



Adapted Bicycles: Rehabilitation Implications for Children with Physical Disabilities


Presented by Riley Hospital for Children's
Community Education and Child Advocacy Department

The purpose of this slide presentation is to:

Discuss a study measuring the benefits of adapted bicycles on the rehabilitation progress of children with cerebral palsy using functional, physical and self-esteem testing.

Emphasize the importance of bicycle safety.

The Community Education Department at the Riley Hospital for Children, at Indiana University School of Medicine, has encouraged and taught bicycle safety classes for children since 1995. The idea for the adapted bike project began from a conversation that took place between a parent of a child with special needs and a staff member. The parent stated that although her daughter had made improvements through occupational and physical therapy, the child was physically unable to ride a traditional bike with the other children in the neighborhood. As a result the child spent much of the summer sitting on the porch by herself. Department staff began to think, "How could we create a situation where we can provide children with special needs an opportunity to be involved in bike riding with children who are able-bodied?" The answer: adaptive bikes. "How can we ensure the children are safe using these new bikes?" The answer: safety education.




Funding provided by:

The National Highway Traffic Safety Administration

The Indiana District of Kiwanis International

This project, funded by the National Highway Traffic Safety Administration and the Indiana District of Kiwanis International, involved three parts: compiling information on adaptive bicycles currently available, research on the effects of the bicycles on children who use them, and bicycle safety education and training.



Purpose of this presentation

- introduce adapted bike technology
- discuss a study measuring the benefits of adapted bicycles
- demonstrate how to encourage safe and proper bicycling for all persons

The Community Education and Child Advocacy Department at Riley Hospital for Children has encouraged and taught bicycle safety classes for children since 1995. The Riley Riders and Striders Bike and Pedestrian Safety Program provides resource packets to educators statewide who are interested in planning and presenting bike and pedestrian safety courses. This program received national recognition in 1997 from the Secretary of Transportation's Community Partnership Awards Program and was commended for connecting with many partners across the state to teach bike safety at the local level. But the program was not complete, since its focus at that time was only on reaching children who are able-bodied.



Adapted bicycle products

Commercially available

The bicycles and related adaptive equipment are shown as samples of the types of equipment available, and are not to be construed as product endorsement.

The first step was to research what type of adaptive bikes were available to meet the needs of these children. Most children who are unable to ride a bike cannot do so because of challenges in their upper extremities (arms) or lower extremities (legs) or a combination of both. Other children cannot ride because of postural, visual or cognitive challenges. Research identified many companies specializing in providing adaptive bikes that help children with many different challenges ride bikes effectively.

This slide presentation highlights models of adapted bikes that are currently available to consumers and shows how these bikes can be used to accommodate children who have a wide variety of physical and/or cognitive challenges.



Three-wheel cycle



For most children who are unable to ride a two-wheel bicycle, the best option is to purchase a three-wheel cycle similar to these two cycles. (Trailmate)



Three-wheel cycle



From a basic three-wheel design, many options are available to fit each child's needs. This tricycle adds foot straps and trunk support. (Triaid)



The three wheel cycles provide stability and allow modifications to be added.
(Haverich)



Foot support

- 
 - foot support similar to a traditional exercise bike
- 
 - conventional racing bike foot support
- 
 - another example of pedal modification

There are three types of foot support that can be added to a bike. The first is the same foot support used on exercise bikes and is easily added to any bike.

The second foot support is more complex, but again, the same as can be found on conventional racing bikes.

The third pedal adds even more support. Velcro allows the pedal to exactly conform to the rider's foot.



Trunk support



E1251

- trunk support modification
- back rest for added support
- advanced trunk support system

The first tricycle has a trunk support brace made for a child with balance and trunk control problems. (Triaid)

In the second photo, trunk support can be added that provides simple support.

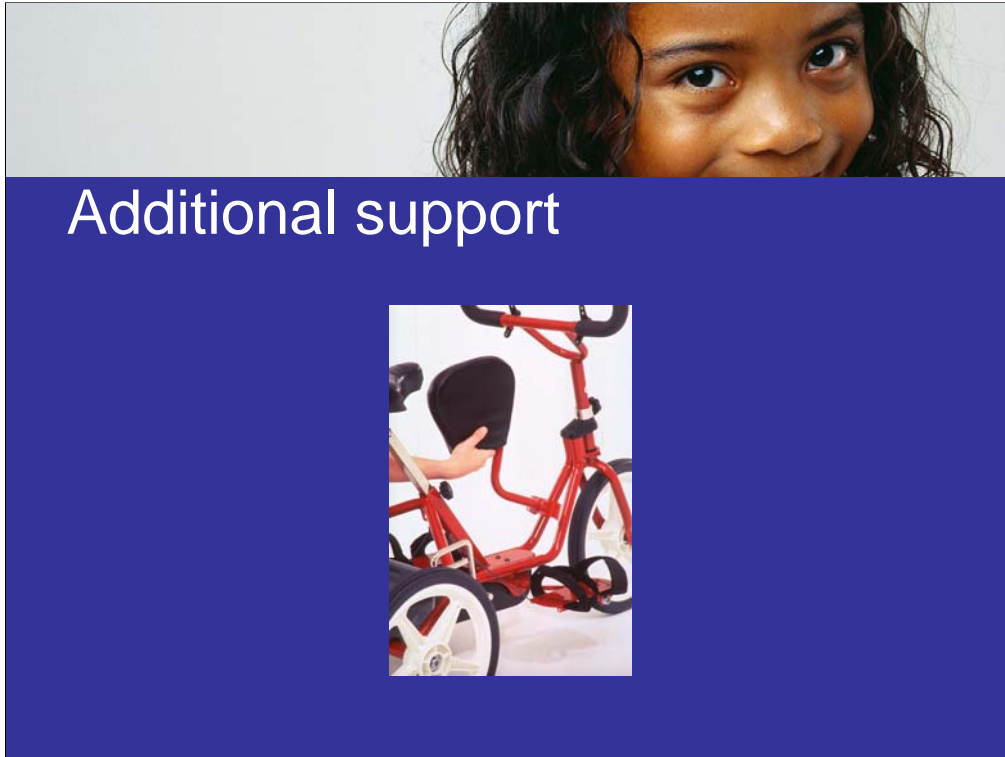
The third system offers even greater support for a child with less trunk control.



Additional support



The tricycles also can be made more complex, with head padding for a child with poor head control; greater trunk support; and an abductor wedge to maintain leg alignment. (Triaid)



This abductor wedge is removable for easier bike mounting and aids in abduction of the lower extremities.



Adaptations for foot and trunk support



The following five tricycles have various adaptations for trunk and foot support.
(Haverich)



Adaptations for foot and trunk support



GS

The image shows a young girl's face in the top left corner. Below it, the title "Adaptations for foot and trunk support" is displayed in white text on a dark blue background. In the center, there is a photograph of a bicycle with a specialized frame that includes a large, adjustable seat and a backrest, designed to provide support for the rider's trunk and feet. A small logo with the letters "GS" is visible in the top right corner of the bicycle image.

(pause)



This bike has a pull stick which is used to teach a child how to ride a bike. (Rifton)



Adaptations for foot and trunk support



(pause)



Adaptations for foot and trunk support



(pause)




This tricycle is built for a small child and provides both trunk and foot support. The loops on the handles are used to maintain hand position. (Flaghouse)





Additional adaptations




This is another type of adaptation to improve hand position.





Recumbent tricycles



These two tricycles are recumbent tricycles. Recumbent tricycles allow a person to be closer to the ground and to maintain more leg extension. (Angletech)
Adaptations could be made to both of these tricycles to provide greater foot and trunk support. (Trailmate)



Tricycles



The first tricycle is built for a young child who is not able to use leg motion but is able to use her upper body to propel the cycle. The second cycle has hand powered movement and is made for a small child. (Flaghouse)

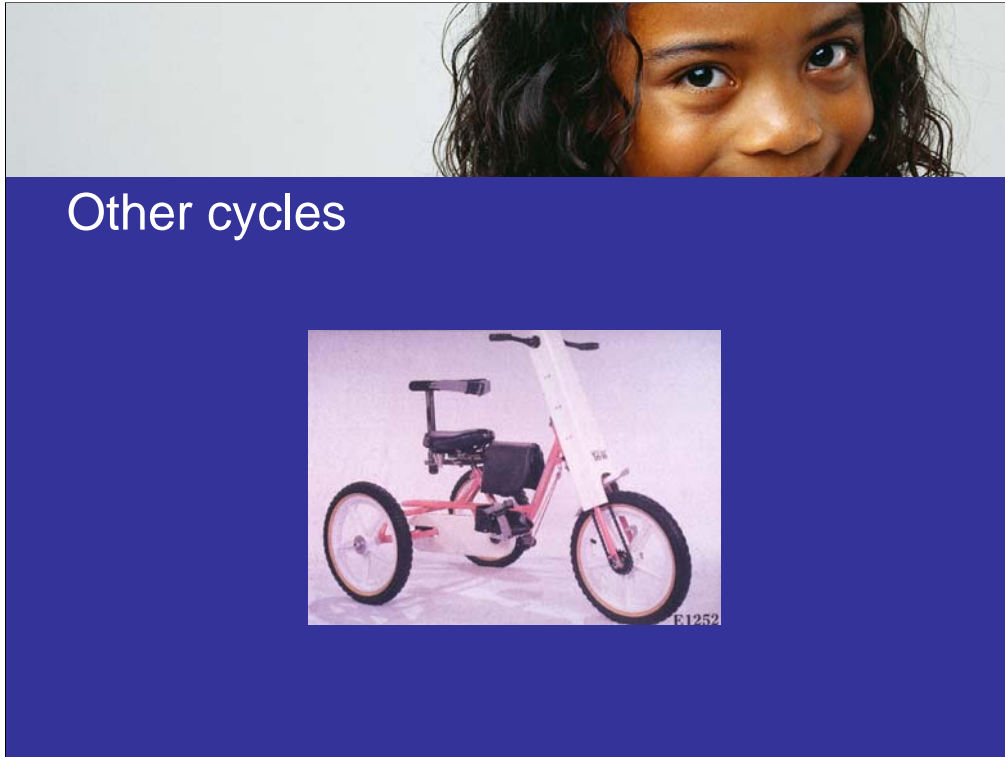
Both cycles have hand pedals that move in the same motion as a foot-powered bike. (Triaid)



