Introduction

This paper aims to assess the viability of employing recently developed automated health monitoring technology for remote occupational health surveillance, particularly in comparison to traditional, assessor-operated methods. Specifically, it seeks to evaluate the efficacy, reliability, and user acceptability of these newer methods, which are administered by the user in-person, compared to established practices. The study will determine whether these remote monitoring technologies can deliver accurate health status measures while being user-friendly and time efficient. Recent studies by Boente et al. (2024) have shown the feasibility and acceptability of home spirometry for rural patients with interstitial lung disease. Their study highlighted the significant barriers faced by rural patients, such as lack of local specialty care, long distances to expert centres, and the high cost and time associated with travel.

Additionally, it aims to explore the potential of remote technology to enhance access to rapid health surveillance screening, addressing limitations such as staffing costs, assessment time, and employee travel distances to screening venues. Furthermore, this research will investigate the potential of remote technology to overcome these barriers and improve access to health monitoring, while also considering the challenges related to cost and reimbursement (Boente et al., 2024). Ultimately, this paper will contribute to the understanding of whether automated, user-administered health monitoring technologies can effectively replace traditional methods and provide a sustainable solution for occupational health surveillance.

Purpose

The purpose of this paper is to compare two sets of data collected from the same 100 employees, each attending two appointments. The first appointment involves in-person assessment by a technician using the current gold standard health surveillance devices, while the second appointment is unassisted and utilises the YODHA remote health surveillance box.

Overall Objectives

The primary objective involves analysing data from both visits conducted as part of the project. Specifically, the aim is to compare outcomes obtained using newly developed technology integrated into the YODHA mobile screening kit and software with those from the old technology. This analysis will evaluate the reliability of outcome measures obtained from different technologies, determining whether the new technology can produce consistent results comparable to the old technology. Additionally, the goal is to assess data collected by end-users and analyse its reliability compared to data collected in person by a nurse. Finally, the objective is to investigate whether data collected in workplace

conditions using the new technology aligns with results obtained in controlled environments. Through these analyses, valuable insights will be provided to address the project's objectives.

Methodology

Study Design: This study aimed to compare the efficacy, reliability, and user acceptability of newly developed automated health monitoring technologies with traditional assessor-operated methods. Specifically, the focus was on remote occupational health surveillance using the YODHA remote health surveillance box versus established gold standard devices. The study involved 100 employees who each attended two separate health assessment appointments.

Participants: Participants were selected from a diverse pool of employees, ensuring a representative sample. The gender distribution included 73 males and 27 females, with ages ranging from 18 to 67 years (mean age = 39.7 years, SD = 14.2).

Experimental Procedure

Appointment 1: In-Person Assessment by Technician

Participants were greeted by a technician at the onset of the study, where they were introduced to the study's purpose and procedures. The importance of their informed consent was emphasised, ensuring they understood their participation and any associated risks. Following the consent process, demographic data, including age and gender, were collected from each participant. This information helped in ensuring a diverse and representative sample for the study.

Subsequently, participants underwent audiometric testing to assess their hearing thresholds. Utilising a gold standard audiometric device (Amplivox), operated by the technician, measurements were taken at various frequencies of 500Hz, 1000Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz, and 8000Hz. Attention was paid to ensuring the proper placement of headphones and the accurate administration of the test for consistent and reliable results.

Spirometry was then conducted to evaluate pulmonary function. Participants were guided to perform spirometry measurements, including Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), and Peak Expiratory Flow (PEF), using the Mirobank spirometer. The technician provided instructions on taking a deep breath and exhaling forcefully into the spirometer, ensuring correct technique for accurate data collection.

Finally, blood pressure and pulse rate were measured using an Omron blood pressure monitor. Participants were instructed to sit quietly for five minutes before the measurements were taken to ensure accurate readings, thus contributing to the reliability of the collected data throughout the study.

