Spring 2018

Do Cochlear Implants Limit Bicycle Riding in School-Age Children?

Rachel Canon

DO COCHLEAR IMPLANTS LIMIT BICYCLE RIDING IN SCHOOL-AGE CHILDREN?

by

Rachel Canon

A thesis submitted in partial fulfillment of the requirements
for graduation with Honors in the Speech Pathology and Audiology

_____

Elizabeth A. Walker
Thesis Mentor

Spring 2018

All requirements for graduation with Honors in the
Speech Pathology and Audiology have been completed.

_____

Yu-Hsiang Wu
Speech Pathology and Audiology Honors Advisor

Do Cochlear Implants Limit Bicycle Riding in School-Age Children?

Rachel A. Canon

The University of Iowa

Author Note

Rachel A. Canon, Department of Communication Sciences and Disorders, The University of Iowa. Completed under the direction of Elizabeth A. Walker, assistant professor in the Department of Communication Sciences and disorders at the University of Iowa.

This research was supported with funding through the Iowa Center for Research by Undergraduates (ICRU).

Correspondence concerning this article should be addressed to Rachel Canon, Department of Communication Sciences and Disorders, The University of Iowa, Iowa City, IA 52242. Contact: rachel-canon@uiowa.edu

Abstract

Cochlear implants (CIs) support auditory access and communication development for children who are deaf. CIs support social engagement but may also limit participation in daily activities. Specifically, participation in bicycling may be reduced because a CI cannot fit comfortably under a typical helmet. This project aimed to investigate how bicycling habits of children with CIs compare to same-age hearing peers. An online Qualtrics questionnaire was sent to parents of children with CIs and hearing children. Nineteen parents of eight- to twelve-year-old children with CIs and forty-five parents of hearing children completed the questionnaire. Our results indicated that children with CIs rode their bikes more often than hearing children but wore helmets less often. Results also indicated that children with CIs began biking without training wheels at an older age. Fifty-eight percent of parents believe their child's hearing loss poses a significant safety risk with cycling. The long-term goal of this study is to bring awareness to the effects of hearing loss on the quality of life for children and reduce participation restrictions for children who are deaf.

Introduction

A cochlear implant (CI) is a surgically implanted device which replaces the lost or damaged hair cells of the cochlea. An internal receiver is positioned under the skin behind the ear and a stimulator converts the electric signal into electric currents sent through the wires inserted in the cochlea. Electrodes in the wire stimulate the auditory nerve which sends the impulse to the central nervous system to be interpreted as sound. The external parts of the CI include a behind-the-ear processor with an ear hook and battery case, and a headpiece that magnetically connects to the internal receiver (Zeng, Rebscher, Harrison, Sun, & Feng, 2008).

CIs are critically important for auditory access and social development. Without a CI, a child with a profound hearing loss has minimal access to speech. To learn to speak and to understand what others say through spoken language, a child must be able to perceive speech. Through the hearing technology of a CI, language comprehension and production skills improve in deaf children (Tomblin, Spencer, Flock, Tyler, & Gantz, 1999). Improved spoken communication enables children who are deaf to fully participate in the hearing world. At the same time, the external CI equipment may create barriers to engaging in daily life activities.

This current study will seek to determine whether children with CIs face limitations with one common daily activity, bicycling. Because parts of the CI are external, we hypothesized that it may limit participation in bicycling. Anything that makes contact with the head, like a helmet, would be an issue for CI users. Ideally, successful implantation would mean that the individual can live, participate, and learn as if they did not have hearing loss. There is little evidence on how CIs impact participation in age-appropriate activities.

