



BACKGROUND

What is REAT, PAR and APV?

Real-Ear Attenuation at Threshold (REAT) = Difference in thresholds *with* vs. *without* earplugs (BS EN ISO 4869-1:2018).

Personal Attenuation Rating (PAR) = Individualised rating of real-world protection (from REAT) (Murphy et al., 2022).

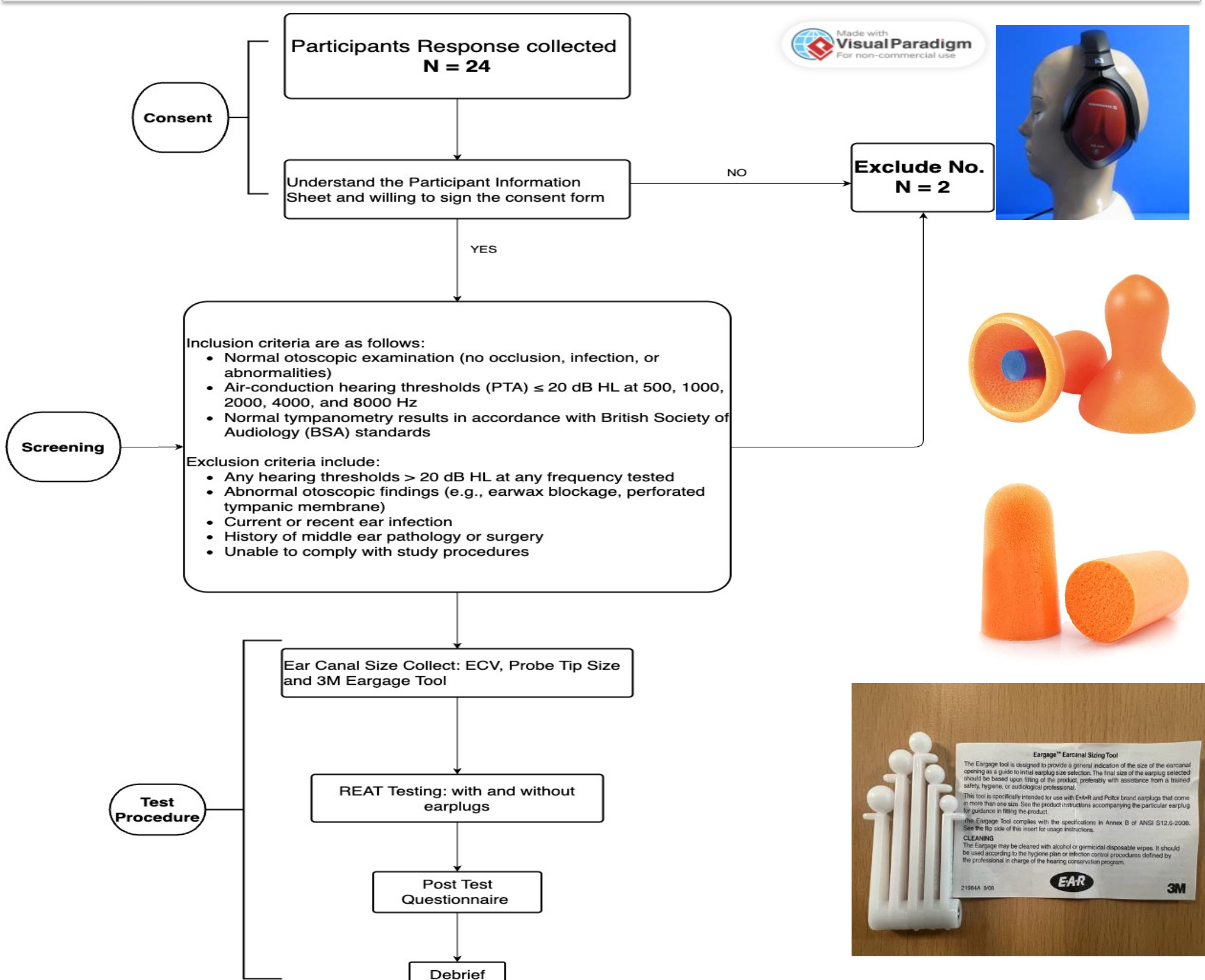
APV: Assumed Protection Values

Hypotheses

H1: Do one-size-fits-most earplugs fit all? Ear canal size influences attenuation, with greater variability expected in push-in pre-moulded earplugs compared to roll-down foam plugs.

