

## Comparison of Anterior and Posterior Walkers with Respect to Gait Parameters and Energy Expenditure of Children with Spastic Diplegic Cerebral Palsy

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The purpose of this study was to compare gait pattern and energy consumption in children with spastic diplegic cerebral palsy, when using anterior and posterior walkers, and to determine which walker should be recommended as a walking aid for these children. Ten spastic diplegic cerebral palsied children, of average age 9 years, were enrolled in this study. Before assessment, they had all received a practice period of 1-month to familiarize themselves with both types of walker. Gait characteristics were evaluated by computer-based kinematic gait analysis using Vicon 370 Motion Analysis, and energy expenditure was determined by KBI-C while they were using the walkers. The oxygen consumption rate was significantly lower whilst using the posterior walker, as was the oxygen cost. Walking velocity and cadence on gait analysis showed no significant difference between the walker types. However, step length, single support time and double support time were significantly different for the two walkers. Flexion angles of the trunk, hip and knee were lower using a posterior walker. Gait analysis data and oxygen consumption measurements indicated that the posterior walker has more advantages in terms of upright positioning and energy conservation than the anterior walker.

**Key Words:** Gait pattern, energy consumption, walker, cerebral palsy

### INTRODUCTION

Many children with cerebral palsy have difficulty walking independently because of impaired postural control, abnormal muscle tone and pathological muscular coordination.<sup>1-3</sup> Walkers are frequently prescribed to these children to provide

the additional stability required for ambulation. Traditionally, anterior walkers have been used as a walking aid. However, a child using an anterior walker has a tendency to lean forward while pushing the walker.<sup>4,5</sup> The posterior walker is designed to be positioned behind the child has been advocated because it facilitates a more upright position,<sup>4</sup> decreases double support time and increases the walking speed.<sup>6</sup>

Extremely high heart rates and slow walking speeds were recorded in the children with cerebral palsy during ambulation with walking aids.<sup>7</sup> Therefore, information about energy expenditure during ambulation with a walker will provide additional data with respect to which device should be used on daily basis by children with cerebral palsy. Investigations on energy expenditure during ambulation with assistive devices have been primarily based on oxygen consumption data.<sup>8</sup>

There is general agreement that the closer a gait pattern is to normal, the less energy will be expended.<sup>9-11</sup> Although several reports have suggested that children using posterior walkers show better gait characteristics than those using anterior walkers, no study has been undertaken that shows the advantage of a posterior walker in terms of energy consumption.

The purpose of this study was to compare the effect of anterior and posterior walkers on gait parameters and the oxygen consumption rate of children with spastic diplegic cerebral palsy. In particular, this study was intended to determine whether a posterior walker is associated with reduced energy expenditure in these children.

Received August 9, 2000  
Accepted November 13, 2000

## MATERIALS AND METHODS

Ten children (6 males, 4 females) participated in the study. Their mean age was 9.1 years (range from 7 to 12 years), mean height was 123.0cm (range from 111 to 140cm), and mean body weight was 24.9kg (ranges from 18 to 30kg). Inclusion criteria were as follows:

- 1) Spastic diplegic cerebral palsy.
- 2) Be able to understand verbal commands.
- 3) Be able to walk independently with a walker.

Informed consent was obtained from the parents of all subjects.

The anterior walker used for the study was the Pediatric Guardian walker and the posterior walker was the Kaye Posture Control (two-wheeled) walker (Fig. 1). All subjects were able to walk independently without any walking aid for a short-distance, and had used walkers for longer distances. The both types of walker were provided by our hospitals physiotherapy unit. Under the guidance of a physical therapist, ambulation with both anterior and posterior walkers was practiced for 1 month before the evaluation, so that the subjects were familiarized with both types of walker. The children were tested twice, once with each walker in random order. They walked with ankle foot orthoses with a hinged joint at a self-selected comfortable speed. After each trial, the children rested for at least 15 minutes for their heart rates to return to basal level. Vicon 370 Motion analysis system (Oxford Metrics Inc, Oxford, U.K.) was used for gait analysis. Reflec-

tive markers were attached to the following anatomic locations; sacral marker at the midpoint on the line between both posterior superior iliac spines, bilateral pelvic markers at both anterior superior iliac spines, thigh markers at the midpoint on the line between the greater trochanter and the center of the knee, bilateral knee markers at the lateral knee joint, bilateral shank markers at the midpoint on the line between the lateral knee joint and the lateral malleolus, bilateral ankle markers at lateral malleolus, and bilateral forefoot markers at the 2nd metatarsal head. Step length, gait velocity and percent of double support time and single support time of the gait cycle were measured. At selected points of initial contact, mid-stance, pre-swing and mid-swing in the gait cycle, trunk, hip and knee flexion were determined. Temporo-spatial data and kinematic values in sagittal plane were also collected.

