**Adapted Bicycles for Teaching Riding Skills**

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Beverly was born with cerebral palsy. At age 10, she was pedaling a three-wheeler that suddenly overturned, throwing her to the pavement. She suffered serious injuries and required reconstructive facial surgery. As Beverly grew into her teenage years, she wanted to ride a two-wheeler but was often too apprehensive to even make attempts. At times she and her parents tried tandems and other adaptations, but nothing seemed right for her. Training wheels proved to be nonproductive, cumbersome, and humiliating. At age 15, she and her mother heard about a camp program designed to teach challenged youngsters how to ride bikes. Beverly was enrolled. Because of her strong desire and hard work, she learned to ride a two-wheeler without training wheels in one day—her very first day at the camp. After returning home with her mother, Beverly bubbled with pride: “If I can ride a bike, I can do anything!”

Beverly’s story is true, and in our files we have dozens of similar stories—stories of children whose lives and outlooks have suddenly brightened after learning to ride a bike. They can now do something that until then had been only a dream—to simply ride a two-wheeler down the street like other children (see box, “What Does the Literature Say?”).

**Alternatives to Training Wheels**

Training wheels represent an established methodology, even an institution, in our culture. As a consequence, in our programs we find ourselves dealing with that fraction of children (and adults) for whom training wheels didn’t work, some of whom are individuals with disabilities. Introducing a new methodology involves a paradigm shift. The numbers of children who have participated in our program are small when compared to the total candidate riding population; however, in cases where training wheels would otherwise mean the end of the bicycling journey, our methods represent an invaluable alternative.

Of course, children without disabilities can benefit considerably from our methodology, as well; but we believe the mass marketing culture that gives us training wheels isn’t about to reverse its reliance on training wheels. Those children who aren’t able to master riding using the training wheel paradigm will be candidates for our trainers and methods.

**Addressing the Challenge**

The challenge faced by the learning rider is to acquire effective internal feedbacks for balance while initially riding what is perceived by the learner to be a precarious and unstable device. The sense of instability experienced by the novice rider causes natural fears and activates ineffective defensive responses. The body tenses up, and the defensive response actions which become reinforced, are delayed, erratic, and often counterproductive.

Similarities exist in patterns of learning among children with and without physical and cognitive disabilities. The primary difference for children with disabilities is that learning may require additional time and specialized teaching strategies. Our methodology includes both specialized equipment and innovative teaching techniques designed to overcome the problems faced by novice riders and thereby to facilitate success. An unusual feature of our adapted bike programs is that a common methodology tends to work for children with a wide array of disabilities or challenges (as well as for youngsters and adults without disabilities).

**Providing Stability**

The methodology involves mechanically modifying the bike so as to mitigate its instability. The concept is to start off with a stable, adapted bicycle and then to incrementally progress to a traditional two-wheeler. The progression is adjusted to meet individual needs. The first of a series of trainer bikes has crowned rollers on the front and the back that ensure stability and yet retain the dynamic attributes of a two-wheeler (see Figure 1). This bike isn’t very agile, but it doesn’t fall over—even should the rider make awkward or faulty move-
eventually standard wheels replace ability to tip, replace flatter rollers, and pronounced crowns, and thus with greater movement for involvement in more activity. While many active alternatives exist, such as swimming, skating, horseback riding, and various team sports, the bicycle has the special aspect of being an easily accessible and relatively inexpensive individual activity. Bicycling is a pleasurable, independent activity, and it is a lifetime sport. The “Missing Bicyclists.” Nobody yet knows for certain how many people fail to master riding two-wheelers. Many nonriders have stopped trying, and hence we don’t see them out there trying and falling over. Nonetheless, based on inquiries to a number of professionals and our own straw polls, we estimate that a minimum of 3% of all children do not master riding two-wheelers, for various reasons. Some professionals who work with children have estimated the number of nonriders as high as 11%. Rintala et al. (2001) reported that 4%-5.7% of children have severe motor problems, and also that about 15% were found to have moderate or mild motor problems. We conjecture that the number of nonriders is correlated with these findings. Whatever the estimate, significant numbers of children are affected. The State of the Art and Developing Wheels. The scientific literature related to bicycles and engineering explanations sheds scant insight on how bicycles actually function, and even less on teaching children to ride. Hand (1988) examined 20 papers in the scientific literature related to bicycles in general, and found 17 of them to have outright errors or untruths. For overviews of the scientific bicycling literature, see Hand, as well as Åström, Klein & Lennartsson (2005).

