The Impact of Full Time Use in Pediatric Cochlear Implant Users

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Background

Cochlear implantation for infants diagnosed with congenital profound hearing loss has become a standard treatment option, with literature supporting better spoken language outcomes the younger the child is implanted. While cochlear implants (CIs) offer a powerful means for spoken language development, retention of cochlear implants for babies and toddlers can be challenge. Current generation speech processors provide datalogging information regarding the average time the speech processor is powered on and locked to the internal device.

There is no universal definition of full-time CI device use. Wear time is known to increase with age; however, this is quite possibly due to smaller sleep requirements as children age.

The Hearing Hour Percentage (HHP) calculates CI device wear time as compared to age equivalent normal hearing peers. The calculation considers the average time typically developing children spend awake and listening based on age. By contextualizing device to use the amount of time typically hearing peers have access to sound, clinicians can make age-appropriate recommendations to encourage age-appropriate language. For example, the average 2-year-old is awake and accessing speech for 12 hours a day. A peer wearing a CI 8 hours a day would have 67% HHP or 67% equivalent access to sound as their age equivalent peer. Early establishment of 80% HHP Has been found to be a better predictor of spoken language than age a cochlear implantation (Park et al. 2019) and higher HHP values have been found to predict higher language scores (Gagnon et al. 2020).

Clinicians need guidance on what constitutes full-time CI use and how much wear time they should expect for their patients. Moreover, research is needed to establish how much use is necessary to yield age-appropriate spoken language.

Aim

The aim of this study is to produce an evidence-based definition of full-time cochlear implant device use that yields typical spoken language and to analyze cumulative HHP and spoken language outcomes at age 3 years as an extension of Gagnon et al. (2020).

Methods

This was a retrospective chart review, approved by the institutional review board at the University of North Carolina at Chapel Hill. Data logs were studied for forty pre-lingually deafened children who had completed a speech and language evaluation at age 3 years, a minimum of one year of cochlear implant use, and used a speech processor with datalogging. Subjects were excluded if they had a major anatomical malformation or a significant developmental delay that would preclude spoken language.

Average awake hours per age were calculated by using the inverse of the average recommended sleep times recommended by the American Academy of Sleep Medicine (Paruthi et al, 2016) which aligns with typical sleep times as noted in a meta-analysis by Galland et al. (2012). Table 1.

Cumulative datalogging from the time of activation to the speech and language evaluation date was obtained from programming software. A cumulative HHP was calculated as noted below:

$$\frac{\text{Total Hours Worn}}{\text{Total Expected Hours Awake}} * 100 = \text{Cumulative HHP}$$

Language testing was completed using either The Preschool Language Scale: Fifth Edition (PLS-5) or Oral and Written Language Scales: Second Edition (OWLS-II). Standard scores between 85 – 115 indicate age-appropriate language.

Table 1. Average awake times used to calculate HHP.

Age	Average Wake Time (Hours)
Under 3 Months	9.4
3 Months	10.4
6 Months	11.1
9 Months	11.4
12 Months	11.1
2 Years	12
3 Years	12.25

Results

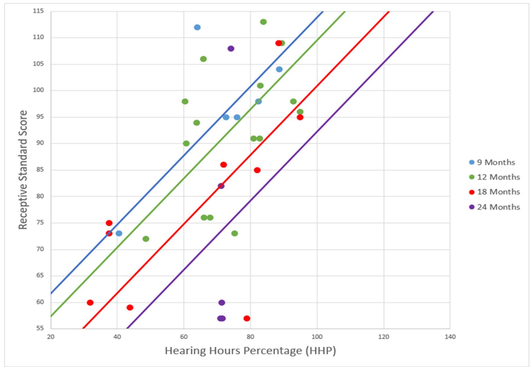
Two multiple regression models were created: one for receptive language and one for expressive language (Table 2). HHP and age at implant were the independent variables and standard scores were the dependent variables. Both models were significant [Receptive $F(2,37) = 22.23$, $p < 0.001$, $R^2 = 0.55$) Expressive $F(2,37) = 32.48$, $p < 0.001$, $R^2 = 0.64$]. Age at implant and cumulative HHP were significant predictors for each. The regression equation to predict receptive language was [Y = 61.476-1.435(Age in Months) + .653(HHP)] and the equation for expressive language was [Y=68.994-1.311(Age in Months) + .547 (HHP)]. Based on these equations, a wear time recommendation for cumulative HHP resulting in a standard score of 100 for both receptive and expressive language is noted in Table 3. Figure 1 displays the findings.

Table 2a and 2B. Summary of the multiple regression analyses for receptive (2a) and expressive language (2b) at age 3 years.

Table 1a: Receptive Language	B	SE_B	ß	p
Intercept	61.476	9.088		
Age at CI	-1.435	0.4	-0.4	.001
Cumulative HHP	0.653	0.109	0.667	< .001
B = unstandardized regression coefficient; SE_B = Standard error of the coefficient; ß = standardized coefficient.				

Table 1b: Expressive Language	B	SE_B	ß	p
Intercept	68.994	6.442		
Age at CI	-1.311	0.283	-0.461	<.001
Cumulative HHP	0.547	0.077	0.705	< .001
B = unstandardized regression coefficient; SE_B = Standard error of the coefficient; ß = standardized coefficient.				

Figure 1a and 1b. Predicted receptive (1a) and expressive (1b) standard scores based on cumulative HHP and age and implantation.



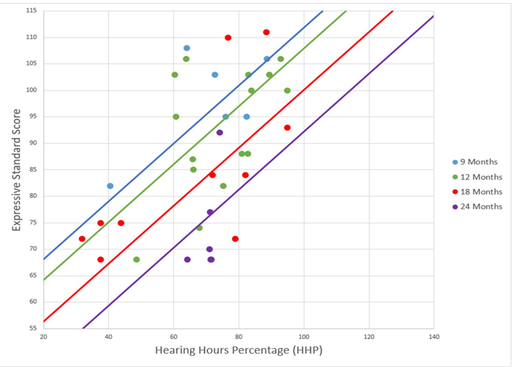


Table 3. Cumulative HHP required for age-appropriate spoken language at age 3 years.

Receptive Language		Expressive Language	
Age at Implant	Cumulative HHP Needed	Age at Implant	Cumulative HHP Needed
9 Months	79%	9 Months	78%
12 Months	85%	12 Months	85%
18 Months	99%	18 Months	100%
24 Months	112%	24 Months	114%

Conclusions

This study provides recommendations for cumulative HHP based on age at implantation when the goal is age appropriate spoken language. A minimum of 80% HPP is required for those implanted at the youngest ages. For children implanted at 12 months and older, a greater HHP is needed along with listening and spoken language therapy to help close language gaps (Leigh et al, 2016). As the age at implantation increases, the requisite HHP also increases, helping to also reinforce reduced age at implantation for optimal spoken language outcomes..

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