H2: Reduced-frequency test protocols (e.g., 500, 1000 and 2000 Hz) can provide accurate estimates of PAR compared to full-frequency testing, improving efficiency.

TEST MATERIAL & TEST PROCEDURE



RESULTS

- Earplug type:** Roll-down > Push-in (higher, more stable attenuation)
- Anatomy:** Larger canals ↓ attenuation for push-in; roll-down unaffected
 - 3M™ tool:** Useful predictor (esp. roll-down), limited at extremes
- Reduced-frequency:**
 - 500-2000 Hz ≈ Full-frequency for roll-down. Less reliable for push-in plugs
 - Other subsets (e.g., 500, 2k, 8k) sometimes consistent, but **1 kHz alone = poorest accuracy**.
 - Subsets including **higher frequencies** generally showed **smaller errors** compared with the full 8-frequency baseline.
 - Results **do not fully replicate Murphy's findings** (limitations)
- Questionnaire:** Roll-down rated more comfortable, secure, effective

CONCLUSION

- Roll-down foam earplugs** provided higher and more consistent attenuation than push-in pre-moulded designs.
- Ear canal size** strongly influenced push-in performance, but had little effect on roll-down plugs. The **3M™ Eargage tool** was a practical predictor of fit, though limited at extreme canal sizes.
- Reduced-frequency protocols** (especially 500–2000 Hz) approximated full-frequency results for roll-down plugs, but were less reliable for push-in designs. Subsets including **higher frequencies** showed smaller errors relative to the full 8-frequency baseline.
- User feedback** supported the quantitative results: roll-down plugs were rated more comfortable, stable, and effective, while push-in plugs were often described as loose or uncomfortable.
- Implication:** Laboratory attenuation ratings overestimate real-world protection. **Personalised fit testing and user training are essential** to ensure reliable hearing protection.

RESULTS (Fig.)

Fig.1 → Lab ratings > real-world, roll-down > push-in. (mean REAT)

