FOUNDATION RESEARCH

Eric M. King*, Donald S. Bloswick*, Don R. Brown*, Judy L. Gooch**, Monica Peters**. *Department of Mechanical Engineering, **Department of Rehabilitative Medicine, The University of Utah Salt Lake City, UT U.S.A.

Abstract

Many people diagnosed with cerebral palsy (CP) or similar disorders have difficulty walking. This research evaluated the effectiveness of a Hip Extensor Tricycle designed to isolate and exercise the hip extensor muscles in children with cerebral palsy. Four children diagnosed with cerebral palsy and one with Maple Syrup Urine Disease were given Hip Extensor Tricycles for home use during an eight-week test period. The subjects were tested every two weeks during the eight week study in which the effects of Hip Extensor Tricycle (HET) use were documented. It was found that the subjects experienced improved gait and increased self-esteem.

Background

Cerebral palsy (CP) is a chronic disability which can affect persons of all ages. CP can result from nerve damage before, during and after birth. There is no single effective preventive measure, and no cure (1). A key factor is reducing the effects of CP in rehabilitative therapy. There is a general agreement that the effect of therapy is enhanced if initiated at an early age (2). The lack of strength and motor control in the hip extensor muscle group is a primary reason people with CP experience difficulty walking. This group of muscles consist of the gluteus maximus, semitendinosus, semimembranosus, biceps femoris and adductor magnus.

Physical therapists experience difficulty getting children with CP to perform conventional calisthenic exercises because they tend to be unenjoyable (3). Many children with CP lack the strength and coordination required to use traditional tricycles. A new therapeutic device called the Hip Extensor Tricycle was developed to provide enjoyable therapeutic exercise. The HET was designed to pattern the motion produced during walking. To accomplish this the seat of the tricycle was set up high so the user would approximate a standing position during use. A lower back brace and waist belt provided support and stability for the user. The legs were supported by braces with a bend at the knee. A four-bar linkage transferred power resulting from contraction of the hip extensor muscles and leg extension to rotary power in the rear wheels.

Research Objective

It was determined from previous research that the HET isolated the desired muscle group during its use by normal children (4). The objective of this research was to determine if extended use of the HET would help children with CP increase strength in hip extensor muscle group, improve gait, and increase self esteem.

Methods

Five subjects were chosen by a physical therapist for the study. All test subjects were male and ranged in age from five to seven years. Female children were unavailable during the test period. The subjects varied in strength and ability due to their age and type of CP. As noted earlier, one of the subjects was diagnosed with maple syrup urine disease which has many of the same symptoms and recommended therapies as CP. The subjects were tested at the beginning of the test and after two, four, six and eight weeks of HET use. The experimental methods are divided into three sections: strength tests, gait analysis, and parent evaluation.

Strength tests: A prototype HET was modified into a stationary test device. The device was modified by

1. Adding a brace connected to the drive wheel which prevented crank rotation.
2. Adding load cells in line with the connecting rods to measure the amount of force produced.

The subject was placed on the test HET and encouraged to generate his maximum strength in leg extension at the hip. The physical therapist helped the subject understand which muscles to contract to produce the required backward pushing motion against the load cells. A second strength test consisted of a standing subject generating maximum hip extension against a strap around the ankle. Again the physical therapist helped the subject.

Gait analysis: The subject was video tape while walking approximately four meters in both directions several time during each of five tests over the eight-week period.

A physical therapist who was familiar with each subject's personal therapy reviewed the videos of each subject for every test. The most representative gait pattern for each particular subject for each test was selected. This resulted in a single video tape of each subject in each direction for test one through five (weeks 0, 2, 4, 6 and 8) which was representative of the subject's gait pattern at that point in time. The videos of each subject's tests series (one through five) were transferred to another single video in random order to conceal the actual order of the five tests. The random video was viewed by four rehabilitation physical therapists and one doctor of rehabilitative medicine who were asked to rank the five trials for worst (1) to best (5). The evaluators were not allowed to discuss their findings or opinions during the evaluation. In cases where a difference between two test

series could not be determined, the evaluators were allowed to rank them as the same. The average ranking scores of tests one and two (week 0 and 2) were calculated and compared to the average ranking scores of test four and five (week 6 and 8) for each subject. Test three was excluded form the analysis to provide two equal groups for comparison of the beginning and ending of the test series. A paired samples t-test was performed between the average ranking scores of tests four and five for each subject. The same test was performed for all subjects combined.

Parent evaluation: A parent evaluation form was used to document any noticeable physical or psychological changes in the subjects and suggestions concerning improvements in the HET.