The Benefits of Hearing Devices

Despite the difficulties of living with a hearing loss, hearing devices—such as CIs and hearing aids—have largely helped those with hearing impairments to socially interact with others and the world around them. For children in particular, hearing devices have aided in achieving social development milestones at similar rates to their hearing peers (Bat-Chava & Deignan, 2001). Each year, more and more children receive CIs and are enrolled into regular education schools instead of residential schools for the deaf. Bat-Chava and Deignan (2001) found that children with CIs in regular education schools performed better on standardized scores in reading comprehension and mathematics computation than those who attended specialized schools. Immersed in an environment of children with normal hearing (NH), students with CIs perform well academically, achieving higher standardized scores in reading comprehension and mathematics than students who were integrated to a lesser degree in a local school or attended a specialized school. Despite the tremendous benefits of the CI, it still has its limitations, however. We describe some of these limitations in the next section.

Limitations of CIs

CIs have an external transmitter that attaches to the side of the head via a magnet and a speech processor that fits behind the ear, similar to behind-the-ear hearing aids. This external equipment can interfere with wearing a helmet. Proper safety gear is not only important in protecting the child, but in protecting their hearing device as well. Bat-Chava and Deignan (2001) reported that several parents were tentative to let their child participate in contact sports because they worried the device would be damaged with a blow to the head. In the same study, more than 25% of parents expressed that their child had difficulties participating in athletic activities with their CI. They reported that the CI did not improve their child's hearing enough in environments where there was commotion with participants and background noise. For these

reasons, CIs may prevent children from participating in sports and other activities with their peers.

Physical Activity Involvement

Importance of participation in physical activities. Physical activity is critical to the well-being of children (Murphy & Carbone, 2008). Especially for those with disabilities, involvement in recreational activities promotes inclusion and keeps the body in good physical health. Murphy and Carbone (2008) found that children with disabilities have lower levels of fitness and higher levels of obesity because of their restricted participation. Participation encompasses the involvement of an individual in activities that involve personal care, physical activity, education, recreation, and community life (Murphy & Carbone, 2008). Participation in physical activity promotes teamwork and communication, and establishes independence, a strong work ethic, and a healthy lifestyle among children. Despite the abounding benefits, they can often be overlooked by physicians and parents.

Parental and peer influences on involvement. Some parents have concerns for the safety of their child and their child's CI when it comes to participation in physical activities. Bat-Chava and Deignan (2001) found that 28% of parents were concerned about physical complications and the ability of their child to hear in certain activities. These fears can restrict parents from allowing their children to participate in group sports or activities. If parents are not fostering their child's interest in sports or encouraging their involvement in activities with other children, their child could miss out on opportunities to develop socially and independently. Hartman, Houwen, and Visscher (2011) noted that young children do not participate in sports and other activities based on the understanding of their skills, but rather, on parental and peer influence. A child will most likely believe they can do anything, unless someone makes them

believe otherwise. Bat-Chava and Deignan (2001) found that children with NH had a strong positive influence on children with CIs. Being surrounded by peers with NH, those with CIs were more likely to be socially integrated and establish social relationships. This promoted learning and positive self-esteem in children with CIs. Results demonstrated that when no one made them feel as though they were different or restricted because of their disability, children with CIs felt like they fit in with their peers and were not limited by their hearing device.

In addition to parents and peers, it is part of the audiologist's job to ensure their patient succeed in life and enjoy their hobbies (Williams, 2017). Although an audiologist cannot modify the device, they can encourage the use of proper safety equipment, depending on the availability of such equipment. Parents, peers, and audiologists should all encourage children with CIs to try new things and not let their hearing impairment prevent them from engaging in daily activities. That being said, it is important that all children participate safely, and that children with CIs have the safety equipment that will comply with their hearing device.

Importance of proper safety equipment. In order to address the concerns of child and hearing device safety (Bat-Chava & Deignan, 2001) and promote the involvement of all children in physical activity, proper equipment must become available. Proper bicycling safety is especially important for children, as bicycle crashes are among the most common causes of injuries in childhood (Nikolas, Elmore, O'Neal, Kearney, & Plumert, 2015). Children in general have poorer attention and inhibitory control than adults. They are more likely to choose tighter gaps between cars when crossing a busy intersection, putting themselves at greater risk for injury.