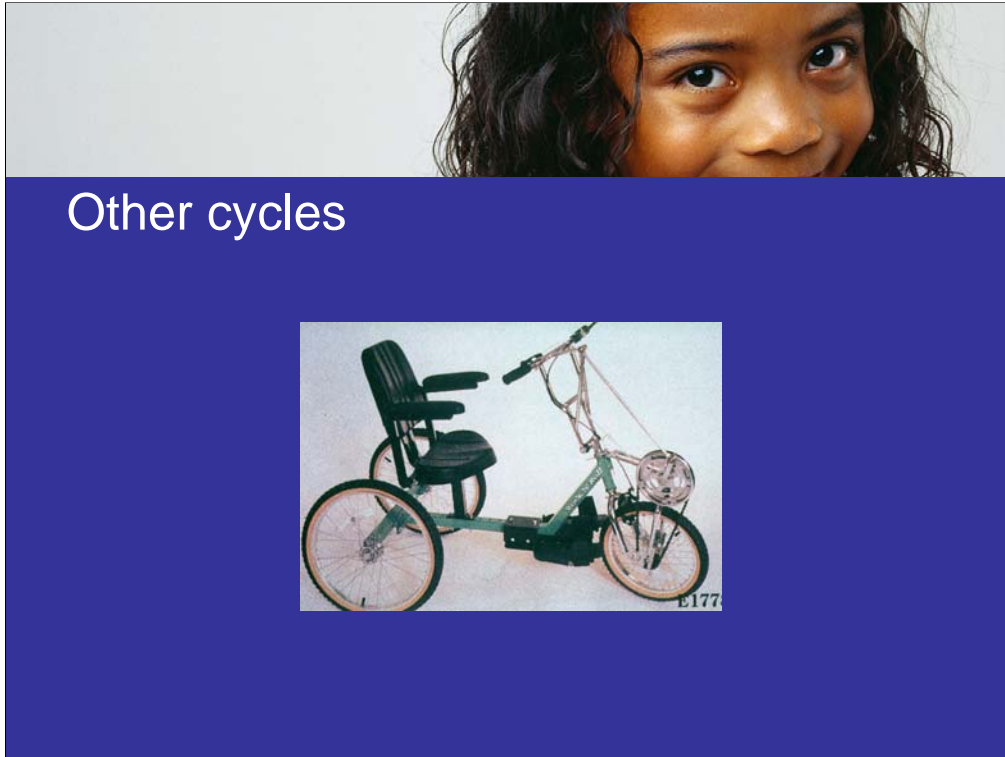
This cycle is powered by the hands, using a rowing motion. (Rock n' Roll)



Models also are created that incorporate both the hands and the feet. (AmTryke)



These types of cycles work well to strengthen weak leg muscles or to provide passive range of motion to the legs. Like the other cycles, these cycles can add trunk and foot support. (Triaid)



The cycles are powered with an upper body rowing motion and regular foot power motion. (Rock n' Roll)



Other cycles



(pause)



Other cycles



This cycle combines foot and hand power and also provides a way for the child to brake the cycle manually. The other cycles slow down when children stop propelling with their hands or feet. (Haverich)



Children who have difficulty with motor control, decreased cognitive abilities, or visual impairments have several options that enable them to ride a bicycle. Tandem cycles are one alternative. (Freedom Concepts)



Side-by-side cycles



Side-by-side cycles also provide options for persons who have difficulty with motor control, decreased cognitive abilities, or visual impairments. (Flaghouse)



Side-by-side cycles



The advantage of these cycles is that they give the child the opportunity to participate in cycling while their riding partner is able to ensure that the child is safe. (Trailmate)



Racing cycles



Action Top End® Li1 Excelsator™ Handcycle

The image shows a young girl with dark, curly hair smiling. Below her face is a blue rectangular area containing the text 'Racing cycles' and a photograph of a green and black handcycle. The handcycle is a specialized bicycle with a large rear wheel and a smaller front wheel, designed for use by individuals with limited or no lower extremity movement. The text 'Action Top End® Li1 Excelsator™ Handcycle' is printed below the photograph.

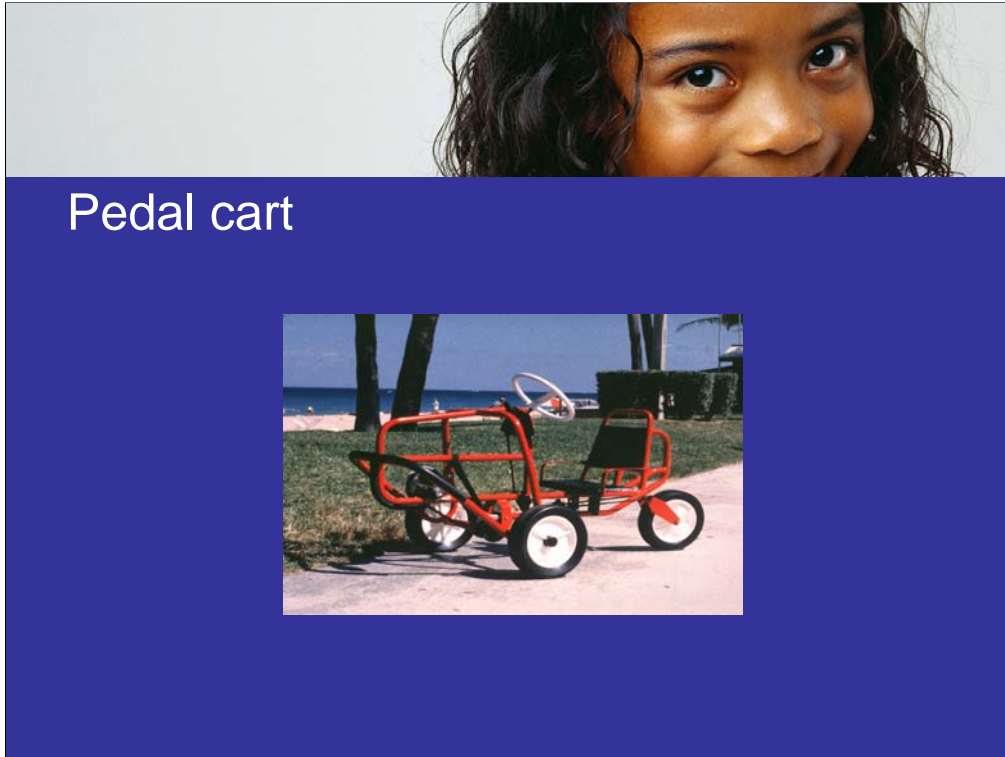
For the advanced rider, many forms of racing cycles are available. These models are high performance hand racing cycles. They focus on speed and are most widely used by people with limited to no lower extremity movement. (Action Top End)




Some models attach to the rider's everyday wheelchair. (Quickie)




Riders often prefer recumbent cycles due to the special design, which provides increased comfort and speed.



This design is called a pedal cart. They are available for young children. (Gozio)



Other cycling options




If a person cannot ride a cycle, there are options available to include the person in cycle riding. This cycle attaches to a wheelchair so the person in the wheelchair can join others in the cycle ride. Notice that these riders are not wearing bike helmets, which are critical pieces of equipment for rider safety. (Frank Mobility Systems).




Other cycling options



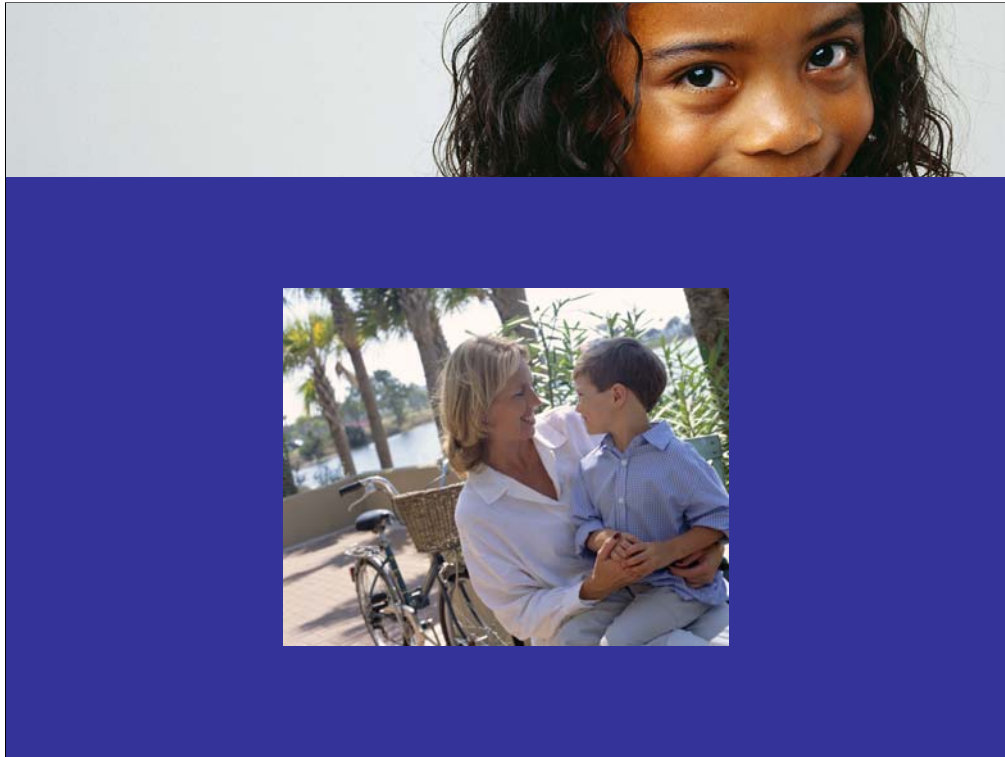
This is a carrier that attaches to a bicycle. It is unique since it provides the passenger the opportunity to pedal.