The energy expenditure was measured using a KBI-C (Aerosport Inc, Ann Arbor, Michigan, U.S.A.). During the 5 minute ambulation test, the first 2 minutes were considered as an adaptation period, and therefore, the average value of the final 3 minutes determined the oxygen cost.

## Statistical analysis

The Wilcoxon signed rank test was used to compare the effects of anterior and posterior walkers on the energy expenditure and the gait parameters. A value of  $p < 0.05$  was considered to be significant.

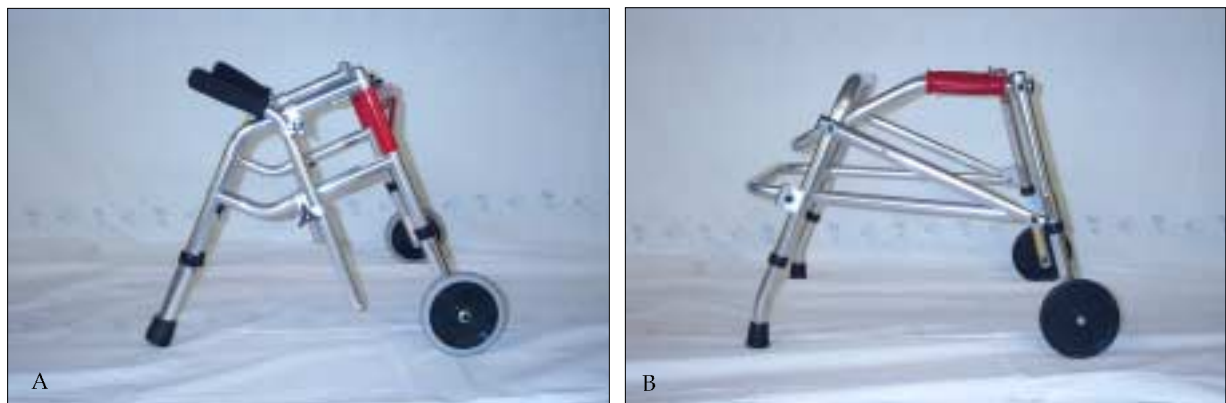


Fig. 1. Pictures of Walkers. (A) Anterior Walker, (B) Posterior Walker.

## RESULTS

### Temporo-spatial variables on gait analysis

Results are shown in Table 1. Average walking velocity and cadence with the walkers was similar. Step length and single support time were significantly greater with the posterior walker ( $p < 0.05$ ). Double support time when walking with the anterior walker was longer than with the posterior walker ( $p < 0.05$ ).

### Kinematic values in sagittal plane

Kinematic values while walking are shown in Table 2. The pelvic tilting angle was significantly lower throughout the gait cycle when using the

posterior walker, and the hip flexion angle was significantly smaller at initial contact and at midstance of the gait cycle when the children used the posterior walker. Knee flexion angle at initial contact of the gait cycle was significantly smaller with the posterior walker. No subject showed knee hyperextension at the stance phase.

### Oxygen cost

The average oxygen cost per minute and the average oxygen consumption rate for the posterior walker were lower than those of the anterior walker. The posterior walker was, therefore, associated with significantly less energy expenditure ( $p < 0.05$ ) (Table 3).

**Table 1.** Temporo-spatial Values while Ambulating with Walkers

	Anterior walker	Posterior walker	p-value
Velocity (m/min)	16.23 $\pm$ 10.51	20.37 $\pm$ 12.62	0.214
Cadence (steps/min)	56.20 $\pm$ 23.35	63.25 $\pm$ 30.78	0.297
Step length (m)	0.27 $\pm$ 0.11	0.31 $\pm$ 0.09	0.021
Single support time (%)	16.15 $\pm$ 5.90	22.41 $\pm$ 8.85	0.028
Double support time (%)	64.79 $\pm$ 11.45	56.83 $\pm$ 14.27	0.028

Values are given as mean and standard deviation.

**Table 2.** Trunk, Hip and Knee Flexion Angles while Walking with Anterior (AW) and Posterior Walkers (PW)

	Initial contact		Mid-stance		Pre-swing		Mid-swing	
	AW	PW	AW	PW	AW	PW	AW	PW
Pelvic tilting (degrees)	25.54 (5.80)	20.94 (6.30)*	30.73 (7.85)	22.25 (6.52)*	29.29 (8.63)	22.93 (5.62)*	26.66 (6.45)	21.57 (4.10)*
Hip flexion (degrees)	59.09 (8.63)	54.23 (8.98)*	33.90 (11.36)	24.48 (11.96)*	15.51 (16.23)	11.57 (16.89)	63.09 (9.73)	59.02 (8.74)
Knee flexion (degrees)	48.67 (9.45)	45.59 (10.21)*	24.27 (16.96)	20.07 (17.90)	28.86 (18.19)	24.27 (20.18)	69.68 (15.75)	65.33 (14.46)

Values are given as mean (standard deviation).