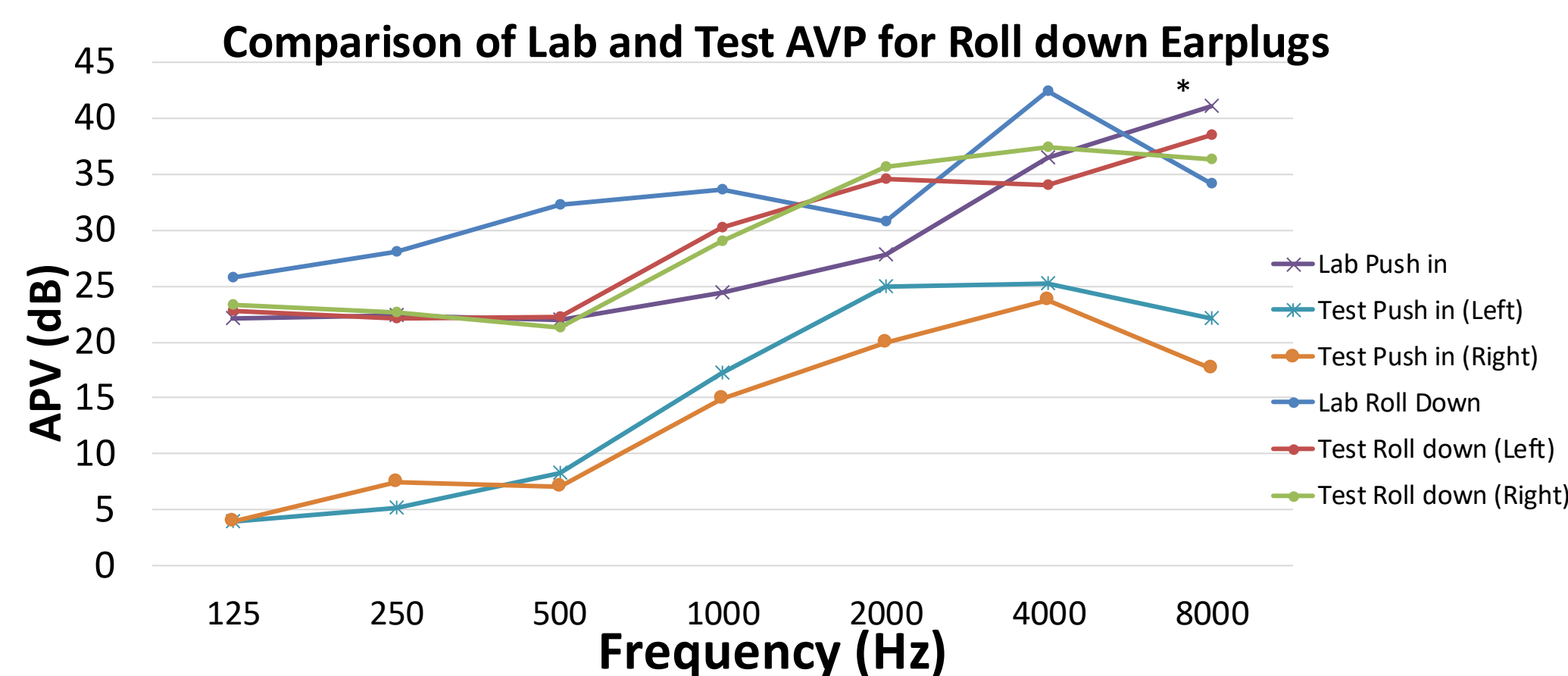


Fig.2 → 3 methods predict roll-down and push-in earplugs' performance. (PAR)

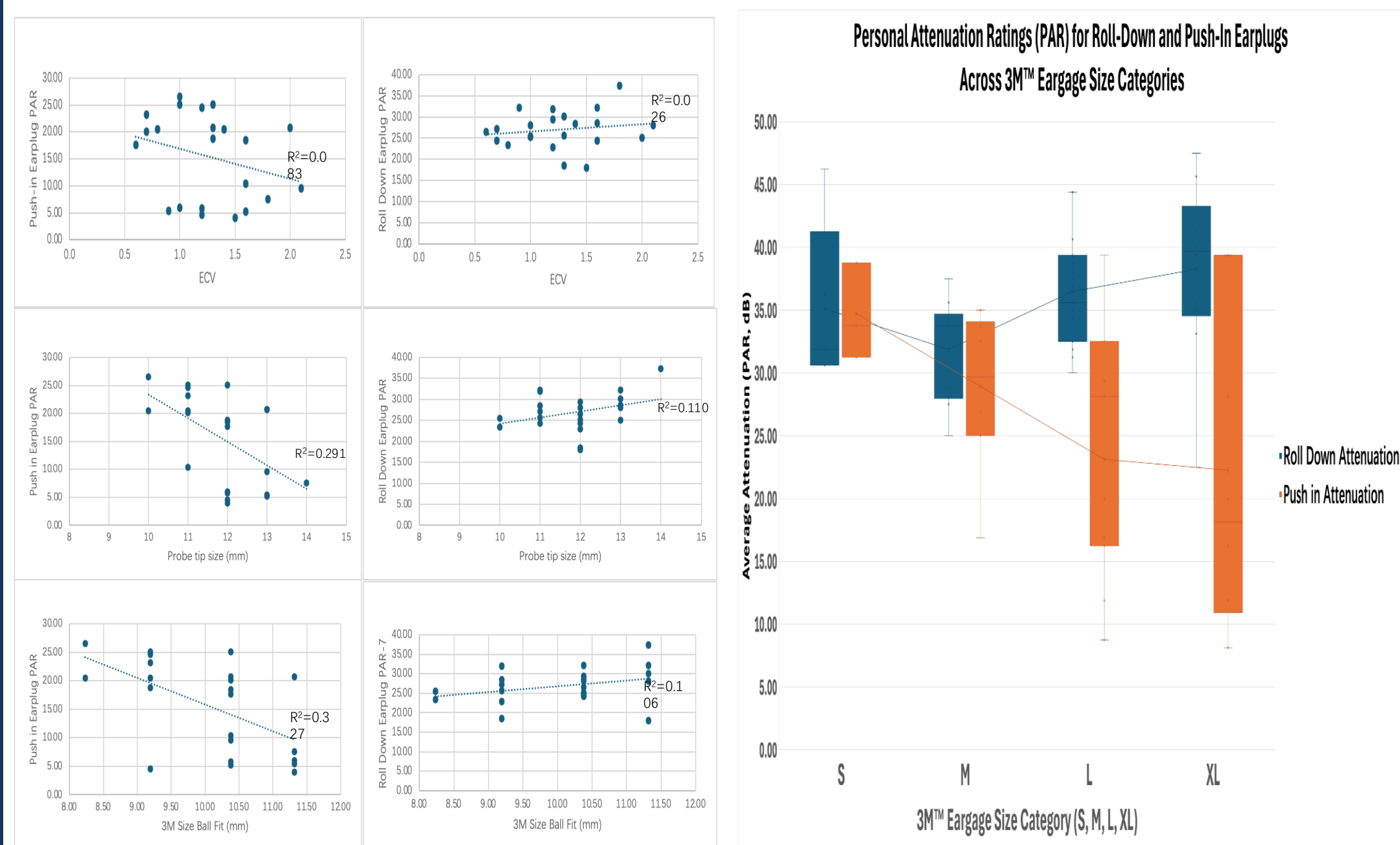


Fig.3 → Attenuation: Full-Frequency vs. Subset Protocols (PAR)

