child was swimming. Higher value for $\dot{V}O_2$ max (45m/kg min) was obtained in CP's walk than in the same age of non-handicapped children (39ml/kg min from Matsui et al, 1974). The result indicated that higher $\dot{V}O_2$ due to swimming exercise for the CP children showed significant effects on the improvement of physical fitness.

EXP. 2;

It is well known that training program for the disabled can increase $\dot{V}O_2$ and decrease HR at a given work load (Bar-Or et al, 1976 and Pollock et al, 1974). Many of previous papers have reported the effects of a training program on adult disabled but little physiological data have been collected on CP child. The aim of the present study was to establish the training program of CP's walk. EMG pattern during CP's walk demonstrated the lack of reciprocal inhibition, partial co-contraction and asymmetrical discharge. The pattern of HR responses during outdoor walking was shown in Fig. 2. Mean HRs were higher in comparison with non-handicapped subjects. The findings suggested that CP's outdoor walk were relatively hard work. After 6 months training, walking HRs had a

**Fig. 2** Characteristic pattern of heart rate during outdoor walk in a CP child.

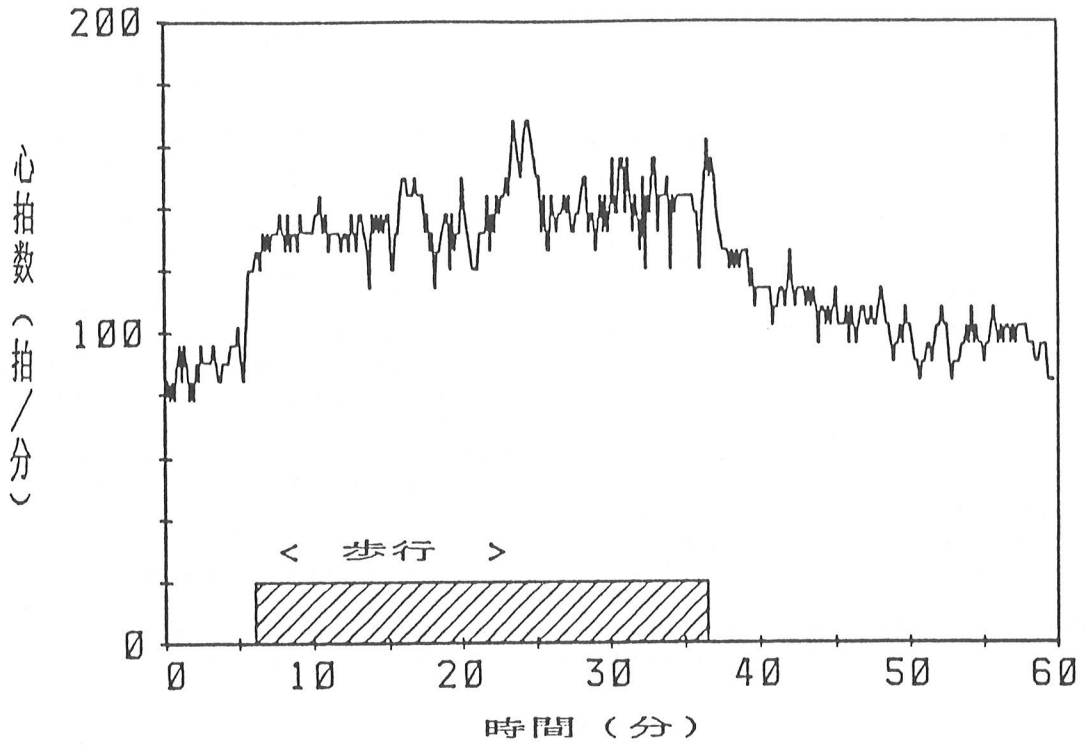
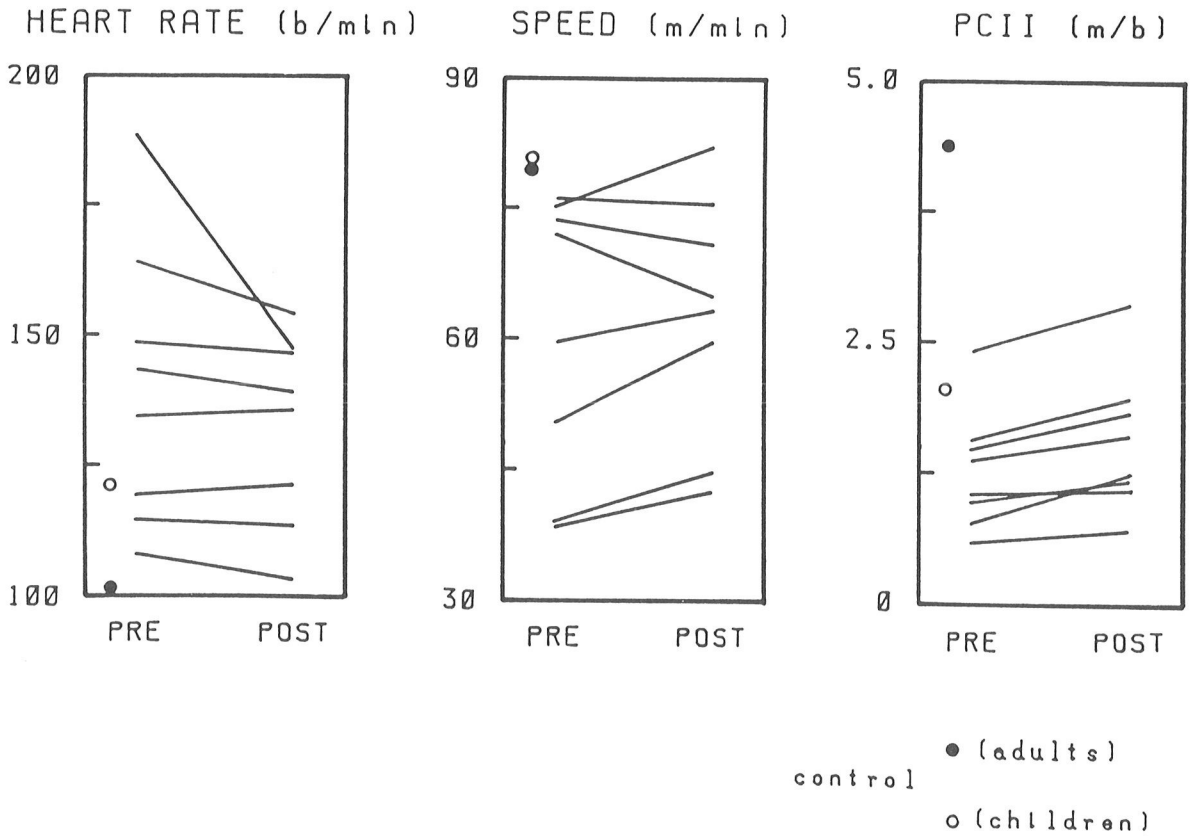