For children with disabilities, as well as for some children without disabilities, training wheels become a crutch that won’t at times allow the child to transition to riding a two-wheeler. Bad postures and habits are formed as well as fears. Typical traits include stiff arms, a hunched-over posture, a downward stare, and a cautious cadence, as well as excessive reliance on upper torso leaning in response to sensations of instability. For some children, training wheels result in repeated failure, consequent frustration, and even injury.

Examination of the literature finds little in the way of actually teaching bicycle-balancing skills. One source is a Bicycling magazine pamphlet (1991); however, the portion devoted to achievement of balance focuses on use with a conventional bicycle and, by implication, able-bodied children. The pamphlet addresses balance attainment with the abbreviated statement, “Let the child develop a sense of confidence along with his balance.”

Klein (1989) initiated an engineering study of bicycle dynamics at the University of Illinois, which resulted in a series of prototype designs and clinical experiments (Klein, 1998) designed to modify two-wheelers to make the learning environment more gradual and less threatening. Burt (2002), using some of Klein’s adapted bicycle designs, examined the matter of teaching bicycling skills to children with mild mental retardation.

ments. As children ride and become more comfortable, we incrementally adjust the bike’s behavior, through mechanical modifications, so as to make it more and more like a conventional bike. (See the adapted bike with modified rear roller, as well as the nearby supply of interchangeable rollers, in Figure 2). Rollers with more pronounced crowns, and thus with greater ability to tip, replace flatter rollers, and eventually standard wheels replace

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their movements and the responses of the bike, they experience an “Aha!”

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The Roots of the Methodology

Our instructional methodology is based on the idea that people can learn or improve a skill provided that they are in an environment that allows them to be successful as they master progressively more challenging tasks. In the field of motor development, dynamic systems theory supports the concept that learning results from the interaction between an individual, the task, and the environment. Altering the task and the environment can facilitate learning (Gagen & Getchell, 2004). In the case of our adapted bike therapy program, we alter the task (i.e., riding a stable bike that has the dynamic qualities of a two-wheeler and incrementally increasing the challenge) and the environment (one-on-one teaching, specialized instructional methods, and the immersion experience in a camp or clinic setting). The child experiences success in riding at each level of challenge. Each level allows the child to improve balance and associated motor skills including visual discrimination, and thus become more graceful, coordinated, and efficient. Success at each level permits advancement to a yet more challenging configuration.

How It Works

Unlike bikes equipped with training wheels, our adapted bike therapy trainers retain the ability to tip or lean. Children thus get the feel of this action, albeit in a reduced or slow motion mode so that they are able to maintain an adequate degree of balance and control. As the child learns or “encodes” effective motor responses to maintain balance and control in one zone, we progressively adjust the bike’s dynamics to make the riding increasingly challenging. Increased challenge means that the rider is called upon to play a greater role in maintaining balance (through the use of increased visual discrimination as well as steering actions) and, as a corollary, enjoys increased maneuverability.

As teacher-facilitators, our task is to fashion and manage the environment so that the children can learn in a safe and efficient manner. We look for “participation in steering” as an important milestone in the learning process of the beginning rider. We define this as appropriately and continually turning the handlebars into the direction of the bike’s lean while riding forward and pedaling.