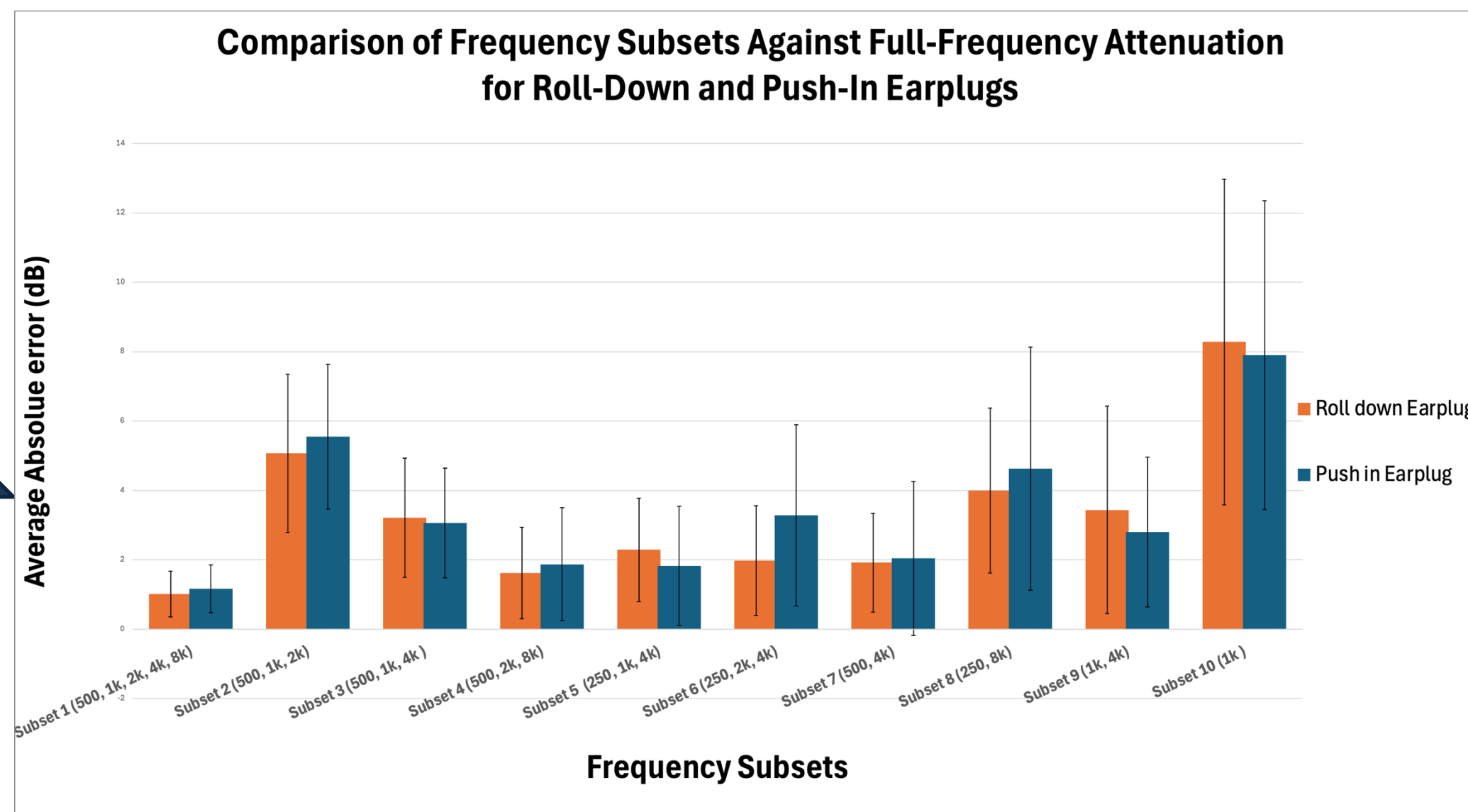


Fig.4 → Roll-down rated more comfortable and secure.