Appointment 2: Unassisted Remote Assessment

Participants were provided with the YODHA remote health surveillance box and given instructions on its use. These instructions were delivered either via written guidelines and images or a brief video tutorial, ensuring clarity and ease of understanding.

Subsequently, participants engaged in self-administered audiometric testing utilising the YODHA device, mirroring the frequency spectrum examined during their initial appointment. They adhered to on-screen instructions to ensure precise placement of headphones and calibration of the device, thereby facilitating consistent and dependable measurements.

Following audiometric testing, participants progressed to conduct self-administered spirometry using the YODHA device. They followed on-screen prompts to execute spirometry measurements, including the correct positioning of a new mouthpiece onto the spirometer and its subsequent disposal after use. These instructions were meticulously designed to uphold proper technique and mitigate the potential for contamination, thereby ensuring the reliability of the acquired data.

Furthermore, participants employed the YODHA device to autonomously measure their blood pressure and pulse rate. Preceding the acquisition of measurements, participants were instructed to observe a period of quiet rest for five minutes, thereby ensuring uniformity and precision in the obtained readings.

Ethical approval was obtained from the institutional review board. Informed consent was collected from all participants. Data privacy and confidentiality were strictly maintained throughout the study. This methodology ensures a robust comparison between traditional and remote health monitoring technologies, providing valuable insights into their potential application in occupational health surveillance.

Data Analysis

Descriptive and inferential statistical analyses were conducted using JASP software. The dataset included variables such as gender, age, hearing test results, spirometry measures, and blood pressure readings. Descriptive statistics were calculated to summarise the data, including frequencies, percentages, means, medians, modes, standard deviations, interquartile ranges, and ranges. For gender, frequency tables and distribution plots were created. Age statistics included measures of central tendency and dispersion, while visual representations were provided using distribution plots and bar charts.

Paired samples t-tests were employed to compare the differences between the Gold and Yodha hearing test measures at various frequencies (e.g., 1000Hz, 2000Hz). Normality assumptions for these tests were checked using the Shapiro-Wilk test, with significant results indicating deviations from normality. Similarly, paired samples t-tests and normality checks were conducted for spirometry measures (e.g., FVC, FEV1) and blood pressure readings (systolic, diastolic, pulse).

Correlation analyses were performed using Spearman's rank-order correlation to assess the relationship between hearing test results across different frequencies. Significance levels were reported, with p-values less than 0.05 considered statistically significant. These analyses provided insights into the reliability and consistency of the measures across different devices and conditions.

Results

Demographic Characteristics of the Sample: Gender Distribution and Age Profile

The gender distribution of the sample shows a significant imbalance, with 73% of participants identified as male and 27% as female, out of a total of 100 subjects (see Tables 1, 2; Figures 1, 2 3, 4 for details). The age characteristics reveal a diverse range, with the mode at 34 years, median at 39 years, and mean age of 39.7 years. The standard deviation (SD) is 14.2 years, indicating a moderate spread around the mean, with ages spanning from a minimum of 18 to a maximum of 67 years. The interquartile range (IQR) is 25 years, highlighting substantial variability within the middle 50% of the age distribution. The 25th percentile age is 27 years, showing that a quarter of the participants are younger than this age. The 50th percentile (median) age is 39 years, indicating that half of the participants are younger than this age. The 75th percentile is at 52 years, showing that 75% of the participants are younger than 52 years.

