

Background

- Pediatric amplification best practices include measurement of each child's real-ear-to-coupler-difference (RECD) in at least one ear, to account for ear canal acoustics in the assessment and fitting processes (Figure 1)^{1, 2, 3, 4}.
- Probe tube insertion depth directly affects the accuracy of the measured eardrum sound pressure level (SPL) measured as part of the RECD.
- Current insertion depth guidelines recommend a range spanning 11 mm from the ear canal entrance, to 15-25 mm from the intertragal notch for infants and children^{5, 6, 7, 8}.
- Insertion depth should be within 3 to 5 mm of the tympanic membrane for a valid RECD measurement (see Figure 2)^{9, 5, 10}.
- Age-specific probe tube insertion depth recommendations are unavailable.

Objective: To investigate the relationship between a child's age and biological sex, and clinician-determined probe tube placement to refine probe tube insertion depth guidelines for infants and children.



Figure 1. RECD measurements on an infant (A) and a child (B)

Methods

Participants:

- Sixty-three (63) children aged 3-months to 17-years; females (n = 28) and males (n = 35) with normal hearing or hearing loss. All participants had ear canals clear of occluding wax to facilitate the RECD measurement.

RECD Measurement:

- Real-ear measurement probe tubes with marker rings compatible with the Verifit 2 hearing aid test system (Audioscan[®]) were used.
- RECDs from at least one ear were measured using a foam tip or the child's own earmold. These measures were made by CASLPO-registered audiologists who were experienced and trained in the Ontario Infant Hearing Program Protocol for the Provision of Amplification¹. Audiologists commented on the quality of each measurement session for data cleaning purposes (see below).

Probe Depth Measurement:

- We measured probe tube insertion depth (PTID) as the distance (mm) from the medial end of the probe tube to the external black marker ring positioned at the intertragal notch (Figure 2 & 3).

PTID = distance from intertragal notch to probe tube outlet

Data Cleaning:

- PTIDs were reviewed by a research audiologist for inclusion in data analysis.
- Exclusion Criteria = measured RECDs were excluded if they showed evidence of shallow probe tube placement (i.e., real ear responses with high frequency notches or early high frequency roll-off as indicated by RECD values at 3, 4, or 6 kHz being lower than RECD value at 2 kHz by more than 3 dB; Dirks and Kincaid, 1987), or if session comments suggested poor measurement quality (e.g., vocalization, inability to tolerate measurement, shallow placement). Excluded data was validated by a second audiologist.
- 84% of measures were retained for further analysis.