Williams (2017) found that individuals with hearing devices find helmets to be uncomfortable to wear because they press on the device or snag wires connecting the device to

the receiver. Helmets with ear protection can also reduce the efficiency of the device by covering up the microphone. Modifications have been made to a hockey helmet to accommodate a CI while still providing ear protection. However, no bicycle helmet currently exists to accommodate children with CIs.

It is unclear whether CIs restrict participation in bicycling activities, or whether deaf children ride bicycles without wearing their CIs. Bicycling is a significant form of recreation and mode of independent transportation for children. If a bicycle helmet were modified, it would enable children to ride their bicycles with proper head protection while still being able to wear their hearing device. Otherwise, their participation in bicycling will be limited or they will forgo wearing their devices and put themselves at even greater risk for injury. Bicycling provides a great opportunity to interact with others and is an excellent form of physical activity. It is important that children with CIs have the opportunity to participate in bicycling and that the proper safety equipment is made available to them.

The aim of this study was to compare the bicycling habits of children with CIs to same-age hearing peers to determine the effects of a CI. In this study, parents of children with NH and those with CIs filled out questionnaire. Measures of helmet use, frequency of cycling, age to which training wheels were used, and parent confidence in their child's bicycling were assessed. The present study addressed four research questions:

Question 1: Do children with CIs ride bicycles less often than children with NH? *We hypothesized that children with CIs would participate in cycling less than their hearing peers because of the inability for helmets to accommodate their hearing device and potential safety concerns (Bat-Chava & Deignan, 2001; Williams, 2017).*

Question 2: Do children with CIs wear helmets less often than children with NH? *We hypothesized that children with CIs would wear helmets less often than their hearing peers because of the inability for helmets to accommodate their hearing device (Williams, 2017).*

Question 3: Do children with CIs begin bicycling without training wheels at a later age than children with NH? *We hypothesized that children with CIs would begin bicycling without training wheels at a later age because deaf children also tend to have difficulty balancing (Wong, Leung, Poon, Leung, & Lau, 2013).*

Question 4: Are parents of children with CIs less confident in their child's bicycling skills than parents of children with NH? *We hypothesized that parents of children with CIs would have greater caution and less confidence in their child's ability to bicycle independently as found by Bat-Chava and Deignan (2001).*

Methods

Participants

Forty-seven parents who have children with CIs who were asked to complete the survey. Nineteen responded, resulting in a response rate of 40.4%. Of the 71 parents of children with NH who were asked to complete the survey, 45 responded, providing a response rate of 63.4%. The response rate from this study is reasonable as the rate from a similar study was 33% (Muñoz, Nelson, Goldgewicht, & Odell 2011). Nineteen parents of eight- to twelve-year-old children with CIs and 45 parents of children with NH completed the survey for the study. Both male and female children were included. The mean age for the children with CIs was 10 years, 4 months (*SD* = 1.4). The mean age for the children with NH was 10 years, 8 months (*SD* = 1.2). Eighteen of the children with CIs used bilateral CIs and one child had a unilateral CI. All CI participants were affiliated with the University of Iowa Hospitals and Clinics and consented to participate in

the research study. Children with NH were recruited from a longitudinal study on outcomes of children with hearing loss and served in the NH comparison group. All procedures were approved by the Institutional Review Board (IRB) at the University of Iowa.

Procedure

A questionnaire featuring 15 questions was developed to determine how the bicycling habits of children with CIs compared to same-age hearing peers. Our questions were based on a questionnaire on biking habits in children from the Netherlands. The Dutch biking study was shown to be valid and reliable (Ducheyne, Bourdeaudhuij, Spittaels, & Cardon, 2012; Zeuwts et al., 2016). To ensure our questions were psychometrically valid, our questionnaire was developed alongside and reviewed by a biostatistician with experience in survey design.

The questionnaire included various types of questions, including forced-choice, Likert scale, multiple choice, and short answer. Using an online survey service, Qualtrics, the questionnaire was sent out to participants. Elements of the questionnaire included (1) the frequency of bicycling, (2) the age at which the child no longer needed training wheels, (3) who the child biked with, (4) the child's feelings towards bicycling, (5) the parent's feelings about their child's bicycling, (6) the frequency of helmet-wearing, (7) the frequency of CI use while biking, (8) and existing medical conditions.