Other cycling options



If none of these cycles fit a person's needs, pull-behind carts are available in all sizes. (Blue Sky Carts)



These slides are just a sample of types of bikes available today that can be adapted to meet a variety of physical or cognitive challenges that a child may have. The sample of bikes shown here is not complete and is not meant as a product endorsement. The needs and abilities of each child must be carefully assessed to determine the specific bike appropriate for the individual.


Although research revealed many companies that specialize in producing and distributing adapted bicycles, the Community Education and Child Advocacy Department at Riley Hospital for Children also discovered that these bikes typically are expensive. The range in price is from several hundred to several thousands of dollars. Through conversations with parents of children with special needs, the Community Education and Child Advocacy Department at Riley Hospital for Children learned that few of these children had their own adapted bike. Some of these caregivers were not even aware that these bikes existed; others knew of them, but could not afford the cost. Insurance reimbursement would require documenting the physical and emotional benefits gained through bike riding, if any of these families ever were to own an adapted bike.



Development of Functional Tests and Evaluation of Rehabilitation Progress using Bicycles for Children with Cerebral Palsy

A study developed and implemented by Riley Hospital for Children's Community Education and Child Advocacy Department, in partnership with the Adapted Physical Education Department of Indiana University

Therefore, the Community Education and Child Advocacy Department at Riley Hospital for Children, in partnership with the School of Physical Education at Indiana University developed a protocol to investigate the physical and psychological effects of adapted bikes on children and to also teach children how to ride adapted bikes safely.



Project participants

- 10 children diagnosed with Cerebral Palsy
- age of participants ranged from 7 to 16, years with cognitive abilities at or above age 7
- Spastic Diplegia or Quadraplegia

For this study, 10 children with cerebral palsy (a non-progressive motor impairment of the brain arising in early development that can result in various muscular impairments usually involving the extremities) were chosen. Variables were reduced by choosing children with similar characteristics: participants were children between 7 and 16 years old; all but one child had a cognitive level above 7 years; and most of the children were classified with spastic diplegia (increased muscle tone of the legs which adversely affects the child's gait). A few children were classified with Quadriplegia which affects the legs and the arms. After evaluating the children, three types of adaptive bicycles were chosen.



Rifton Tricycle



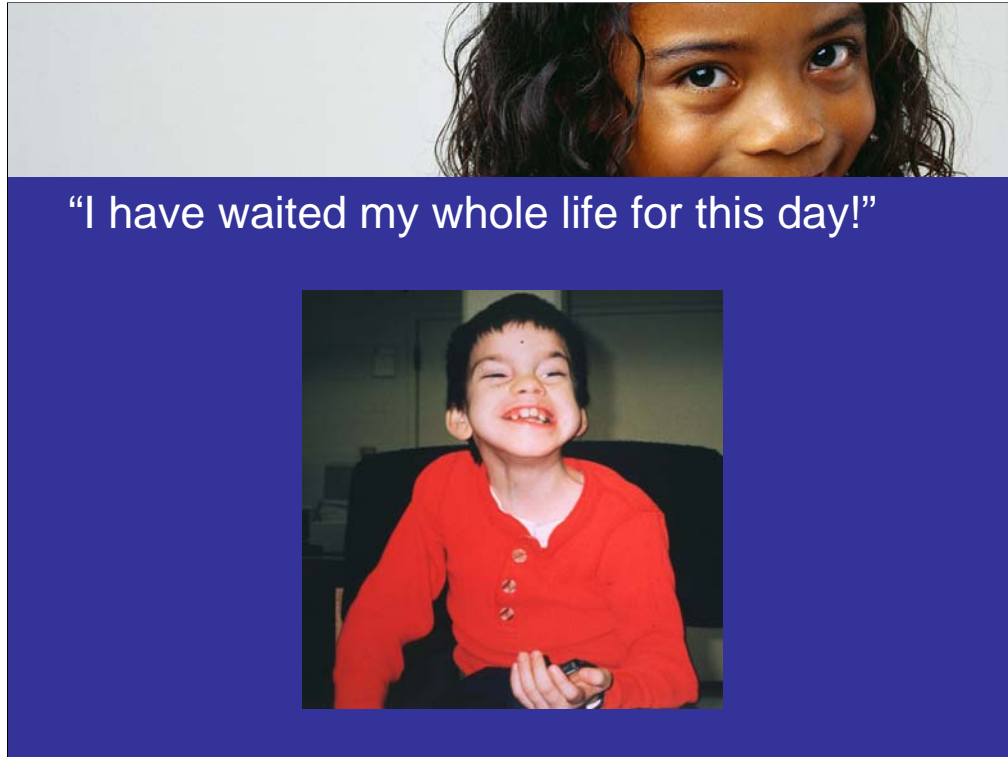
Six of the 10 children were fitted for a Rifton tricycle. All six of the children needed the foot and trunk support. Four of the children required an abductor wedge.



Two of the children received Triaid TMX cycles. One required only a strap to hold his feet in place while the other required minimum trunk support and increased foot support.




The remaining two children received a tricycle by Trailmate. Foot pedals with one strap were added to both bicycles to assist the children in keeping their feet on the pedals.



The 10 children agreed to participate in a nine-month study. From the beginning, each child realized the incredible opportunity that he or she was given by participating in the study. One child summed it up best when upon receiving his bike he excitedly stated, "I have waited my whole life for this day!"

Initial, midpoint, and final tests of functional tasks, strength, and self-esteem are required of each participant. In addition, subjects were required to ride their bicycle a minimum of 30 minutes three times a week during the study. Each week, the subjects filled out data collection sheets that documented the number of times and days that the child rode his or her bike.


The following parameters were measured at each visit.



Anthropometric data

- height
- weight
- percent body fat

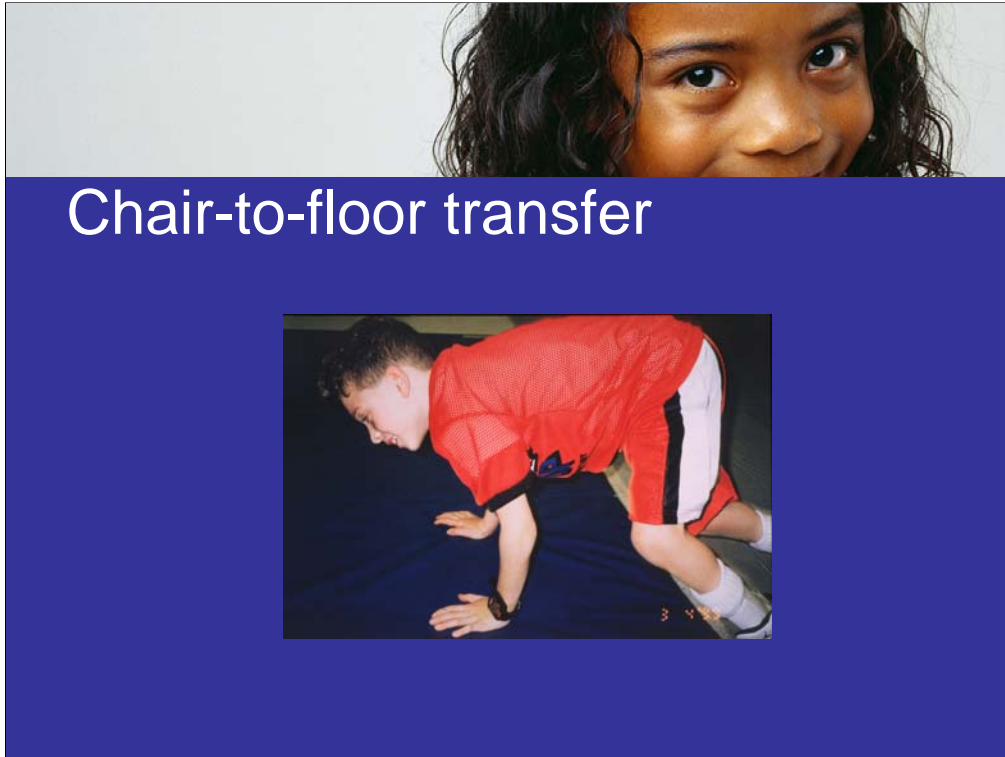
Anthropometric data was collected, including height, weight, and percent. Percent body fat was determined by using skin fold calipers.