Table 1: Frequency Tables Gender

Frequencies for Gender

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
M	73	73.000	73.000	73.000
F	27	27.000	27.000	100.000
Total	100	100.000		

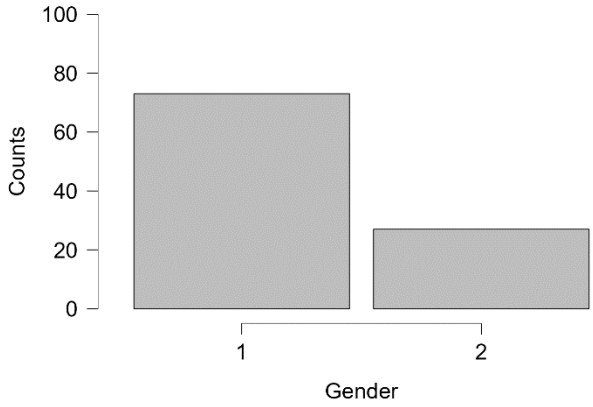


Figure 1: Distribution Plots (1: male, 2: female)

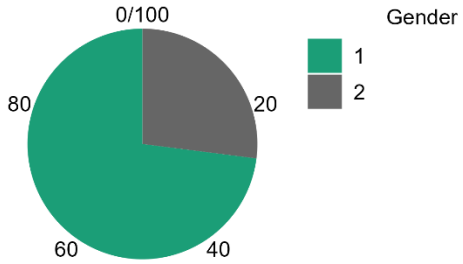


Figure 2: Pie chart Gender

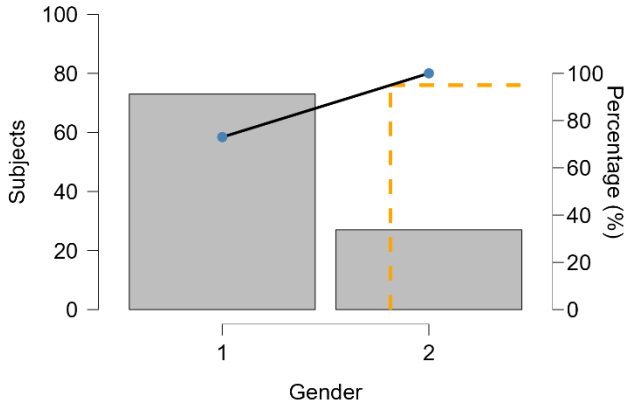


Figure 3: Pareto Plots Gender

Table 2: Descriptive Statistics Age

Descriptive Statistics

	Mode	Median	Mean	Std. Deviation	Coefficient of variation	IQR	Range	Minimum	Maximum	25th percentile	50th percentile	75th percentile
Age	34.000[a]	39.000	39.700	14.237	0.359	25.000	49.000	18.000	67.000	27.000	39.000	52.000

[a] The mode is computed assuming that variables are discreet.

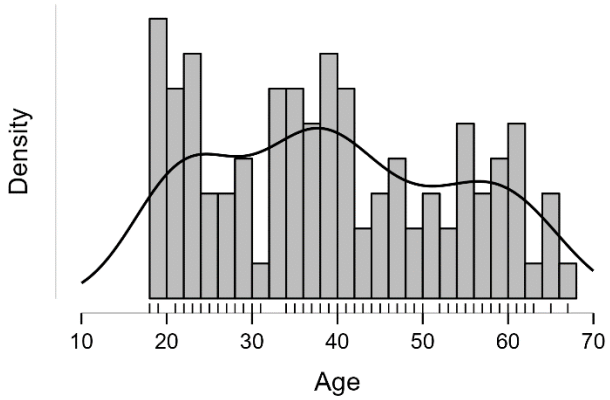


Figure 4: Distribution Plots for Age

Comparative Analysis of Hearing Test Results between Gold standard in person testing and YODHA Remote Health Surveillance Technology

The Paired Samples T-Test results for the hearing test between gold standard in person testing and YODHA remote health surveillance technology indicated significant differences at several frequencies (see Tables 3,4,5; Figures 5,6 for details). For instance, at 1000Hz in the left ear, the mean for gold standard in person testing was 8.4 dB (SD = 7.551), compared to YODHA's 8.7 dB (SD = 7.372), resulting in a t-value of-2.514 and a p-value of 0.014. Similarly, at 2000Hz in the left ear, the mean difference was more pronounced, with gold standard in person testing at 6.15 dB (SD = 7.973) and YODHA at 6.95 dB (SD = 8.131), yielding a t-value of-4.342 and a p-value of <0.001. Other significant differences were observed at 3000Hz in the left ear (t =-2.602, p = 0.011) and at 4000Hz in the right ear (t =-2.514, p = 0.014).