Data Collection and Analysis

The survey took place from June 27, 2017 to October 11, 2017. The questionnaire was first sent out to parents of children with NH and then to parents of children with CIs. The questionnaire was sent by either email or hardcopy to the home address of the family. To those who had not yet completed the questionnaire after four weeks, a follow-up phone call was made. For those who did not answer their phones, a follow-up email was sent. The email included

information about the study as well as an individual subject ID code and the link to the survey. The subject ID code kept patient information confidential while providing the research team with access to who had completed the survey and who needed a reminder phone call. The hardcopies included a printed copy of the questionnaire and a cover letter with information about the study and their subject ID code. Chi-square tests were used to determine the numerical differences between the biking habits of the CI group and NH group.

Results

Research Question 1: Do children with CIs ride bicycles less often than children with NH?

Figure 1 shows the frequency of bicycling by subject type (CI or NH). There was no significant difference in the frequency of bicycling between the children with CIs and children with NH. For children with CIs, 83.3% rode their bikes three or more times per week compared to 81.8% of children with NH. Out of children with CIs, 16.7% rode their bikes less than five times per year compared to 18.2% of children with NH. Our initial prediction that children with CIs ride their bicycles less often was not confirmed by these data. Children with CIs rode their bicycles as often as children with NH.

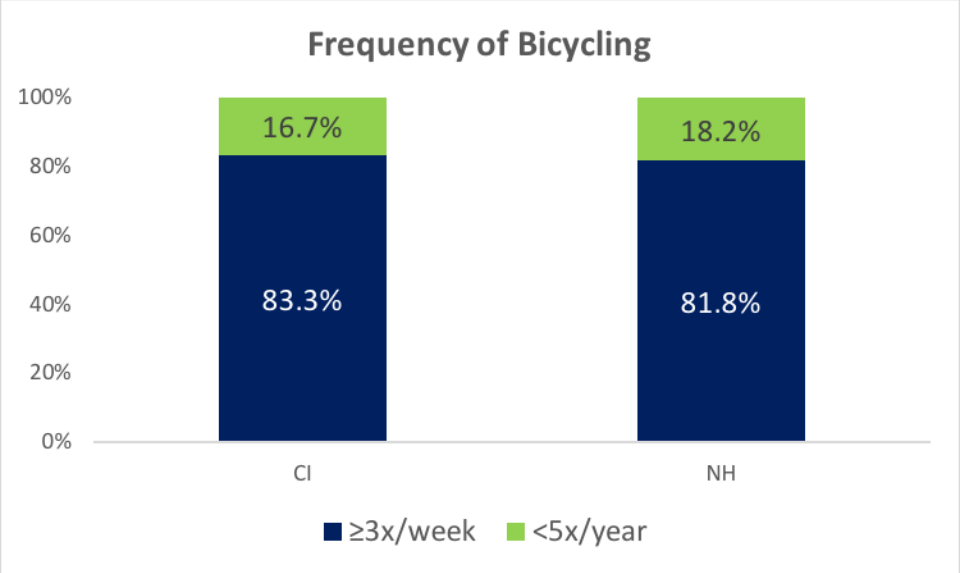

Figure 1. Frequency of bicycling

Research Question 2: Do children with CIs wear helmets less often than children with NH?

Figure 2 shows helmet use by subject type. Children with CIs were significantly less likely to wear bike helmets compared to children with NH, $\chi^2(1) = 4.8$, $p = .03$. For children with CIs, 27.8% rarely or never wore their helmets compared to 7.0% of children with NH. For children with CIs, 72.2% wore their helmets *at least sometimes* compared to 93.0% of children with NH. These results agree with our prediction that CIs may intervene with helmets fitting properly, leading children go without wearing a helmet.