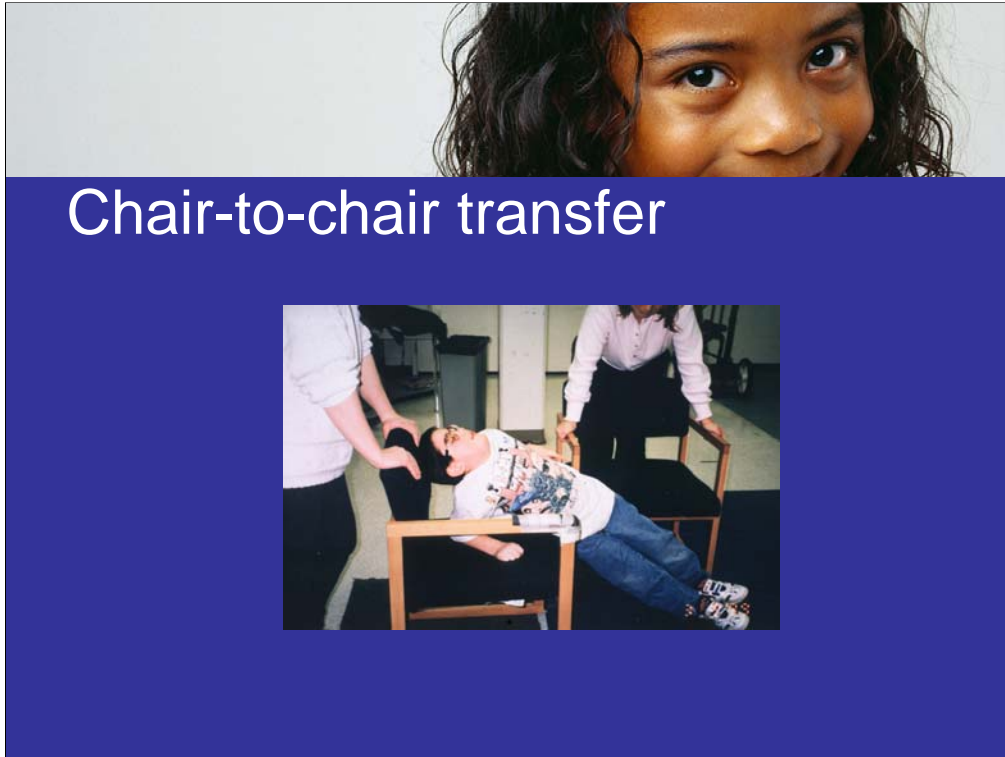
Functional tasks

- chair-to-floor transfer
- chair-to-chair transfer
- stair climbing

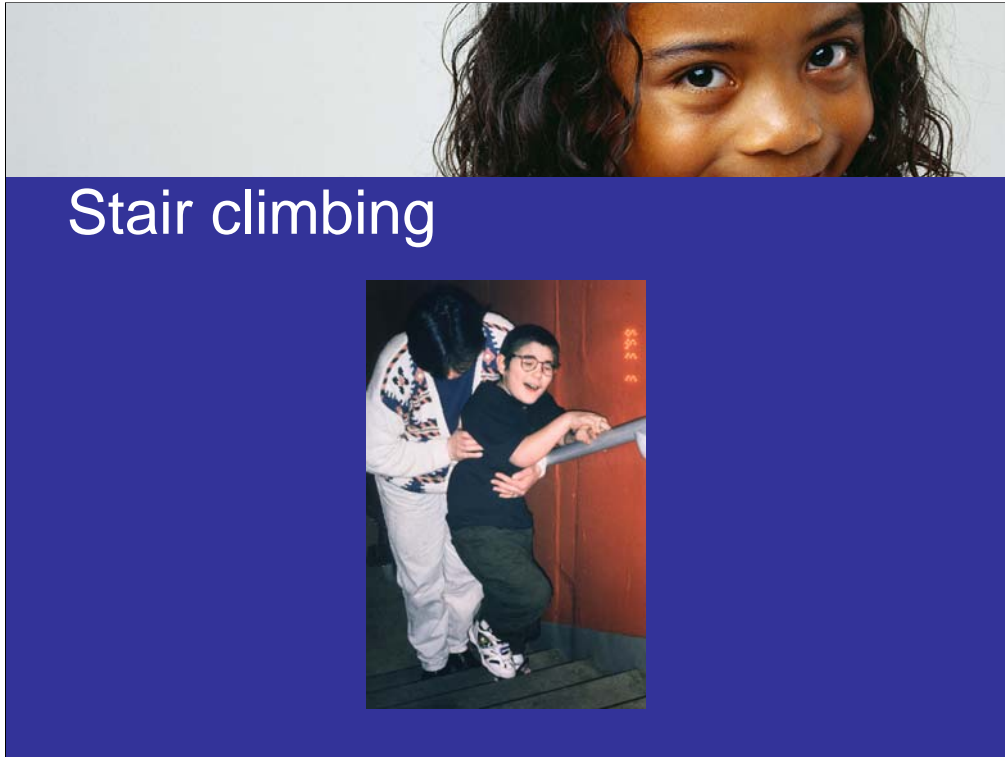
The child then participated in three functional tasks during which heart rate and perceived exertion were measured. These functional tasks examined the child's mobility and simulated various aspects of transferring, which the child faces everyday.




The first task was the chair-to-floor transfer. The child was timed from the moment they initiated getting up, to the floor (head must touch), until they were seated again in the chair.



The second task was chair-to-chair transfer. The child was timed from the moment they initiated movement until they were seated in the chair at a ninety-degree angle from the first chair.



The third task consisted of the child climbing a flight of stairs while being timed. If the child was not able to climb the entire flight, the number of stairs that she was able to climb was recorded.



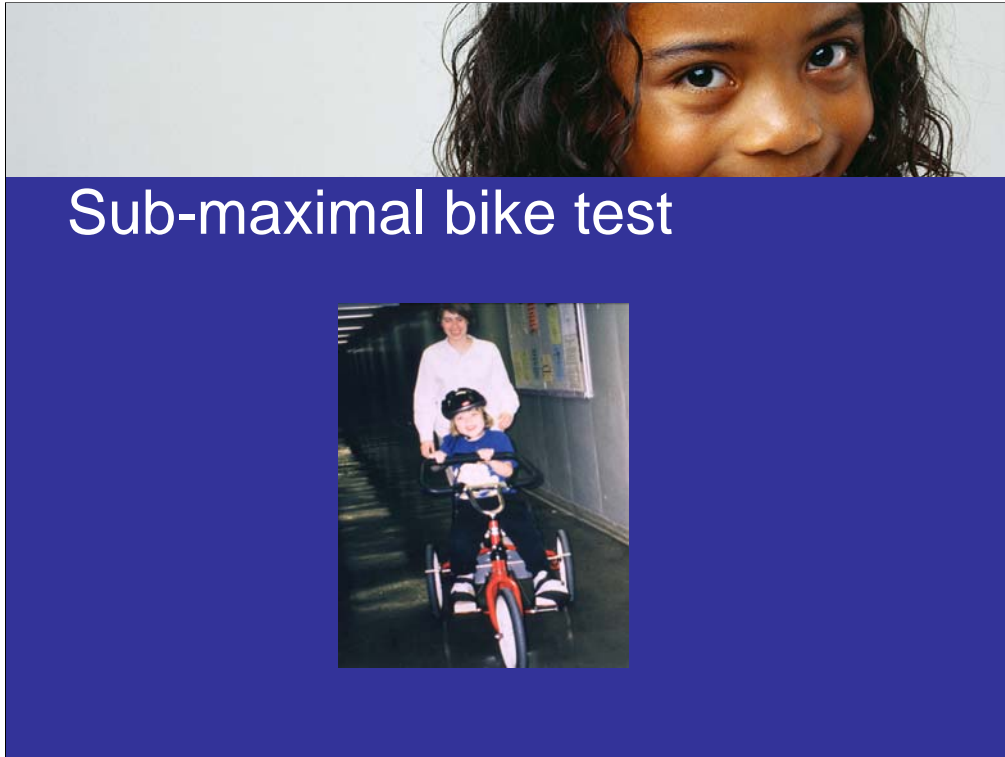
Additional physical tests

- 2D gait analysis
- sub-maximal test (endurance)
- lower extremity strength
- upper extremity strength
- heart rate

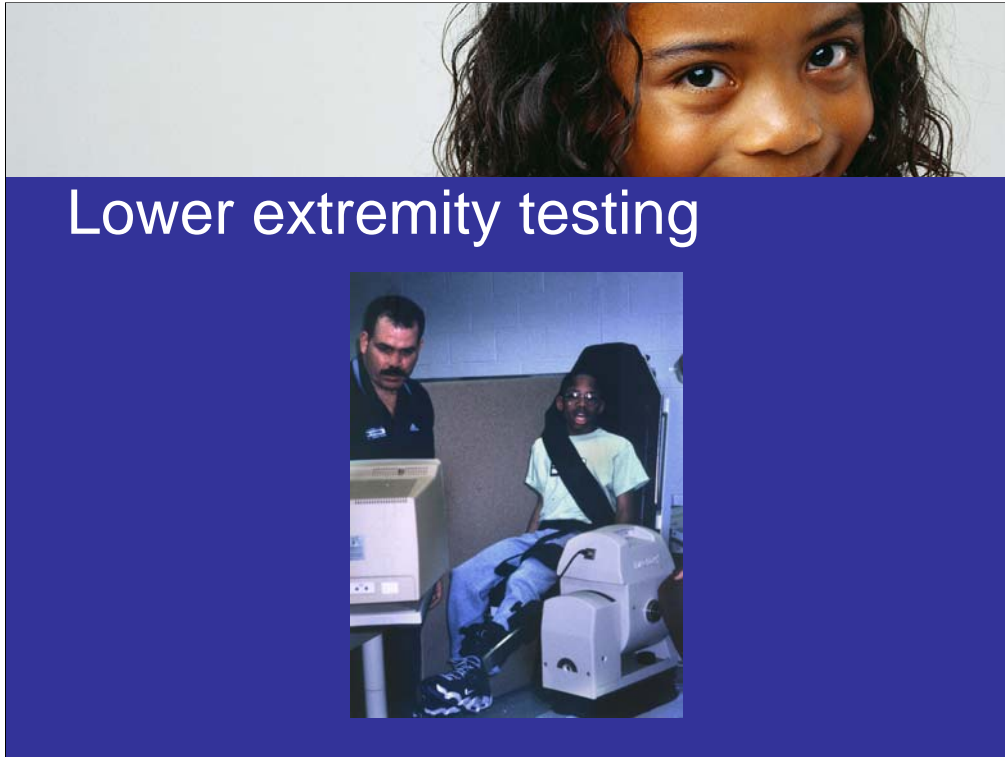
Additional physical tests included: (pause and give time to read)



2 D Gait Analysis was used to measure quality of walking patterns. This measurement showed hip, knee, and ankle movement, which indicated the muscle groups being used during the walking cycle. The gait analysis helped to determine if the child's participation in the bike project caused any changes in the walking pattern by highlighting the lower extremity muscle groups. However, this data did not prove useful due to the complexity of walking patterns presented by the children. A 3D analysis would be recommended for future studies.




The sub-maximal bike test was done to track changes in heart rate which gave the measurement for endurance. If the child was unable to pedal constantly for two minutes, he was assisted with a pull. At the beginning of the study, 7 subjects were unable to ride for 2 minutes. By the midpoint testing, 9 children had gained the strength to ride for at least 2 minutes. The tenth child dropped out of the study. The children that completed the study maintained the ability to complete this task.