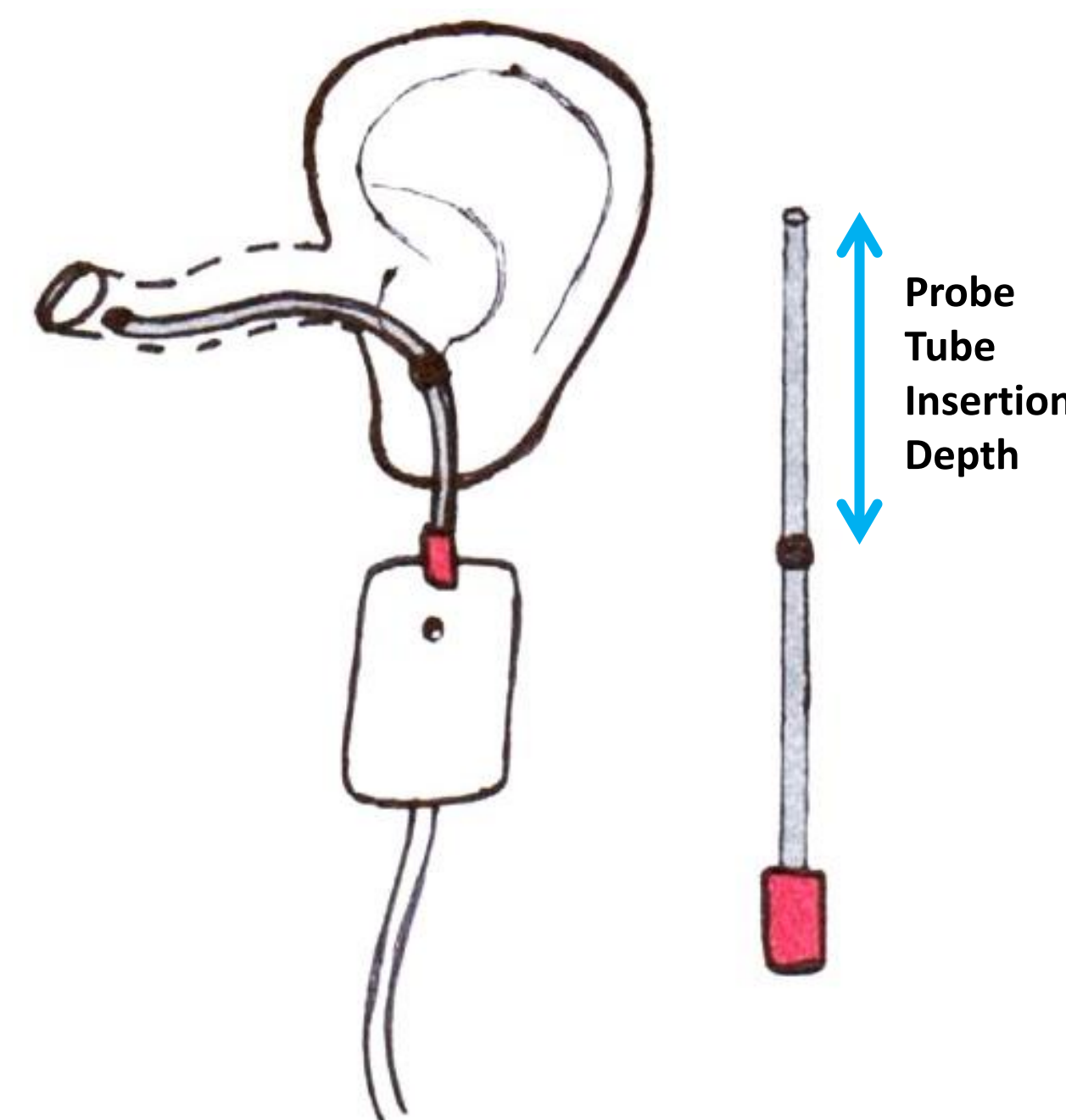


Figure 2. Probe tube insertion depth measurement

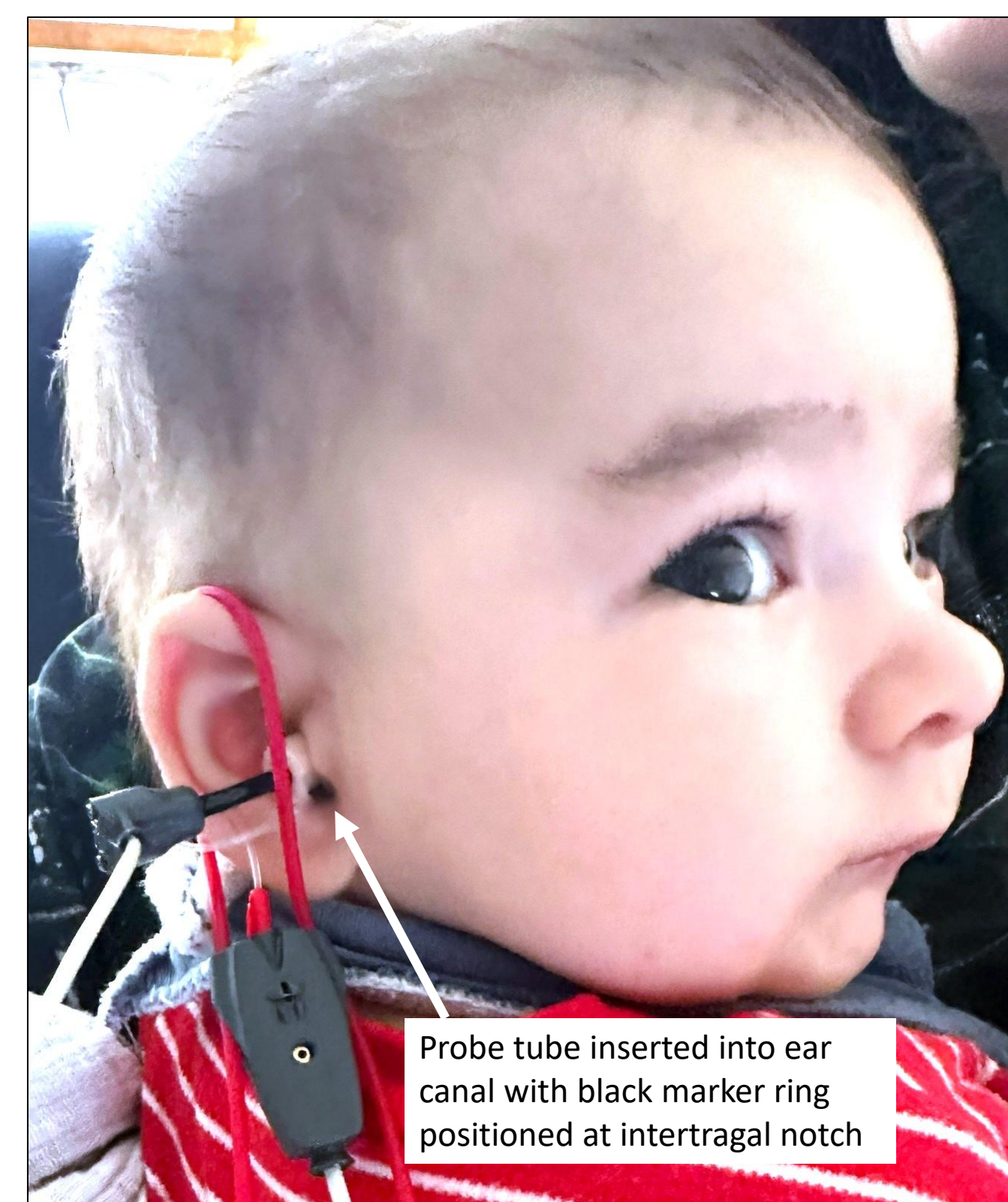


Figure 3. Example of an RECD measurement on a 3-month-old infant

Results

Data analysis included 85 ears (females = 42 ears; males = 43 ears; see Table 1). A linear regression model was used to evaluate the relationship between PTID and age (see Figure 4). Overall, PTID showed a positive association with age, regardless of biological sex (see Table 2). Average PTID ranged from 19.0 mm (S.D. = 3 mm) for children 3 to 12-months of age, to 27.2 mm (S.D. = 3.4 mm) for children 96.1 to 215-months of age, collapsed across biological sex (see Figure 5).