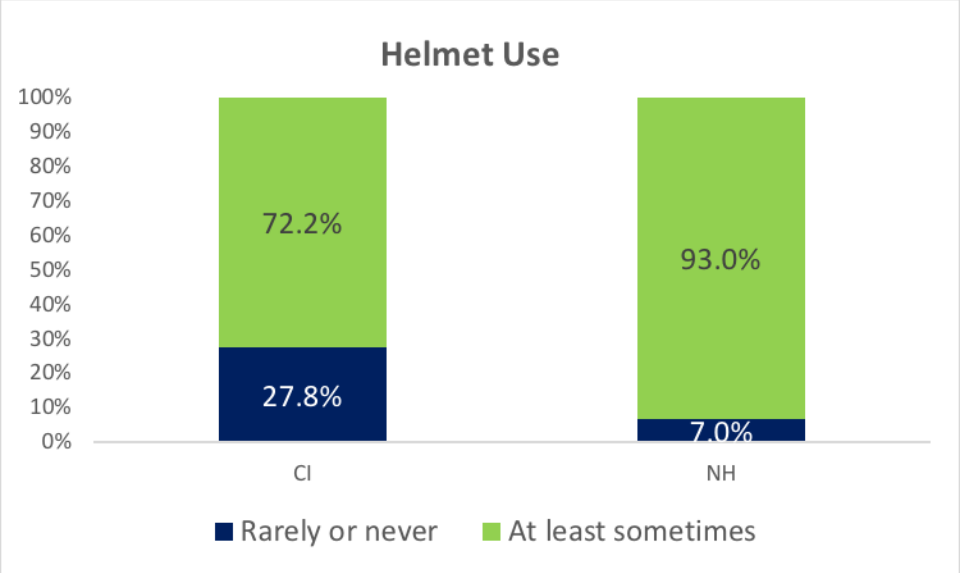

Figure 2. Helmet use

Research Question 3: Do children with CIs begin bicycling without training wheels at a later age than children with NH?

Figure 3 shows the percentage of children from each group who rode their bicycle without training wheels before and after age 7 years. Children with CIs were less likely to begin biking without training wheels by age 7, $\chi^2(1) = 7.4$, $p = .006$. For children with CIs, 47.4% began riding their bicycles before age 7 compared to 82.1% of children with NH. For children

with CIs, 52.6% began bicycling without training wheels after age 7 compared to 17.9% of children with NH.

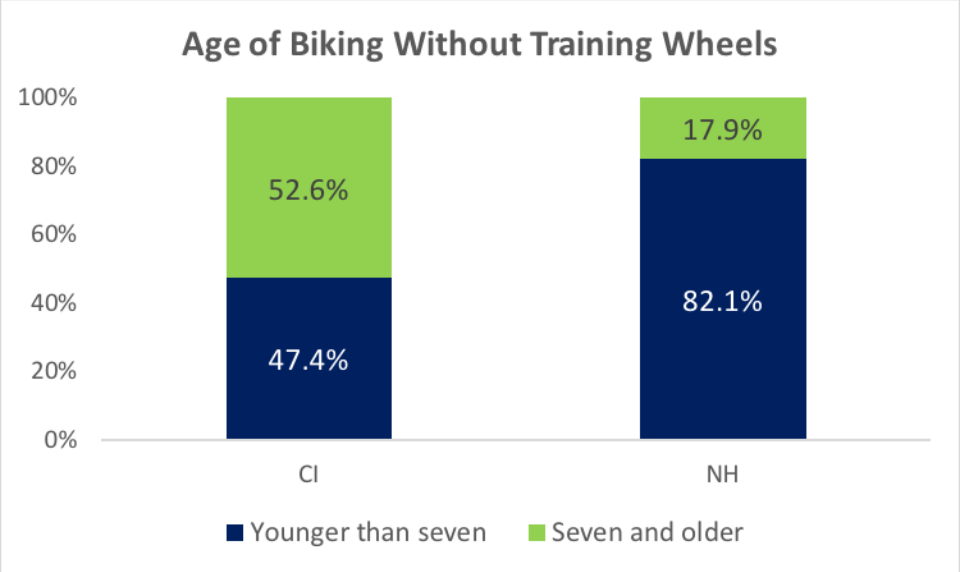

Figure 3. Age of biking without training wheels

Research Questions 4: Are parents of children with CIs less confident in their child's bicycling skills than parents of children with NH?