Lower extremity strength was measured using a Kin-Com machine with a focus on knee flexion and extension.



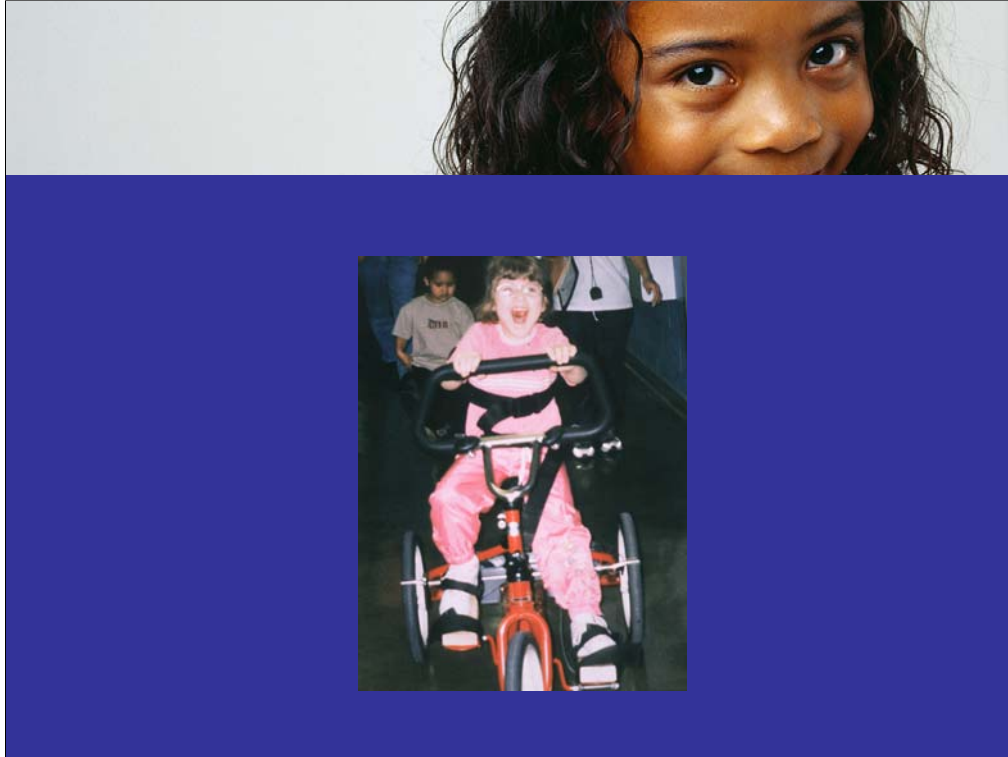
Upper extremity strength was measured by pushing weights on a dip weight machine with a focus on elbow extension and shoulder strength.



Self-esteem tests

- Pierce-Harris Self Concept Scale
- child questionnaire
- parental questionnaire

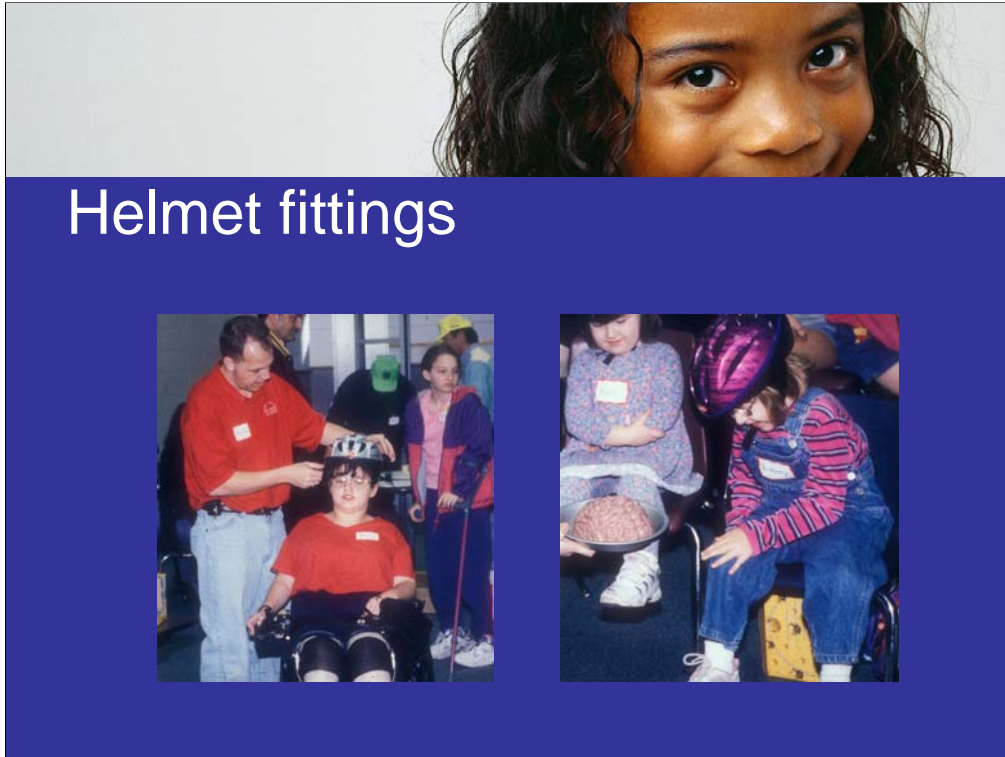
Finally, self-esteem was measured through the Pierce-Harris Self-Concept Scale, Child questionnaire and parental report.



Although smiles cannot be quantified, it was apparent to all present that the children became happier by riding a bicycle for the first time in their lives.



All 10 children arrived on a Saturday to learn about bicycle safety with their family and friends.



All the children were fitted with bicycle helmets and were taught why helmets are important. Life-like props were used to help teach the importance of helmets and safety.



Hand signals and traffic sign training

The children learned about the importance of obeying street signs and how to use hand signals when riding.



The parents attended all classes with the children to ensure that everyone knew the rules. If the child was unable to learn all the rules it is important for families to know them and monitor the child's bike riding.



A child and her new bike



Finally, the children with their families received their new bikes. The families and children were taught proper positioning on the bikes.



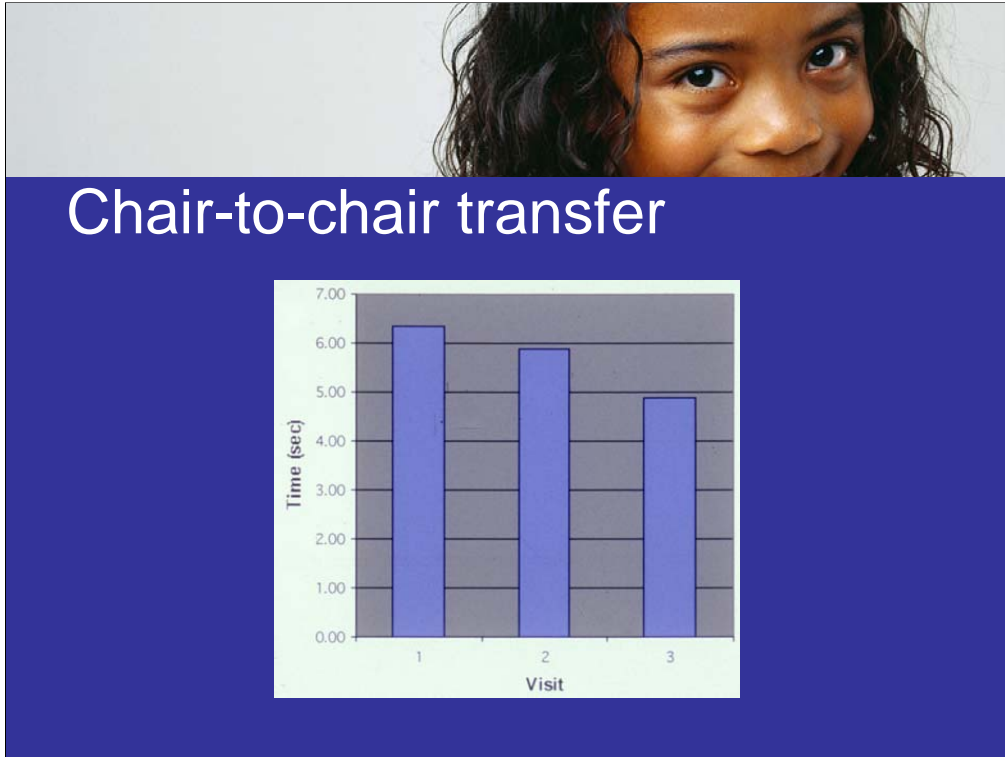
The children then proceeded outside where they practiced the skills they learned indoors. The children were monitored by trained onlookers for safety and additional instruction if needed.



A summer of riding



The children and their families then took the bikes home to begin riding all summer. The children filled out bike logs each time they rode their bike during the summer. The midpoint tests were completed in July.



