Title
Audiometric Validation of a Smart Watch Decibel Meter

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RESEARCH LETTER

Audiometric Validation of a Smart Watch Decibel Meter

The Noise application on the Apple Watch measures the intensity of ambient sounds and is available on the Apple Watch SE and Apple Watch Series 4 and later.[1] One prior study using the Noise application in a critical-care setting recommended further studies to explore the role of wearable devices in measuring noise levels.[2] In addition, the promise of consumer wearables to help inform clinical decision-making has been emphasized as an important direction of future research in otolaryngology.[3] To our knowledge, no studies have formally assessed the performance of the Noise application. Therefore, the aim of this diagnostic study was to assess the performance of the Apple Watch Noise application in comparison with a class 1 sound level meter.[4]

Supplemental content

Methods | Both an Apple Watch Series 6 (Apple) and a Type 2250 Light handheld analyzer with the ZC-0032 microphone (Brüel & Kjær) were placed 50 cm from a speaker inside of an audiometric booth, and pure tones were played in half octaves from 125 to 8000 Hz in an amplitude range from 0.0001 to 1. A total of 21 amplitude measurements were performed within each half-octave frequency to allow sufficient statistical power in device comparison. The BZ-5503 Measurement Partner Suite software (Brüel & Kjær) was used with a D-75A amplifier (Crown) to produce the pure tones. Amplitude was provided as an input variable within this software. The measurement data for each amplitude across different frequencies were averaged for each device and compared with paired sample *t* test. SPSS software, version 17.0 (IBM) was used for statistical analysis, with $P = .002$ considered statistically significant after adjustment. This study was exempt from institutional review board approval because no human participants were involved.

Results | Device measurements demonstrated a range of sound from a minimum of 22.8 dB sound pressure level (A-weighted) to a maximum of 117.3 dB sound pressure level (A-weighted). Measurements between the 2 devices only displayed statistically significant differences between the 2 device outputs at 4 and 8 kHz (**Table**). In addition, correlation of dB measurements between the 2 devices at all frequencies was 0.961 or greater.

Discussion | Very little is known about the noise measurement capabilities of the Noise application given the proprietary nature of the algorithms and modeling assumptions used to create it.[2] This diagnostic study is, to our knowledge, the first to formally quantify these capacities. Based on the present data, the smart watch application was as accurate as a class 1 sound level meter in the frequency range of 125 to 3000 Hz and at 6000 Hz, with minor (<5 dB) differences at 4000 and 8000 Hz. Prior work by Crossley et al in 2021 considered a correlation of 0.9 to represent acceptable accuracy for commercially available iPhone applications.[5] By this metric, the Noise application can be considered accurate across all frequencies tested in this analysis, given correlation of at least 0.961.

The World Health Organization has estimated that 1.1 billion teenagers and young adults are at risk for unsafe sound exposure.[6] Given the present results, this smart watch application may be useful in identifying harmful noise

Table. Comparison of Measured Data by the 2 Devices for 21 Amplitude Measurements Across Different Frequencies

Frequency, Hz	Sample size	Average measurement, mean (SD), dB: Watch	Meter	*P* value[a]	95% CI	Effect size	Relative size
125	21	64.05 (21.10)	66.52 (22.70)	.04	−4.86 to −0.08	0.47	Small
250	21	71.62 (22.20)	72.97 (22.99)	.26	−3.80 to 1.09	0.25	Small
500	21	78.81 (23.01)	79.60 (23.47)	.45	−2.97 to 1.38	0.17	Negligible
750	21	84.90 (23.22)	85.54 (23.64)	.51	−2.60 to 1.33	0.15	Negligible
1000	21	86.57 (23.67)	86.99 (24.01)	.67	−2.45 to 1.61	0.09	Negligible
1500	21	85.76 (23.53)	86.45 (23.43)	.47	−2.62 to 1.25	0.16	Negligible
2000	21	81.52 (24.16)	82.99 (24.19)	.14	−3.45 to 0.52	0.36	Small
3000	21	80.90 (22.50)	82.54 (23.55)	.12	−3.76 to 0.48	0.35	Small
4000	21	85.90 (22.49)	80.06 (22.66)	<.001[b]	3.87 to 7.81	−1.35	Large
6000	21	75.90 (23.11)	75.62 (24.84)	.77	−1.70 to 2.27	−0.07	Negligible
8000	21	59.76 (20.09)	64.30 (21.65)	.002[b]	−7.27 to −1.81	0.76	Moderate

[a] *P* values were calculated by paired sample *t* test.

[b] *P* value was below the threshold for statistical significance ($P < .002$).

exposure environments where a class 1 sound level meter is unavailable.

This study did not assess performance outside of an audiometric booth and only studied pure-tone sound exposures. Specific variables at work in real-life settings that may limit sound measurement include interference with microphones by wind and blockage of sound by clothing. In addition, sound exposure at the wrist is not a perfect representation of sound exposure at an individual's ear. Finally, harmful sound exposure in work environments is rarely composed of pure tones, and the accuracy of the smart watch application at measuring exposures comprising more complex sounds remains a future opportunity for research.

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Author Contributions: Dr Muhonen had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: Muhonen, Abouzari, Djalilian.
Acquisition, analysis, or interpretation of data: Muhonen, Abouzari, Yang, Zeng.
Drafting of the manuscript: Muhonen, Yang.
Critical revision of the manuscript for important intellectual content: Abouzari, Zeng, Djalilian.
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Supervision: Abouzari, Zeng, Djalilian.

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Data Sharing Statement: See the Supplement.

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Association of Visit Volume and Sociodemographic Characteristics With Vocal Improvement Among Older US Adults With a Self-reported Voice Problem

In self-reported data from the US National Health Interview Survey (NHIS), a greater likelihood of vocal improvement in older adults has been associated with treatment and certain sociodemographic characteristics.[1] However, NHIS data do not include comprehensive health care utilization, and self-report of specialty care can be inaccurate with increasing age.[2] Using a novel national data linkage[3] of self-reported data from the NHIS 2012–Voice, Speech, and Language Supplement[4] and health care utilization data from Medicare for individual patients, we created the first national population-based data source to concurrently evaluate clinical care utilization and patient reported voice outcomes. This linkage includes adults 65 years and older, the population subset with the highest voice disorder prevalence.

+ Supplemental content

This study aimed to identify sociodemographic and clinical factors associated with self-reported voice improvement. Based on previous literature,[1] we hypothesized that factors associated with voice improvement in NHIS data would include younger age, White race, urban residence, higher level of education, good overall health, specialty care, and greater Medicare visit volume.

Methods | This cross-sectional survey study used data from the NHIS, an annual US household interview survey of a representative sample of the civilian noninstitutionalized population. Available Medicare enrollment and claims data were obtained for NHIS respondents who agreed to provide personal identification data to NHIS, and included Medicare enrollment and fee-for-service health care claims.[3]

Self-reported presence of voice problems and subsequent improvement was assessed via NHIS.[1] Two-year Evaluation and Management visit volume intensity with Clinical Provider Specialty Codes were extracted from Medicare claims (eTable in Supplement 1). We used 1 year of prior fee-for-service utilization data with the 2012 NHIS survey data to capture current and past utilization by Medicare beneficiaries. Owing to small raw sample sizes, specialty types were categorized as general medical only (general practice, family practice, internal medicine) or specialty (allergy/immunology, otolaryngology, gastroenterology, neurology, pulmonary). In secondary analysis, 2-year overall visit intensity was analyzed as a categorical variable (above/below median[5]), along with patient demographic information and self-reported data. Owing to small sample size. race and ethnicity were categorized as non-Hispanic White or other.