The child shown in Figure 6 is demonstrating proper participation in steering by turning the handlebars into the direction of lean or tilt. This steering action causes the front tire’s ground contact point to continually reposition itself underneath the bicycle and rider so as to provide support and thus “balance” the bike and rider. Participation in

Figure 1. The entry-level double roller version of the adapted bike therapy trainer series.

Figure 2. An adapted trainer with single rear roller, along with a nearby supply of interchangeable rollers.
steering is our most reliable indicator of when to switch to a more challenging bicycle. We can evaluate whether the children are participating by watching their arms in action and by observing their point of visual focus and their ability to successfully maneuver the more advanced trainer bikes. In our adapted bike therapy camps, smiling children are the rule—not the exception (see Figure 7).

Implementing the New Methodology

The Camp/Clinic Setting

The methods and bikes that we have developed typically work best in a camp or a clinic environment. Both camps and clinics are typically structured to be a weeklong immersion experience as a succession of daily riding periods. We find that children achieve better success in bike riding when instructional periods are spaced out over a series of consecutive days, in contrast to having an intense program concentrated in 1-day or possibly a weekend (2-day) event. The children appear to learn best when we immerse them in bicycling for a consecutive sequence of days.

At a camp setting, children are typically divided into groups of 5 to 8 children. While one group receives bike instruction, other groups participate in activities like art, swimming, or outdoor games.

At a clinic, on the other hand, three or four bike instruction sessions are scheduled each day for a week. Approximately 3 to 7 children attend each session; children come only for biking and are picked up following their session. In both settings, camps and clinics, the actual hands-on bike sessions typically last 1 to 1 1/2 hours.

Both the clinics and camps take advantage of our social natures. Instruction is one- or two-on-one, and several other children are present in the teaching area, usually a gym. Because the children progress at different rates, the children typically benefit from modeling of peers, (i.e., seeing others putting in effort and succeeding). We sometimes use peers, often able-bodied siblings, who already ride proficiently to motivate participants by modeling the various stages of successful riding.

The camp/clinic format also makes it viable for experienced instructors to participate and provide initial guidance to novice teachers. In addition, in such a setting we can have a fleet of bikes (15-20) available, which makes instruction efficient by minimizing the time needed to change bike configurations, as bikes at many levels of difficulty are consistently ready to go.

Teaching Protocol

Initial instruction centers on getting the children on a bicycle, achieving comfort in pedaling, and using the hands in steering to maintain balance. We use a spacious floor area with few or no obstructions, rather than narrow pathways like sidewalks. The primary objectives are to maintain a forward visual focus, pedal continuously, initiate handlebar steering actions, and consequently remain upright. Self-starting, turning, braking, and navigation (that is, maintaining a desired path and avoiding obstacles) are secondary. We focus on these skills only after rudimentary balance is achieved on a conventional or near-conventional bicycle.

Accidents and falls are virtually nonexistent on the roller trainers. The most hazardous situation we face occurs after the children have made the transition onto conventional two-wheelers. With their newfound freedom, some children may pedal faster than their ability to control the bike. The ability to keep track of and avoid moving or stationary obstacles requires practice over time for refinement. We have the children work on these skills in controlled riding exercises that demand precision, not speed.

Once children are comfortable riding two-wheelers, we engage them in tasks like navigating "figure eights," riding within a defined lane using cones, and coming to a controlled stop at an identified line. Following achievement of rudimentary riding skills, we address pedaling and braking. Finally, if time and facilities permit, children ride on bicycle paths outdoors with instructors who bring their own bicycles and helmets for this purpose.
Kinesthetic Learning and Instructional Cues

We don’t teach anybody how to ride per se; instead, the adapted bicycles do the teaching. The children learn to control the bike through their physical and visual experiences while riding, rather than through reliance on explanations or demonstrations. All students learn more effectively with an experiential approach, but this is especially true in the case of children with disabilities (Wilson, 2001). The “Aha” experienced when the child succeeds in being in command of the bicycle, at whatever level of challenge, is ultimately responsible for achieving mastery.