Figure 4 shows the percentage of parents from each group who were confident or lacked confidence in their child's bicycling skills. Parents of children with CIs were significantly less confident in their children's bicycling skills compared to parents of children with NH, $\chi^2(1) = 7.5$, $p = .006$. For parents of children with CIs, 53.3% were confident in their child's bicycling skills compared to 87.5% of parents of children with NH. For parents of children with CIs, 46.7% were not confident in their child's bicycling skills compared to 12.5% of parents of children with NH.

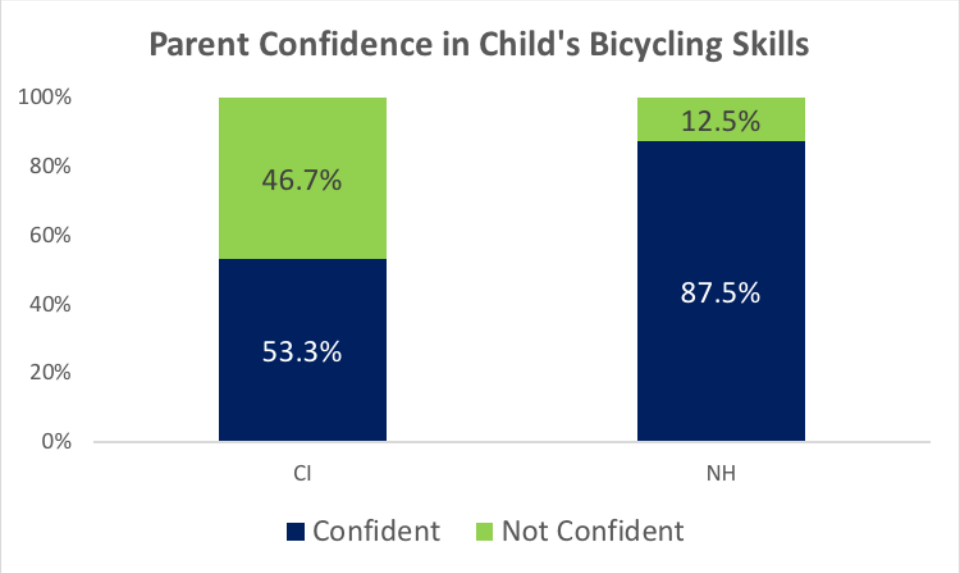

Figure 4. Parent confidence in child's bicycling skills

Research Question 5: What are some of the attitudes of parents of children with CIs toward bicycling?

Figure 5 demonstrates attitudes of parents of children with CIs towards bicycling. Approximately 58% of parents believe that their children's hearing loss poses a significant safety risk with cycling. Approximately 95% percent of parents reported that their children always wear their CIs while cycling. One hundred percent of parents found it difficult to fit a helmet well with CIs.