On the other hand, several frequencies showed no significant differences between gold standard in person testing and YODHA. For example, at 6000Hz in the left ear, the mean for gold standard in person testing was 26.0 dB (SD = 11.481) compared to YODHA's 25.85 dB (SD = 11.238), resulting in a t-value of 0.686 and a p-value of 0.494. Similarly, at 8000Hz in the left ear, the mean values were nearly identical (Gold standard in person testing: 18.8 dB, SD = 10.228; YODHA: 18.85 dB, SD = 10.270), with a t-value of-0.445 and a p-value of 0.657. Other non-significant differences were found at 500Hz in the right ear (t =-1.421, p = 0.158) and at 6000Hz in the right ear (t = 1.750, p = 0.083). Additionally, due to the variance in the difference being equal to zero, the comparison at 500Hz in the left ear and at 8000Hz in the right ear could not be performed, indicating no variability in the differences at these frequencies.

Table 3: Hearing Test Paired Samples T-Test

Paired Samples T-Test

Measure 1	Measure 2	t	df	P
1000Hz_Left_Gold_Visit1	- 1000Hz_ Left_YODHA_Visit2	-2.514	99	0.014
2000Hz_Left_Gold_Visit1	- 2000Hz_ Left_YODHA_Visit2	-4.342	99	< .001
3000Hz_Left_Gold_Visit1	- 3000Hz_ Left_YODHA_Visit2	-2.602	99	0.011
4000Hz_Left_Gold_Visit1	- 4000Hz_ Left_YODHA_Visit2	-1.828	99	0.070
6000Hz_Left_Gold_Visit1	- 6000Hz_ Left_YODHA_Visit2	0.686	99	0.494
8000Hz_Left_Gold_Visit1	- 8000Hz_ Left_YODHA_Visit2	-0.445	99	0.657
500Hz_Right_Gold_Visit1	- 500Hz_ Right_YODHA_Visit2	-1.421	99	0.158
1000Hz_Right_Gold_Visit1	- 1000Hz_ Right_YODHA_Visit2	-2.031	99	0.045
2000Hz_Right_Gold_Visit1	- 2000Hz_ Right_YODHA_Visit2	-4.180	99	< .001
4000Hz_Right_Gold_Visit1	- 4000Hz_ Right_YODHA_Visit2	-2.514	99	0.014
6000Hz_Right_Gold_Visit1	- 6000Hz_ Right_YODHA_Visit2	1.750	99	0.083

Table 4: Assumption Checks

Test of Normality (Shapiro-Wilk)

		W	p
1000Hz_Left_Gold_Visit1	- 1000Hz_ Left_YODHA_Visit2	0.252	< .001
2000Hz_Left_Gold_Visit1	- 2000Hz_ Left_YODHA_Visit2	0.440	< .001
3000Hz_Left_Gold_Visit1	- 3000Hz_ Left_YODHA_Visit2	0.385	< .001
4000Hz_Left_Gold_Visit1	- 4000Hz_ Left_YODHA_Visit2	0.372	< .001
6000Hz_Left_Gold_Visit1	- 6000Hz_ Left_YODHA_Visit2	0.171	< .001
8000Hz_Left_Gold_Visit1	- 8000Hz_ Left_YODHA_Visit2	0.277	< .001
500Hz_Right_Gold_Visit1	- 500Hz_ Right_YODHA_Visit2	0.123	< .001
1000Hz_Right_Gold_Visit1	- 1000Hz_ Right_YODHA_Visit2	0.195	< .001
2000Hz_Right_Gold_Visit1	- 2000Hz_ Right_YODHA_Visit2	0.426	< .001
4000Hz_Right_Gold_Visit1	- 4000Hz_ Right_YODHA_Visit2	0.252	< .001
6000Hz_Right_Gold_Visit1	- 6000Hz_ Right_YODHA_Visit2	0.161	< .001

Note. Significant results suggest a deviation from normality.