Bike Camp Requirements

At present, we as researchers, subject to our limitations, deliver the therapy when we are able to partner with a local institution that serves as host. Six main ingredients are required for a camp or clinic using the host format:

1. Involvement of an institution is critical. This can be a school, a university, an area bicycling club, a park district, or a civic organization. The institution typically provides the space, the liability insurance, nonprofit status to entice donors to contribute, and the infrastructure to recruit children and volunteer instructors.

2. A knowledgeable and dedicated professional, typically a physical therapist, occupational therapist, or adapted physical education teacher, is needed as camp director to see that the camp happens, and provide coordination, troubleshoot, and oversee therapy.

3. A camp also requires one or more people with previous experience to mentor newer instructors and volunteers so that they become skilled in knowing what bikes to use next, what visual cues to look for, and when to accelerate each child onto the next level of challenge.

4. Another essential person is someone with technical, maintenance, and repair expertise. The technical person needs to be familiar with both the therapy and the needs of the children, as well as knowledgeable about the varied equipment options.

5. Some means of documentation is desirable, including video recording, preassessment, on-going charting, and progress assessment for each child.

6. Last, of course, an array of bikes is necessary.

Adapted Bicycle Trainer Availability

The adapted bicycles, as shown in the accompanying photographs, are works in progress and prototypes designed and individually handcrafted by Dr. Klein. Our limited fleet of adapted bikes numbers less than 50 at present, but new adapted bikes and new designs are under development. These adapted bicycle concepts are not patented but rather are in the public domain.

Recruiting Participants

In our bicycle programs to date, we have worked with children with a wide array of disabilities and needs. Diagnosed disabilities include Down syndrome, autism, Asperger’s syndrome, sensory integration disorders, spina bifida (mild), arthritis, cerebral palsy, hydrocephalus, mental retardation, visual disorders, Prader Willi syndrome, fetal alcohol and drug syndromes, learning disabilities, orthopedic challenges, gross motor delays, epilepsy, shaken baby syndrome, developmental delay, hearing and balance problems, and many more. Age ranges are typically from age 7 to age 18, but older individuals can be accommodated.

When we accept or recruit children for camps or clinics, we typically seek out children who want to ride a bicycle, are ambulatory, have sufficient vision to see obstacles, have all limbs and use of those limbs, are cognitively capable of understanding cause and effect, and are able to manipulate and control their extremities in order to grip and turn the handlebars and keep feet on the pedals. However, in some cases children who do not fit these criteria have been successful.

Each child and associated case history is different; therefore, no set teaching formulas exist per se, and no guarantees for success can be made. We can say, however, that every participating child has benefited from the camp or clinic experiences, and 70% to 80% of enrolled children typically succeed in riding two-wheelers without training wheels during a period of 1 week. Some learn in as little as 30 minutes, and some require hours; others return for a second camp.

Evaluating Barriers to Success

In our clinical work to date, having worked with about 600 children, only a small percentage (typically 20%-30%)
has not succeeded in riding two-wheelers. We believe it is important to assess the reasons that some children have not succeeded, with an eye to improving our methodology. To date, we have identified a number of issues or reasons why children do not succeed: inadequate stamina, limited motor control, lack of focus, behavioral challenges, tactile defensiveness, severe obesity, very low muscle tone, and severe cognitive impairment.

As yet, we do not have the resources and professional expertise to achieve success with all children. On the other hand, in a few instances we have been surprised by a child’s success when we didn’t expect it. Thus, we must avoid making assumptions and be open to giving any child with a desire to learn the chance to succeed. Also, although we have successfully taught some adults to ride bikes, at present we have limited equipment in sizes suitable for adults.

Retention and Generalization Issues

After leaving our camps and clinics, children may or may not continue to use their newly acquired skills. To date, our data on retention and generalization are sporadic and anecdotal. Based on informal reports, we estimate that as many as one third of our children fail to incorporate riding into their everyday routines.