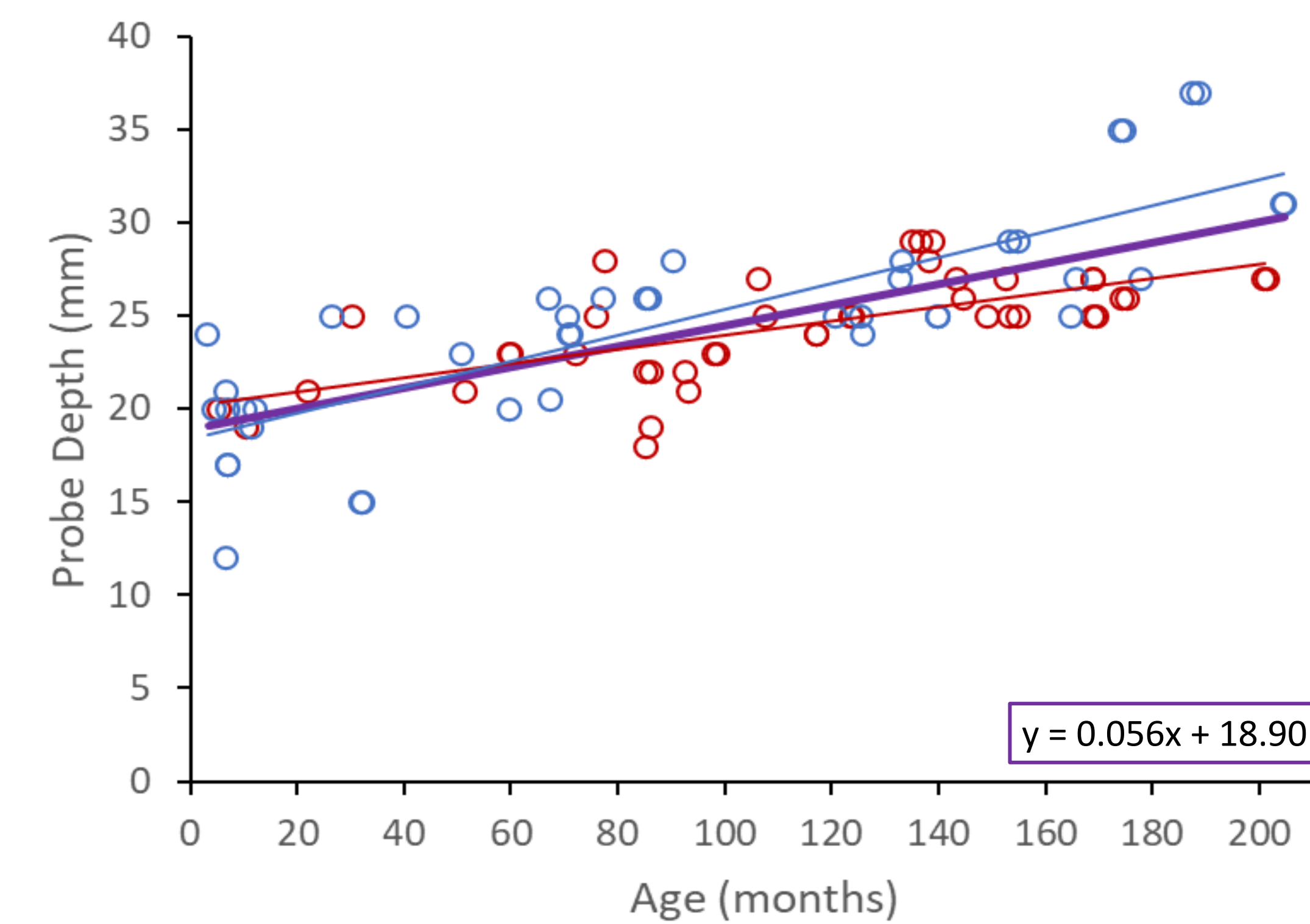


Figure 4. Probe tube insertion depth compared to age in months. Purple line represents linear regression for male and female ears together (equation displayed on graph), blue line represents linear regression for male ears only, and red line represents linear regression for female ears only. Data has been jittered by 2-months.

Table 1. Sample size distribution of number of ears (n) across age for males and females together, females only, and males only.

	3-12 months (0.25 to 1 yr)	12.1-36 months (1-3 yrs)	36.1-60 months (3-5 yrs)	60.1-96 months (5-8 yrs)	96.1-215 months (8-18 yrs)
Males & Females	11	6	6	18	44
Females	2	2	3	9	26
Males	9	4	3	9	18