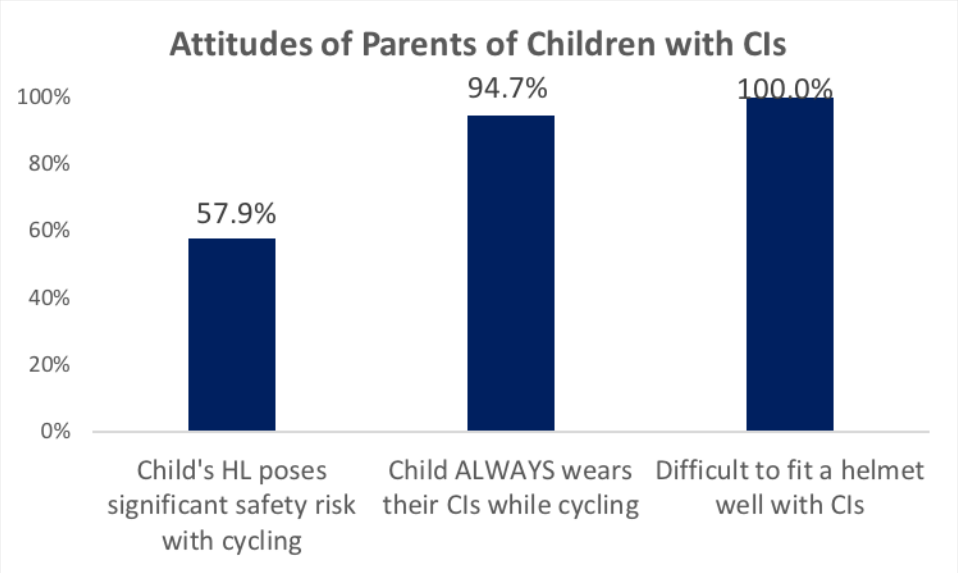

Figure 5. Attitudes of parents of children with CIs

Discussion

The current study investigated whether CIs restrict participation in bicycling activities, or if children who are deaf ride bicycles without wearing their CIs. Our survey results indicate that the use of CIs does not restrict participation in bicycling activities. There was no significant difference between the frequency of bicycle riding between the children with NH and the children with CIs. It was predicted that children with CIs would ride their bicycles less often because the CI would keep them wearing a helmet, parents would have concerns with safety, or because additional disabilities would restrict the child's participation.

Children with CIs did wear their helmets much less often than children with NH. We speculate that reduced use of helmets did not appear to have a negative impact on frequency of biking in the children with CIs. All of the parents who completed the survey agreed with the statement that CIs make wearing a helmet difficult. This is likely why children with CIs forgo wearing helmets more often than children with NH. With 100% of parents agreeing that it is difficult to fit a helmet well with CIs, it raises concern that children are not wearing helmets for

this reason. From sections of the questionnaire where parents could elaborate on their answers, a handful expressed their concern about a helmet knocking off their child's CIs. One parent said, "My daughter is reluctant to wear her helmet because it makes her CI magnets come down. [I] wish there were a special helmet for her." There is need for a specialized helmet for this population, and several parents of children with CIs would be interested in buying one if it were available.

Children with CIs were less likely to wear bike helmets and parents were less confident in their children's bicycling skills, which suggests that there are safety concerns for this population of children. Much of the safety concern lie in parents believing three things: if their child can ride his or her bicycle well, if they can hear well, and if they are safe. One parent stated, "It makes me nervous that she will not be able to hear cars or people approaching." Another said, "It is hard for her to hear others talking to her while riding a bike unless they are next to her." Even while wearing a CI, children may still be at risk for missing important acoustic cues with sounds coming from afar.

We also found a significant difference in children with CIs and children with NH regarding age of bicycling without training wheels. Children with CIs tended to begin learning to ride without training wheels at a later age, which is potentially associated with other disorders. Wong et al. (2013) founds that children with a severe-to-profound hearing loss perform poorly on balancing assessments. Two parents indicated that because of problems balancing, it took their child longer to learn how to ride a bicycle than their peers. Ten parents neither disagreed nor agreed that their child's CI helped him or her to maintain their balance while riding a bicycle.

In summary, CIs did not appear to influence frequency of bicycle riding, however, parents reported that difficulty fitting a helmet with a CI limited helmet use for this population.

There is a safety concern for this population as a quarter of them forgo wearing helmets. There are additional safety concerns from the fears that parents expressed about their child being able to hear clearly while bicycling.

Limitations and Future Directions

This study had several limitations that must be addressed. One limitation is that data were not collected concerning parent education or income level, so the influence of socioeconomic status on response rate is unknown. Another limitation is that the settings in which the children lived was not tracked. Living in a rural versus urban area could largely influence the frequency of their bicycle riding because sidewalks or trails are necessary. One parent acknowledged the impact that living in a rural area has had on their child's frequency of bicycling. "Our home is located on a major highway and has no sidewalk and little paved roadway; she primarily rides to the mailbox and back." We speculate that the majority of the children in the study lived in rural areas because they were all from Iowa or western Illinois. In more urban areas, children with CIs may ride their bicycles more frequently and learn to ride without training wheels at a younger age because of greater access to hard surface roads.