On the other hand, the situation at the North Carolina School for the Deaf (NCSD) in Morganton, a residential school for children who have multiple disabilities, provides some insight into the potential for skill maintenance and generalization. During the 2002-2003 school year, two of our adapted bike trainers were left on loan with staff. In that time, 25 children were introduced to bicycle riding with the trainer bikes, and 23 of the 25 were successful in riding two-wheelers. Moreover, of the 23 successful riders, all but one were able to retain and generalize riding skills, as the school has scheduled weekly bicycling activities. The two children who did not master bicycle riding were low functioning, but progress was made even in these cases. The one child who failed to generalize the bike riding skill developed a behavior problem of jumping off of the moving bicycle—thus, riding was discontinued for the child’s safety.

It is our hypothesis that those children in our regular camps and clinics who fail to continue to ride after camp is over need additional consistent, supervised riding experiences to generalize the skills.

In our clinical experiences to date, we have found that most children with Down syndrome, mild cerebral palsy, and developmental delay are generally able to maintain and generalize the riding of a bicycle. On the other hand, we found that children with severe autism, very low cognitive functioning, and severe visual impairments have greatest difficulty in retention and generalization of the skill. Research involving establishing a suitable postcamp/postclinic infrastructure and protocol is ongoing.

The Magic of the Bicycle

We can do all sorts of things to prepare a child for that first ride on a conventional bike without training wheels. After participating in one of our camps or clinics, the child has encoded the nuances of motor responses needed to balance and steer. But—if a child remains convinced that he or she will fall once on a two-wheeler, then the child will most likely fall. His or her lack of belief causes fears, and the fears incapacitate the body, making it tense and
It is stunning to see how easy it is for most children to ride bikes once they have gotten past the fears and have encoded basic balancing.

...and rigid and causing the visual focus to be fixated on the handlebars and front fork, as opposed to taking the horizon into account. The bike and the child will fall, largely because of the rigidity of the rider and inadequate visual input.

As a result of our research, several points have become clear:

- Children, even those with an array of challenges, are fully capable of learning how to ride a bicycle that is reconfigured with modifications such as ours.
- Even for children with disabilities, the time required to master bicycle riding is relatively short, often a matter of a few hours or a few days.
- Once children are capable of balancing and riding on a two-wheeler, we see remarkable improvements in mobility, level of activity, and self-esteem.

Many children with longstanding histories of being unable to shed training wheels and to master two-wheelers have become delighted, proficient riders as a result of participation in our relatively brief interventions. One child, age 12, mastered bicycle riding in 3 days in one of our clinics, despite years of previous failures owing to cerebral palsy and other issues.

We often find ourselves in the faith and magic business, as the children come to believe (or have faith) that they can do whatever we suggest that they can do. We use a delicate but engaging manner to establish rapport with the children. In addition, we stack the odds in the learner's favor by bringing each child through a series of small steps or progressions in bike adaptations, so that they accept their accomplishment at each stage as the norm, and are willing to try the next step. Belief is the prereq-

uisite; when one believes, all sorts of things become possible. The presence of peer role models helps build belief.

It is stunning to see how easy it is for most children to ride bikes once they have gotten past the fears and have encoded basic balancing. Several years back we worked with one particularly inquisitive and articulate girl, age 9 at the time, who mastered riding a two-wheeler. Following her first successful ride, she turned to us in amazement, and almost indignation, and said, "Why didn't you tell me it was so easy?"

References

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Ad Index

AGS, p 31
Captioned Media Program, p 67
Council for Exceptional Children, pp. 5, 40, 57, 58, 59, cover 4
Crisis Intervention Institute, p 1
Curriculum Associates, p 41
NASCO, p. 49
National University, p 24
Penn State University, p 4
SRA/McGraw Hill, cover 2
University of Nebraska, p 11
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