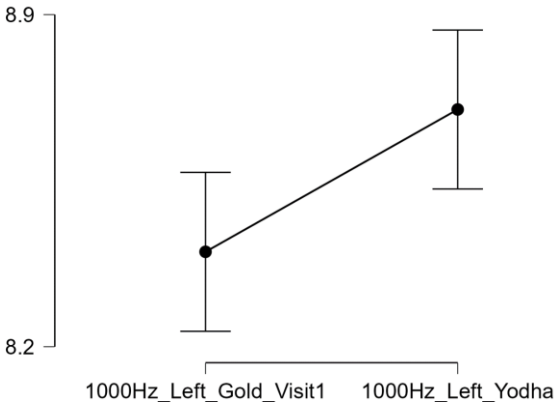
Table 5: Descriptives

Descriptives

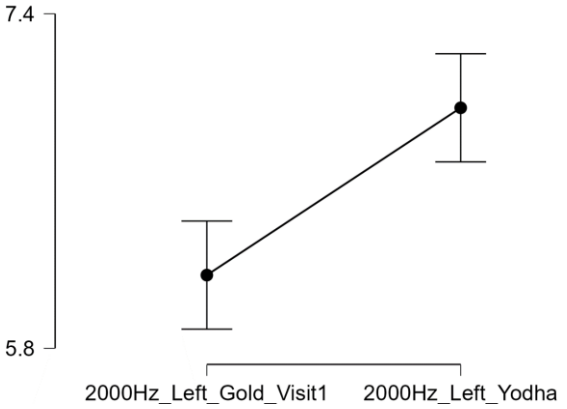
	N	Mean	SD	SE	Coefficient of variation
1000Hz_Left_Gold_Visit1	100	8.400	7.551	0.755	0.899
1000Hz_ Left_YODHA_Visit2	100	8.700	7.372	0.737	0.847
2000Hz_Left_Gold_Visit1	100	6.150	7.973	0.797	1.296
2000Hz_ Left_YODHA_Visit2	100	6.950	8.131	0.813	1.170
3000Hz_Left_Gold_Visit1	100	19.350	17.021	1.702	0.880
3000Hz_ Left_YODHA_Visit2	100	19.750	16.898	1.690	0.856
4000Hz_Left_Gold_Visit1	100	21.400	14.548	1.455	0.680
4000Hz_ Left_YODHA_Visit2	100	21.750	14.964	1.496	0.688
6000Hz_Left_Gold_Visit1	100	26.000	11.481	1.148	0.442
6000Hz_ Left_YODHA_Visit2	100	25.850	11.238	1.124	0.435
8000Hz_Left_Gold_Visit1	100	18.800	10.228	1.023	0.544
8000Hz_ Left_YODHA_Visit2	100	18.850	10.270	1.027	0.545
500Hz_Right_Gold_Visit1	100	8.700	8.751	0.875	1.006
500Hz_ Right_YODHA_Visit2	100	8.800	8.620	0.862	0.980
1000Hz_Right_Gold_Visit1	100	6.850	8.398	0.840	1.226
1000Hz_ Right_YODHA_Visit2	100	7.050	8.412	0.841	1.193
2000Hz_Right_Gold_Visit1	100	7.150	12.003	1.200	1.679
2000Hz_ Right_YODHA_Visit2	100	7.900	11.660	1.166	1.476
4000Hz_Right_Gold_Visit1	100	22.550	16.307	1.631	0.723
4000Hz_ Right_YODHA_Visit2	100	22.850	16.225	1.623	0.710
6000Hz_Right_Gold_Visit1	100	28.750	14.220	1.422	0.495
6000Hz_ Right_YODHA_Visit2	100	28.600	14.144	1.414	0.495