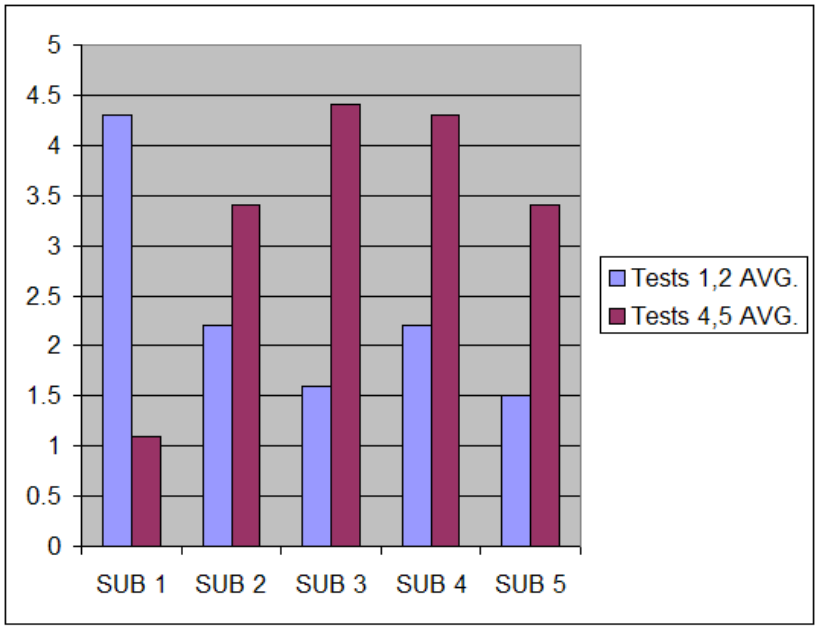
Results and Discussion

The results of the strength test were inconclusive. It was difficult for the children to consistently generate a maximum voluntary contraction.

The gait analysis indicated that four out of the five subjects experienced improved gait (the gate patterns became more normal) over the course of the study.

Figure 1 contains a plot of the sum average ranking scores of test one and two compared to the sum average score of test four and five for each subject.

Figure 1: Gait Analysis Results



This shows the differences between the expert evaluations of the beginning and end of the study. Upon further investigation it was found that Subject 1 had a degenerative hip disorder which was preventing therapeutic progress. The paired samples t-test performed between the average score of test one and two and the average score of test four and five was significant to an alpha of less than or equal to 0.01 for the four subjects that exhibited improvement. The results of the parent evaluation showed that the subjects enjoyed the HET and used it on a daily basis. While there was some decrease in daily use, after the first week, the subjects used the HET for an average of approximately 30 minutes each day and an average of about 2.5 hours per week. While this might seem modest, it must be emphasized that his "play" was, in fact, beneficial hip extension therapy. In the past it has been difficult to get the children to perform hip extension exercises for even a few minutes during their weekly one hour therapy sessions. In addition, it was found that even the most nonfunctional subjects experienced an increased sense of accomplishment and self esteem. For some it was the first time they were able to ride a tricycle of any kind. For others it helped them fit into the normal sidewalk activities which take place in every neighborhood. In at least one case the HET was viewed, not as a therapeutic device, but as a desirable tricycle by other kids in the neighborhood.

Conclusions

The HET provides an enjoyable means for children with cerebral palsy and other similar disorders to exercise and enhance gait. The HET also seems to allow the user to be a part of normal neighborhood activities and enhances self-esteem.

Future Research

Additional research is being performed to determine the changes in gait and hip extensor strength over a longer test period. A period of six months is being considered. A modified strength test is being developed in which the subject will receive visual or auditory feed back relating his/her strength generation. This may increase the reliability of the strength data. Consideration is also being given to the inclusion of a metabolic energy index in the test battery. This will be used as a measure of changes in overall physical condition as a result of HET use.

Acknowledgments

Support for this research was provided by the national Institute for Occupational Safety and Health, Primary Children's Hospital at the University of Utah, and the Ergonomics and Safety Program at the University of Utah. The authors would like to acknowledge Jeff Bean and Glade Howell, who assisted in the design of the tricycle.

References

1. U.S. Department of Health, Education, and Welfare., The NINCDS Cerebral Palsy Research Program, DHEW Publication No. (NIH) 78-1611, 1978.
2. Scrutton, D., Management of the Motor Disorders of Children with Cerebral Palsy, Spastics International Medical Publications, London, 1984.
3. Monica P., Personal conversation with Monica Peters, Physical Therapist, Outpatient Physical Therapy Department at the Primary Children's Hospital, February, 1993.
4. Howell, G., Brown, D., Bloswick, D., Gooch, J., Design of a Device to Exercise Hip Extensor Muscles in Children with Cerebral Palsy., accepted for publication by Assistive Technology, Vol. 5, No. 2, Fall, 1993.