\* $p < 0.05$ .

**Table 3.** Comparison of Energy Expenditure while Walking with Anterior Walker (AW) and Posterior Walker (PW)

	Rank	1	2	3	4	5	6	7	8	9	10	Mean
Oxygen cost (ml/kg/m)	AW	2.05	1.8	0.91	0.73	0.72	0.66	0.51	0.41	0.33	0.3	0.84
	PW	1.99	1.23	0.85	0.69	0.68	0.64	0.42	0.32	0.29	0.24	0.74
Oxygen consumption rate (ml/kg/min)	AW	19.13	13.64	11.92	11.67	11.33	11.32	10	9.8	6.92	5.64	11.13
	PW	15.22	13.18	11.13	10.77	10	9.58	9.33	9.2	5.77	5.56	9.99

## DISCUSSION

This study was designed to determine if a posterior walker reduces energy expenditure and promotes a more normalized gait pattern. To minimize study bias, the subjects involved in this study were restricted to those with spastic diplegic cerebral palsy. None had undergone orthopedic or neurosurgical intervention before being enrolled in this study. Their upper extremities were good functionally and the grade of spasticity in their upper extremities was less than grade 1+ on the modified Ashworth scale. To avoid learning effects, the children were familiarized with both types of walker for a period of 1 month. A report by Greiner et al.,<sup>6</sup> also adopted these avoidance criteria associated with learning effect and chose a homogenous sample group in terms of cerebral palsy classification. The subjects in that study were spastic diplegic cerebral palsied children and they all practiced walker ambulation for 1 week to familiarize themselves with both types of walker. However, the study involved only 5 subjects. Our study involved 10 spastic diplegic patients with a narrow range of ages. The strict inclusion criteria adopted in our study might have yielded more reliable results.

Walking speed was not found to be significantly different for the walker types, although there was a tendency to walk faster with the posterior walker. Prior studies did not reach consensus on the type of walker and walking speed, some reports showed no significant difference in walking speed with both types of walker,<sup>12,13</sup> but others, reported that the walking speed was higher with the posterior walker.<sup>6,14</sup> Children's step lengths were found to be longer when they used posterior rather than anterior walkers. These results are in accordance with the results of Levangie et al.<sup>14</sup> and Logan et al.,<sup>13</sup> but not with results of Greiner et al.,<sup>6</sup> who showed no significant difference between anterior and posterior walkers in this respect. However, as they mentioned in their article this effect might have been caused by their small sample size. A significant reduction in the double support time was attributed to the posterior walker without a significant increase in walking speed suggesting that a posterior walker gave neurologically-im-

paired children more stability than the anterior walker.

Decreased flexion angles of the trunk, hip and knee proved that the posterior walker was more suitable for achieving an upright position during walking. Our results on gait parameters are similar to those of previous studies.<sup>6,13</sup> Therefore, the posterior walker shows more benefit in terms of facilitating a more upright walking position and decreases the amount of double support time.

Cerebral palsied patients showed higher heart rates and low walking speeds when walking with assistive devices,<sup>7</sup> which means that a high physiological workload was sustained during ambulation by these children. It should be borne in mind that ambulation with walking aids must be incorporated into daily life. To encourage walker use for longer durations, a reduced energy expenditure is desirable. Therefore, energy conservation is a major issue when choosing a walking aid. According to the report of Mattsson and Andersson,<sup>12</sup> no significant difference were found in the oxygen cost and oxygen consumption rates of these types of walkers.

This might have resulted from subjects' characteristics in terms of cerebral palsy classification, which classified subjects as spastic diplegic and ataxic cerebral palsied, and also from the learning effect of a previously preferred walker. In the present study, the learning effects of a previously preferred walker could be excluded because an extended practice period was allowed with both walker types. In addition, we restricted subjects to spastic diplegic cerebral palsy only, and therefore, we believe that the present study better shows that the posterior walker is associated with lower energy expenditure than the anterior walker. Moreover, this is quite understandable from the point of view that as the gait approaches normal energy expenditure decreased.

In conclusion, we believe that this study demonstrates that a posterior walker is more desirable as a walking aid, because it achieves a more upright position and requires less effort than the anterior walker in spastic diplegic cerebral palsied children.

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