**Fig. 3** Training effects of walking ability on heart rate (HR), walking speed and physiological cost index (PCI) during outdoor walk.




tendency to decrease, whereas walking speed tended to increase for 5 out of 8 subjects (Fig. 3). The results indicated the greater improvement in efficiency of CP7s walk. This was supported by the fact that modified physiological cost index (PCI) showed the greater improvement, as shown in Fig. 3, right panel.

## References


1) Bar-or, O., O. Inbar and R. Spira: Physiological effects of a sports rehabilitation program on cerebral palsied and post-poliomyelic adolescents. *Med.Sci. Sports,* **8**: 157-161, 1976.
2) Butler, P., M. Engelbrecht, R. E. Major, J. H. Tait, J. Stallard and J. H. Patrick: Physiological cost index of walking for normal children and its use as an indicator of physical handicap. *Dev.Med. & Child Neurol.* **26**: 607-612, 1984.
3) Coutts, K. D., E. C. Rhodes and D. C. McKenzie: Submaximal exercise responses of tetraplegics and paraplegics. *J.Apple.Physiol.* **59**: 237-241, 1985.
4) Matsui, H., M. Miura, K. Kobayashi, S. Toyoshima and S. Goto: The relation between maximum oxygen intake and modified Harvard step test index for elementary school boys and girls. *Report Res.Ctr. Phys.Educ.* **2**: 33-41, 1974, (in Japanese).
5) Pollock, M. L., H. S. Miller, A. C. Linnerud, E. Laughridge, E. Coleman and E. Alexander: Arm pedaling as an endurance training regimen for the disabled. *Arch Phys.Med.Rehabil.* **55**: 418-424, 1974.
6) Yabe, K., T. Shinoda, S. Murachi and R. Natsume: Heart rate responses in cerebral palsy children during swimming exercises. *Jap.J.Rehabil.Med.* **19**: 225-230, 1982, (in Japanese).


(Received January 13, 1987)