Future directions include comparing children who are hard of hearing and use hearing aids to children with NH. This could lead to better understanding about the limitations hearing aids have on bicycle riding and helmet use.

Conclusion

These results suggest that children with CIs ride their bikes as often as children with NH. However, there are safety concerns for children with CIs as they wear helmets less often. Currently, there are no bicycle helmets available that are specifically designed to accommodate CIs. The current study also sheds light on the difficulty to learn to ride a bicycle without training

wheels. Difficulty with balancing along with the child's hearing loss may contribute to parent concerns about their child's bicycling abilities. In the questionnaire, several parents expressed interest in purchasing a helmet if it were made available. With a specialized helmet, children with CIs will not omit their safety as they ride their bicycles and parents may be more confident in their children participating in activities like bicycling.

Acknowledgements

This article was completed as the first author's undergraduate honors thesis in the Department of Communication Sciences and Disorders at the University of Iowa, under direction of Elizabeth A. Walker. This project was supported with funding through the Iowa Center for Research by Undergraduates (ICRU). A special thank you to Marlea O'Brien and Wendy Fick for help with project coordination and database management and Camille Dunn for allowing us to use the CI research database.

References

Bat-Chava, Y., & Deignan, E. (2001). Peer relationships of children with cochlear implants. *Journal of Deaf Studies and Deaf Education, 6*(3), 186-199.

Ducheyne, F., De Bourdeaudhuij, I., Spittaels, H., & Cardon, G. (2012). Individual, social and physical environmental correlates of 'never' and 'always' cycling to school among 10 to 12 year old children living within a 3.0 km distance from school. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 142-150.

Hartman, E., Houwen, S., & Visscher, C. (2011). Motor skill performance and sports participation in deaf elementary school children. *Adapted Physical Activity Quarterly, 28*, 132-145.

Muñoz, K., Nelson, L., Goldgewicht, N., & Odell, D. (2011). Early hearing detection and intervention: Diagnostic hearing assessment practices. *American Journal of Audiology, 20*, 123-131.

Murphy, N. A., & Carbone, P. S. (2008). Promoting the participation of children with disabilities in sports, recreation, and physical activities. *Pediatrics, 121*(5), 1057-1061.

Nikolas, M. A., Elmore, A. L., Franzen, L., O'Neal, E., Kearney, J. K., & Plumert, J. M. (2015). Risky bicycling behavior among youth with and without attention-deficit hyperactivity disorder. *Journal of Child Psychology and Psychiatry,* 1-8.

Tomblin, J.B., Spencer, L., Flock, S., Tyler, R., & Gantz, B. (1999). A comparison of language achievement in children with cochlear implants and children using hearing aids. *Journal of Speech, Language, and Hearing Research, 42*(2), 497-509.

Williams, N. M. (2017). Accommodating active lifestyles: patient-centered hearing care for sports and fitness. *The Hearing Journal*, 22-27.

Wong, T.P.S., Leung, E.Y.W., Poon, C.Y.C., Leung, C.Y.F., & Lau, B.P.H. (2013). Balance performance in children with unilateral and bilateral severe-to-profound-grade hearing impairment. *Hong Kong Physiotherapy Journal, 31*(2), 81-87.

Zeng, F.G., Rebscher, S., Harrison, W.V., Sun, X., & Feng, H. (2008). Cochlear implants: system design, integration, and evaluation. *IEEE Reviews in Biomedical Engineering, 1*, 115-142.

Zeuwts, L., Vansteenkiste, P., Deconinck, F., Van Maarseveen, M., Savelsbergh, G., Cardon, G., et al. (2016). Is gaze behavior in a laboratory context similar to that in real-life? A study in bicyclists. *Transportation Research Part F: Traffic Psychology and Behaviour, 43*, 131-140.