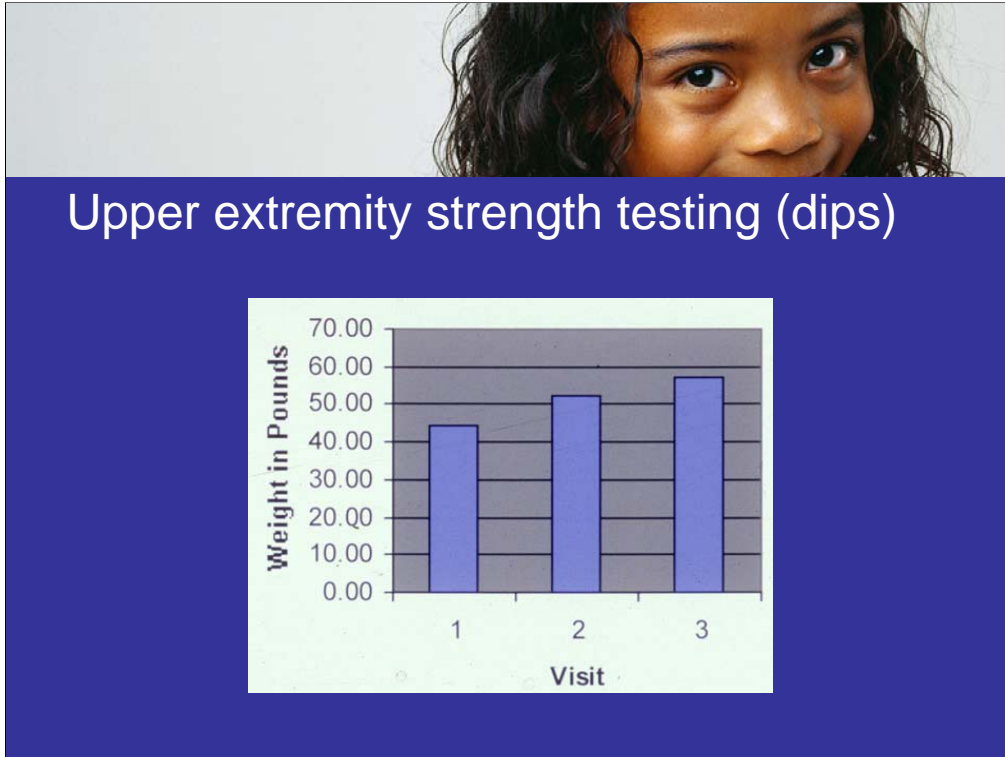
The child then participated in three functional tasks during which heart rate and perceived exertion were measured. These functional tasks examined the child's mobility and simulated various aspects of transferring, which the child faces everyday.



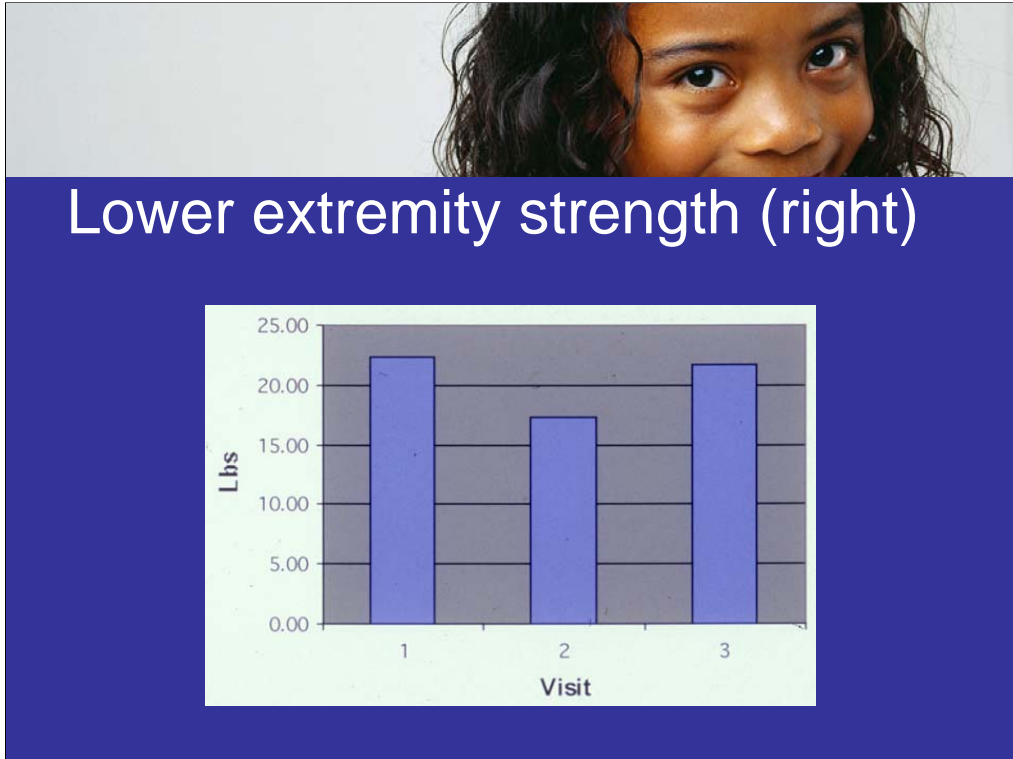
The chair-to-floor transfer times improved from 19.18 seconds to 15.98 seconds at the end of the study.



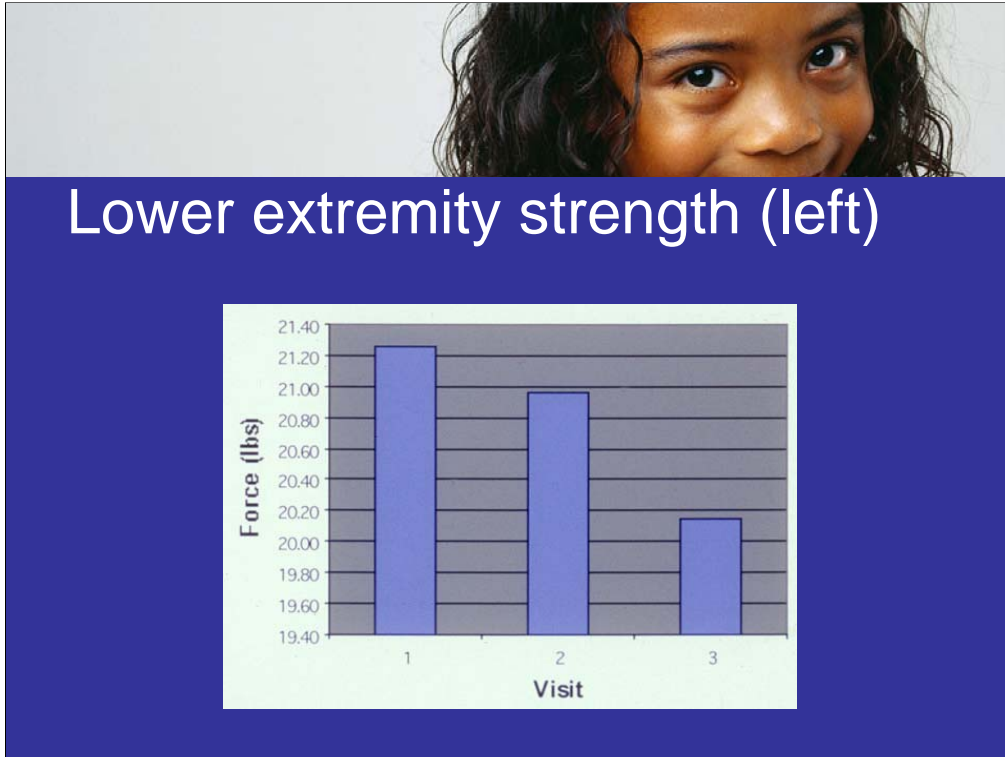
Stair climbing times improved from 2.335 seconds per stair to 2.045 seconds per stair.



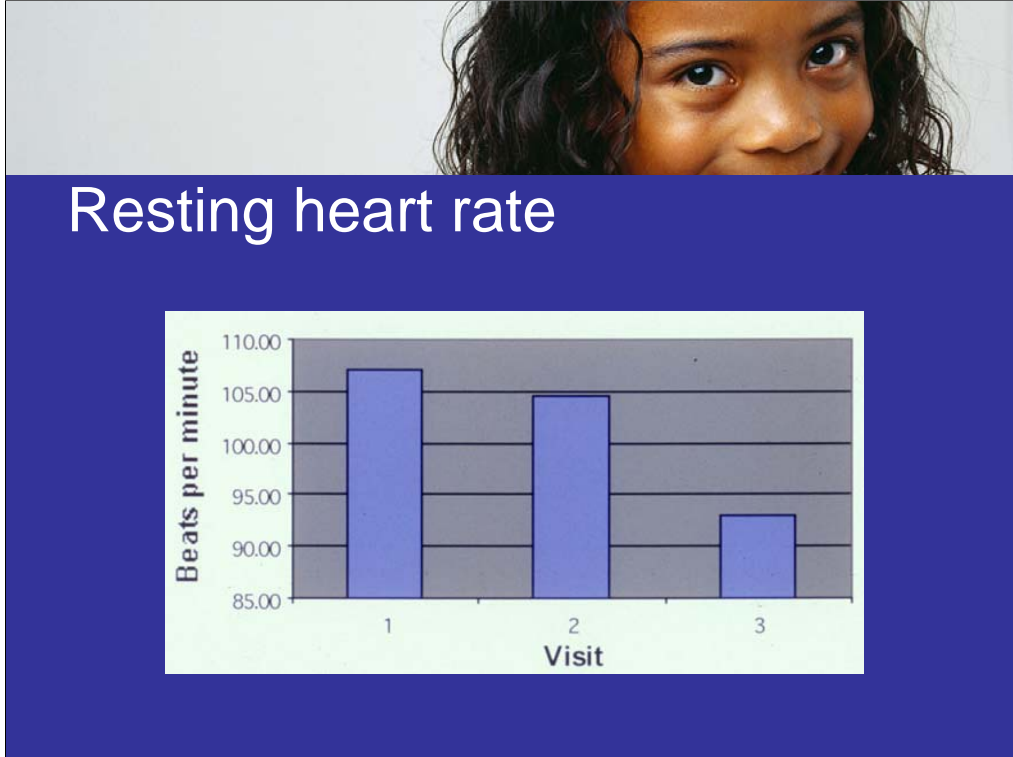
The upper extremity strength improved from an initial average of pushing 44.38 pounds to a final mean of 57.25 pounds.