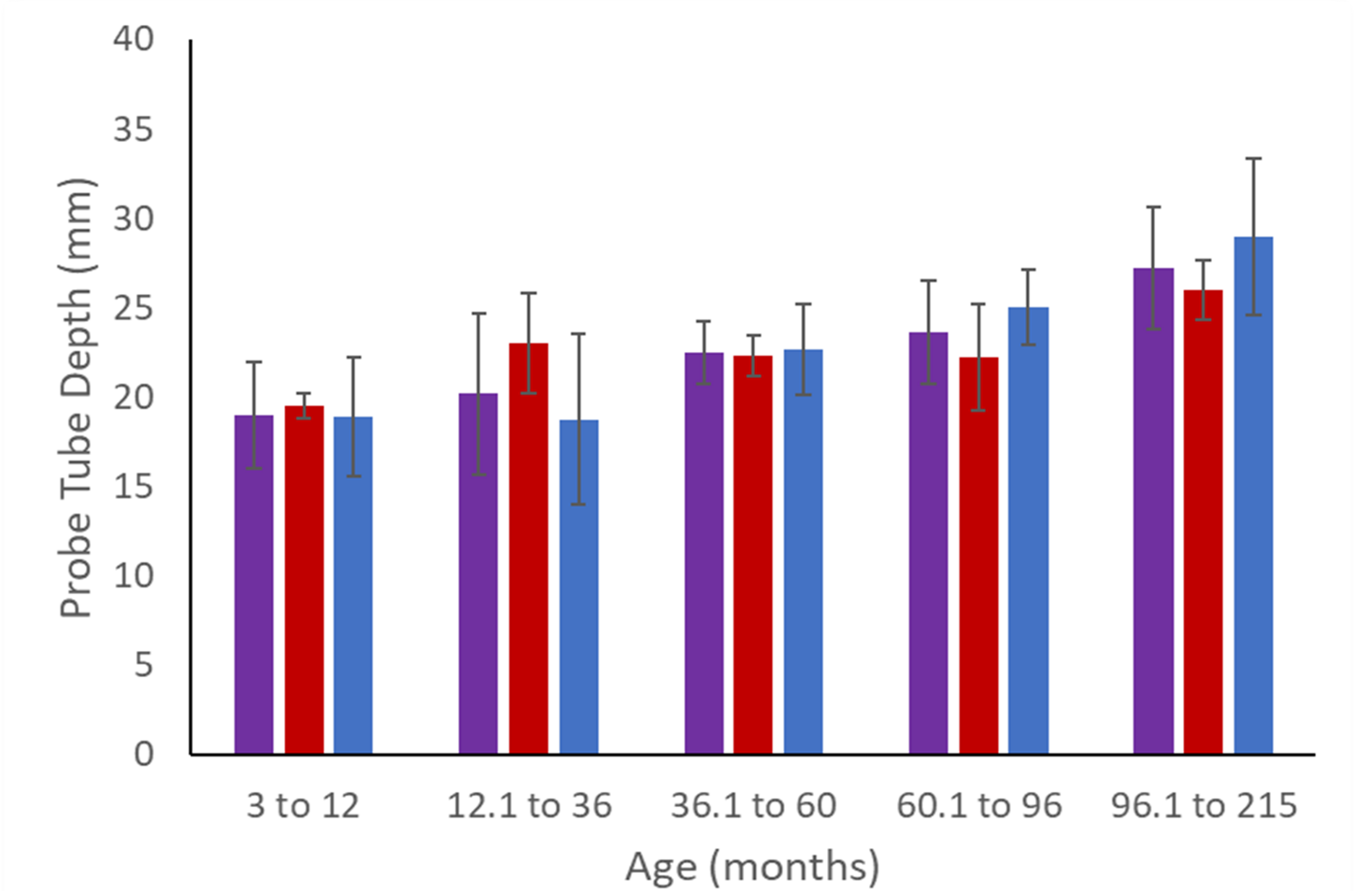


Figure 5. Average probe tube insertion depth (mean ± standard deviation) for males and females together (purple), males only (blue), and females only (red) across age groups. For males and females together, n = 11 for 3 to 12-month-olds, n = 6 for 12.1 to 36-month-olds, n = 6 for 36.1 to 60-month-olds, n = 18 for 60.1 to 96-month-olds, and n = 44 for 96.1 to 215-month-olds.

Table 2. Linear regression coefficients for males and females together, males only, and females only

	Slope	Constant	r ²	p value
Males and Females	0.0559	18.9035	0.5646	1.18 x 10 ⁻¹⁶
Females	0.0382	20.1539	0.4533	1.03 x 10 ⁻⁶
Males	0.0695	18.4051	0.6778	1.23 x 10 ⁻¹¹

Discussion & Conclusions

Probe tube insertion depths used for real-ear measures in children were collected to investigate the impact of age on insertion depth. Results from this ongoing study suggest that PTID recommendations could be sex-specific starting around 8-years of age (96-months). Regression data were used to generate equations to create preliminary PTID recommendations based on age ranges (see Table 3). Data collection is ongoing. This work will support improved real-ear measures for audiologists who fit hearing aids to infants and children.

Table 3. Preliminary recommendations for probe tube insertion depths based on age and biological sex

	3 to 12-months	13 to 36-months	37 to 60-months	61 to 96-months	97 to 215-months
Females	18 to 20 mm	20 to 21 mm	21 to 22.5 mm	22.5 to 23.5 mm	23.5 to 28 mm
Males	18 to 20 mm	20 to 21 mm	21 to 22.5 mm	22.5 to 25 mm	25 to 30 mm

References

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