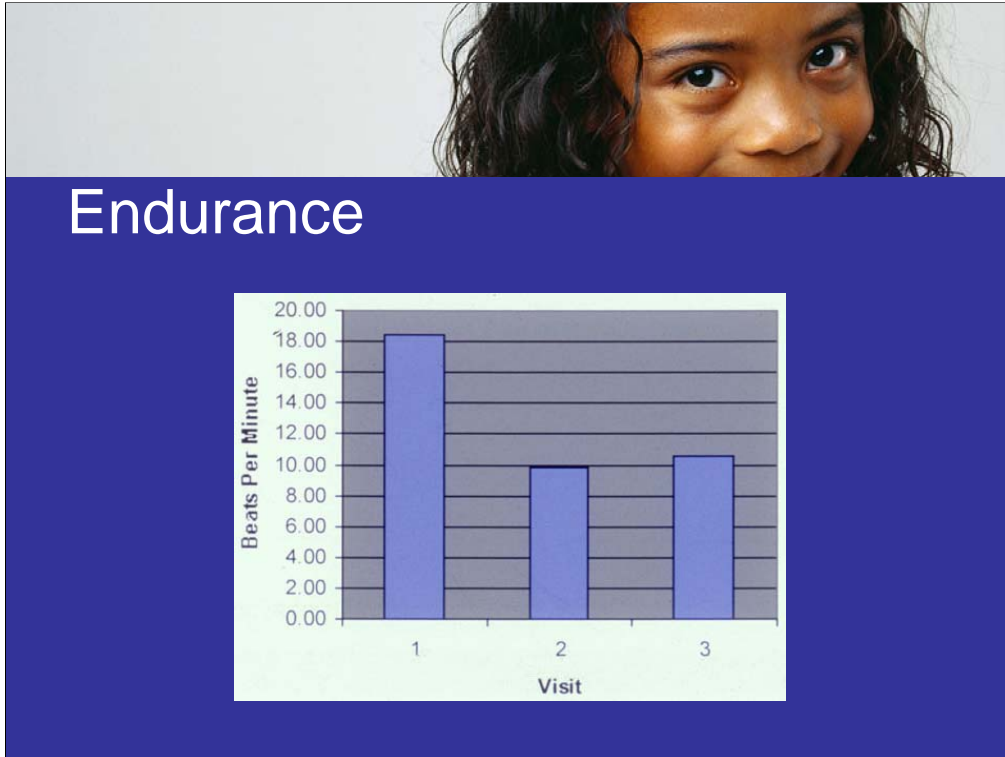
Lower extremity strength did not improve for the right or the left leg.



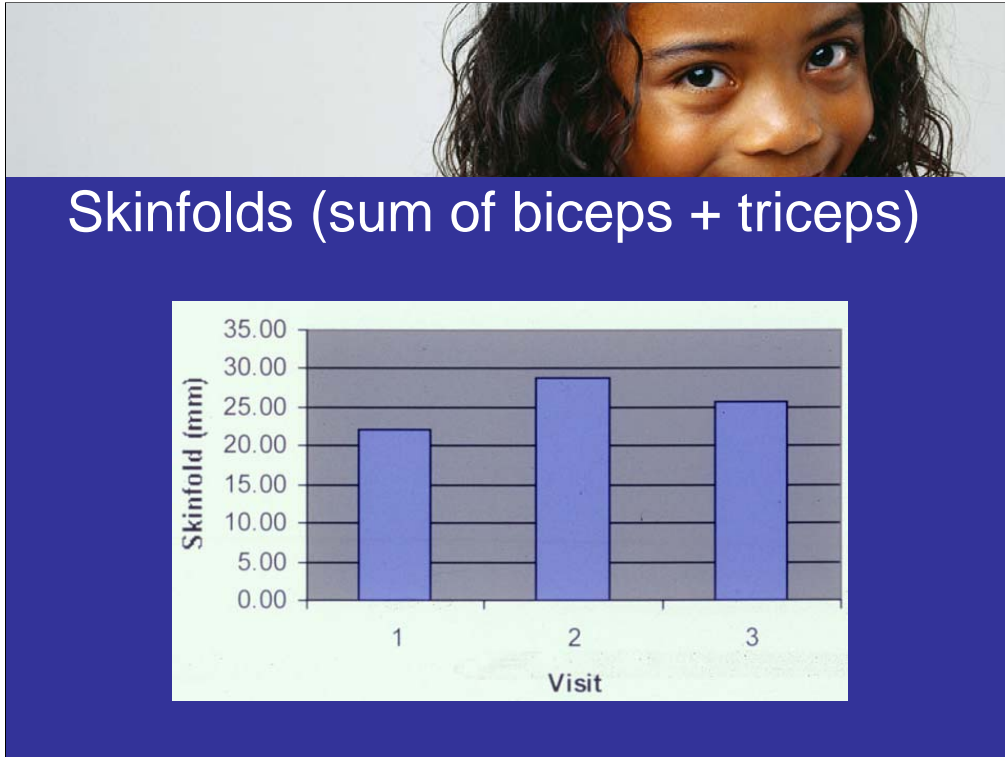
We believe this is a flaw in using the Kin-Com Isokinet testing machine to measure leg strength since the children did not understand the machine and put less effort into the test at the end of the study. Future studies would benefit from the use of standard weight machines similar to the one used for the upper extremity measure.



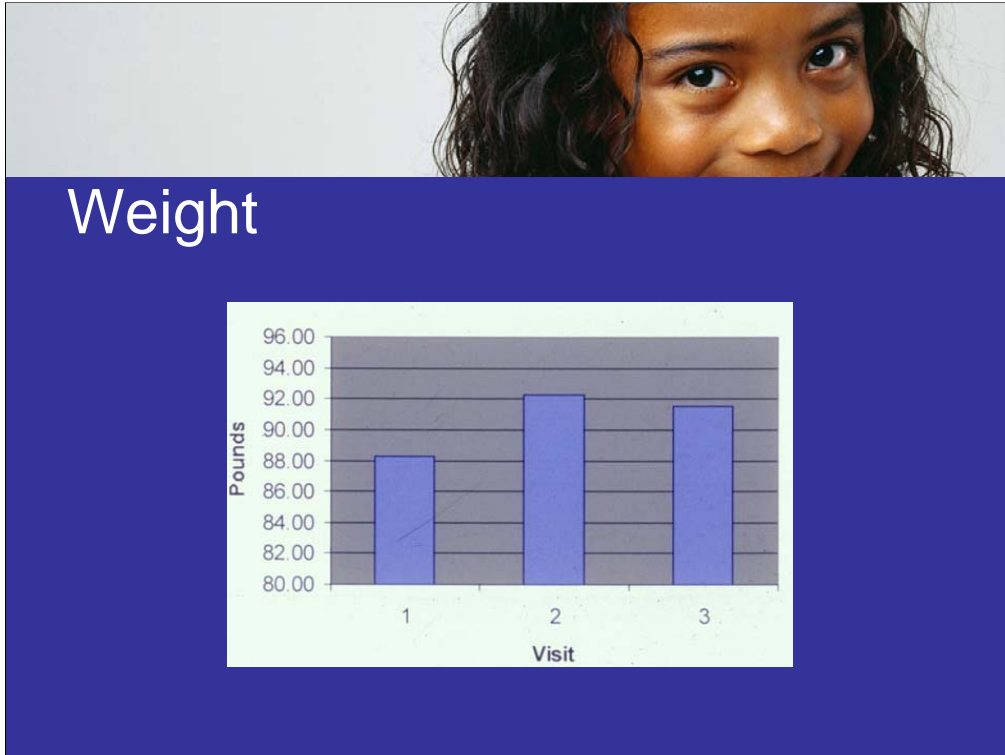
Resting heart rate improved from 107.11 beats per minute to 92.8 beats per minute. A decrease in resting heart rate demonstrates improvement in cardiovascular health.



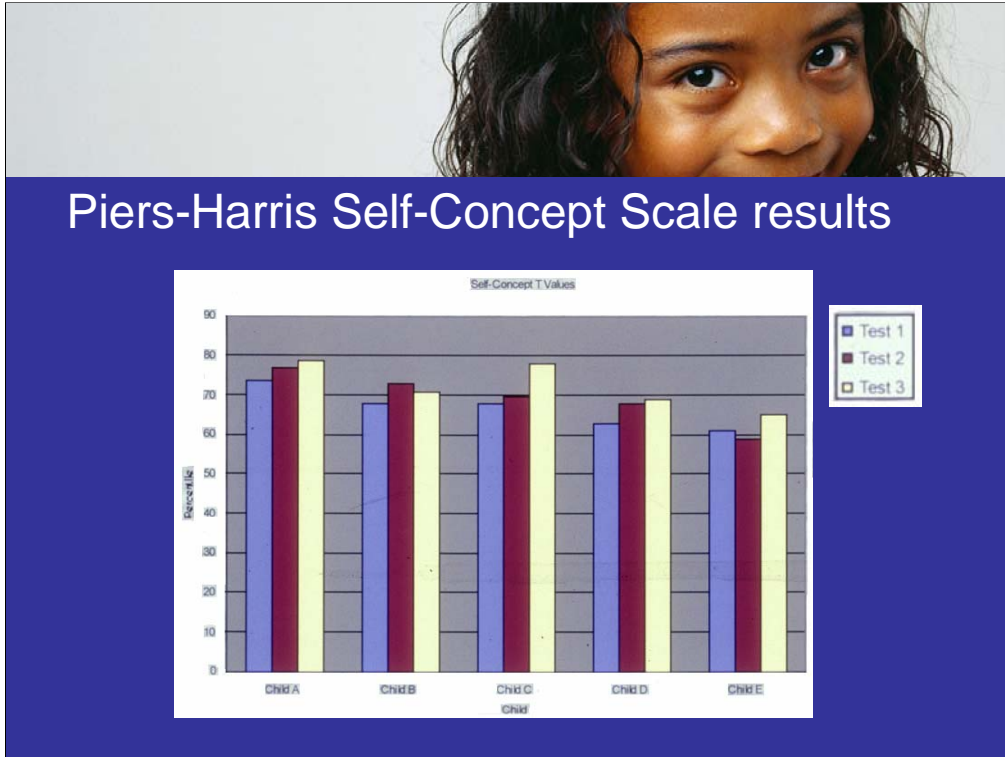
Endurance was measured by evaluating the rate of change in heart rate after riding a bike. The recovery time to baseline improved from 18.43 seconds to 10.63 seconds.




The skinfold measures were not reliable due to differences in researcher techniques and difficulty in measuring the children accurately.



The weight measurement also showed no improvement with a slight overall gain of 2.5 pounds. This could be a result of child growth or muscle development.




The Piers-Harris Self-Concept Scale was valid for five of the ten children. These five children demonstrated a positive self-concept with no significant change.



Bike safety

- 41% of bike riders ages 5-14 do not wear helmets.
- Head injury is the leading cause of death in bicycle-related crashes nationwide.
- Up to 88% of bicycle-related brain injuries could have been prevented if the rider would have worn a helmet.


Current studies show stark consequences for bike riders who are able bodied and uninformed: Up to 41% of children ages 5-14 do not wear helmets. Additionally, 80 of bicycle-related fatalities are due to head injury (National Safe Kids Campaign, 2004). A recent study concluded that up to 88% of bicycle related brain injuries could have been prevented if the rider had worn a helmet (National Safe Kids Campaign May 2002).



Study results

- Nine children participated in the study.
- Data could be used from eight of the 10 children for physical testing.
- Data could be used from five out of the 10 children for the Piers-Harris Self-Concept Scale.


After the bike safety day the children began riding their bikes at home and completed more data collection. The testing of the children completed in November of 1999. Nine of the ten children completed the nine month study. The child that quit the study decided that she did not like bike riding and returned her bike for another child to use. Data could be used from eight of the ten children for physical testing and five of the children completing the Piers-Harris Self-Concept Scale. The data presented was calculated by averaging the data from the eight children and then figuring the mean score for each task.



Functional testing

- Intraclass correlation and Pearson product moment correlation were used to determine the test reliability and the relationship between the test performance and the effort required to perform the task.
- Intraclass correlation were $R=.98, .86, .73$ for the chair to floor, chair to chair, and the stair climb, respectively.

At the beginning of the study, testing was done to ensure the validity of the functional tasks before the child began bike riding. Intraclass correlation and Pearson product moment correlation were used to determine the test reliability and the relationship between the test performance and effort required to perform the task. Intraclass correlations were $R=.98, .86,$ and $.73$ for the chair-to-chair, chair-to-floor, and stairs test.



We asked...

What benefits have you seen from your child participating in the bike project?

“He is much happier. His friends include him in bike riding activities.” (MT)

“Stronger legs. He is now walking 200-250 feet a day with his walker. Last spring it was 75 feet.” (CT)

The parental report provided valuable information on the impact of the bicycle. Some of the comments include: *(pause and allow time to read)*




We asked...

What benefits have you seen from your child participating in the bike project?

“Speed and power! She flies and she loves it! She has gotten much stronger. It’s a joy to see her enjoy herself physically.” (OM)

“His friends come over and he meets new friends.” (IB)

(pause and allow time to read)




We asked...

What benefits have you seen from your child participating in the bike project?

“He can transfer from his wheelchair to his bed without assistance. He couldn’t do this before.” (IB)

“Exercise!! Riding bikes like other kids.” (KS)

(pause and allow time to read)




Bike riding log comments

“Jenna is Ms. Meet Everybody. She is meeting new friends.” (JF)

“The bike is a cool color and is more normal looking than other bikes for disabled kids.” (OM)

“The bike allows me a lot of freedom because I can go places on my own.” (OM)


Additional comments came from the children and families on the bike riding logs. They include: *(pause and allow time to read)*



Bike riding log comments

“Marcus’s life has changed because of this bicycle. He is now one of the kids on the block, not just a handicapped boy sitting and watching his friends ride around the area.” (MT)

(pause and allow time to read)



Bike riding log comments

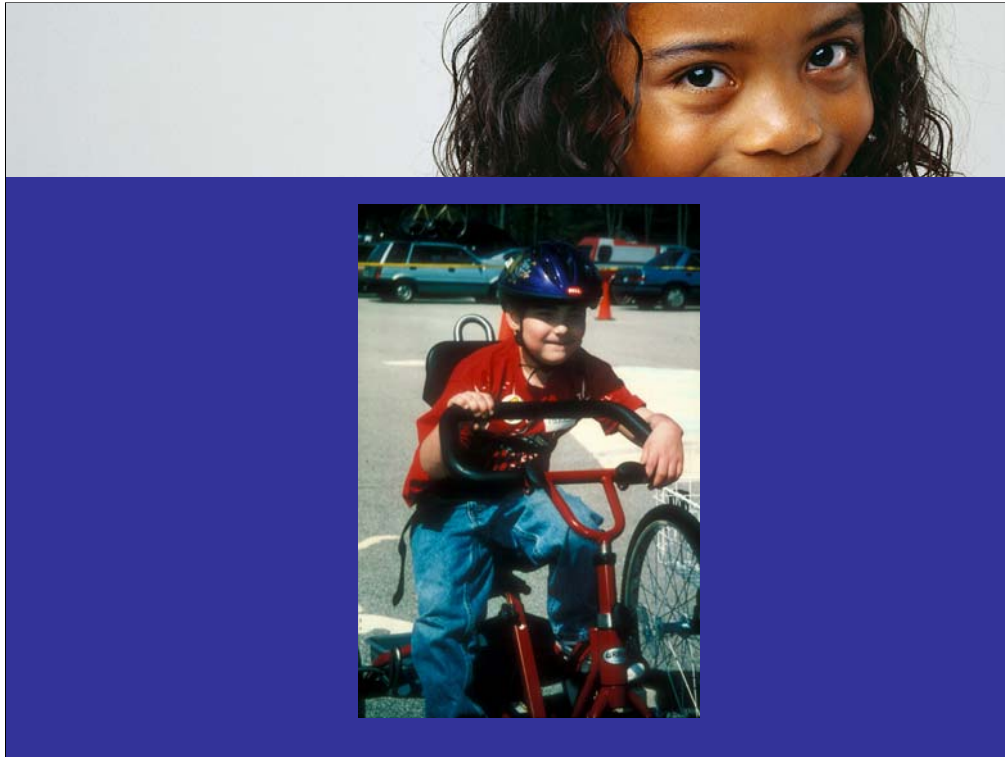
“Had a wreck; he turned too sharp. The helmet kept him from getting hurt worse. He cried, but he wanted to keep riding.” (JP)

“Sometimes I ride fast and my mom has a hard time keeping up with me.” (KS)

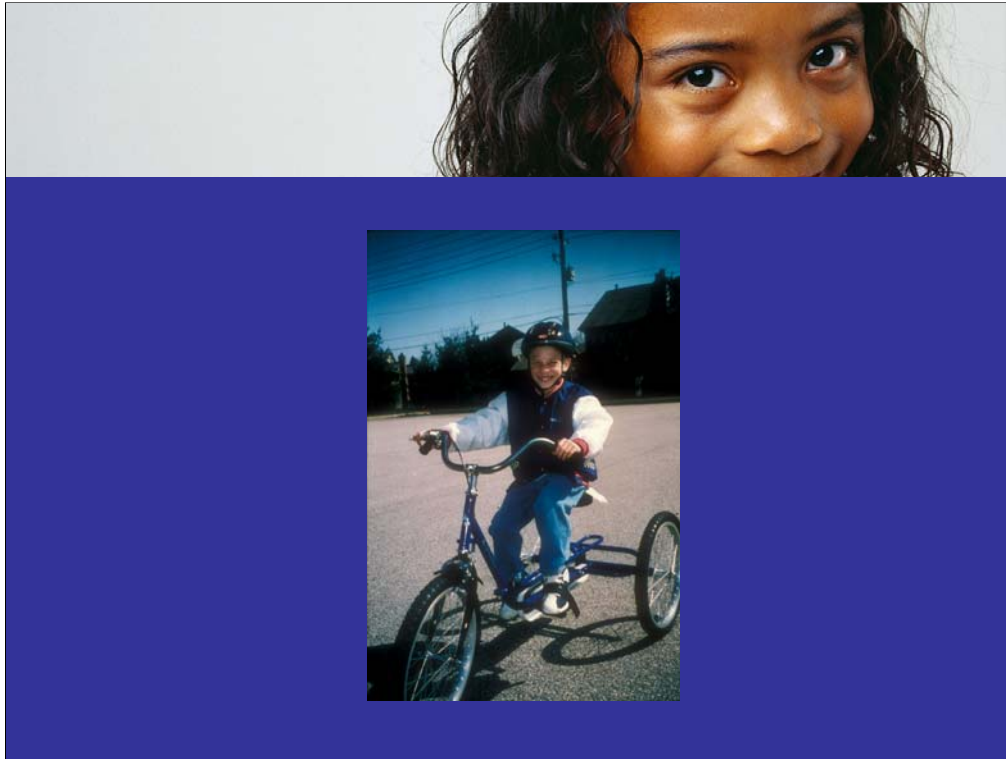
(pause and allow time to read)



Although adaptive bikes are expensive, use of these bikes has the potential to lower healthcare costs by reducing the need for return visits to rehabilitation professionals.



With the supervision of occupational or physical therapists, adapted bikes can be an important tool in the rehabilitation process. The cost effectiveness of the bikes already are being seen by this boy: his doctor reduced his treatments of OT/PT from three times a week to once every two weeks. His doctor also stated that the adapted bike has increased this child's function more than any other previous treatment that the child has had.



The adapted bike project at Riley Hospital for Children began with the idea that no child should be excluded from the opportunity to ride a bike. Given the opportunity to ride a bike, children with disabilities were able to interact with family and friends in a meaningful manner, and made improvements in physical and emotional health.



Research of this nature can help validate therapy techniques and is a model for evaluating any therapy idea and proving how the idea works to increase function.



This presentation has reviewed adapted bicycles, the measurement of functional gains, the teaching of injury prevention and the importance of these meaningful activities. Special thanks to the National Highway Traffic Safety Administration and the Indiana District of Kiwanis International for funding this project. The Riley Hospital for Children adaptive bike project is just the first step in allowing children with disabilities the opportunity to participate in bike riding with children who are able-bodied. This project serves as a pilot for communities and organizations to replicate and contribute additional research on this topic. More research needs to be conducted to fully understand the benefits that children with disabilities may gain through the use of adapted bikes.



For More Information

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Are there any questions?