Figure 5: Descriptives Plots

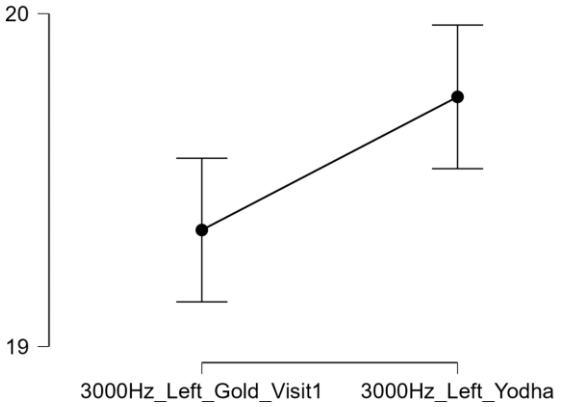
1000Hz_Left_Gold_Visit1 - 1000Hz_Left_Yodha



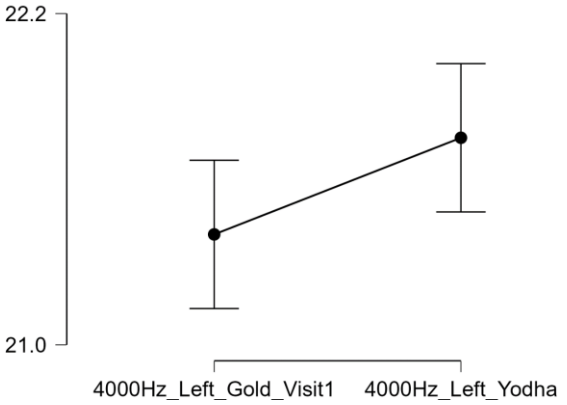
2000Hz_Left_Gold_Visit1 - 2000Hz_Left_Yodha



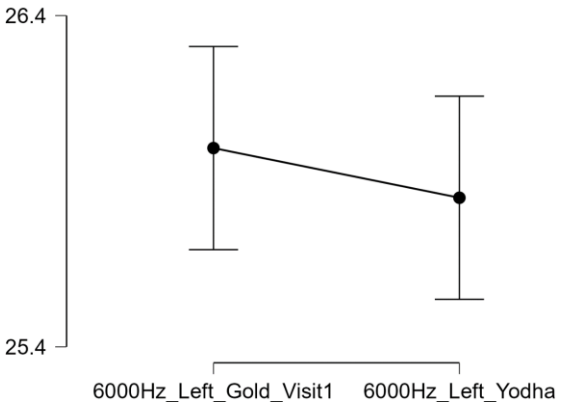
3000Hz_Left_Gold_Visit1 - 3000Hz_Left_Yodha



4000Hz_Left_Gold_Visit1 - 4000Hz_Left_Yodha



6000Hz_Left_Gold_Visit1 - 6000Hz_Left_Yodha



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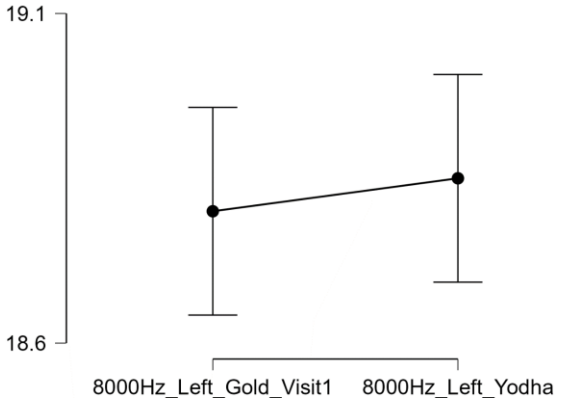

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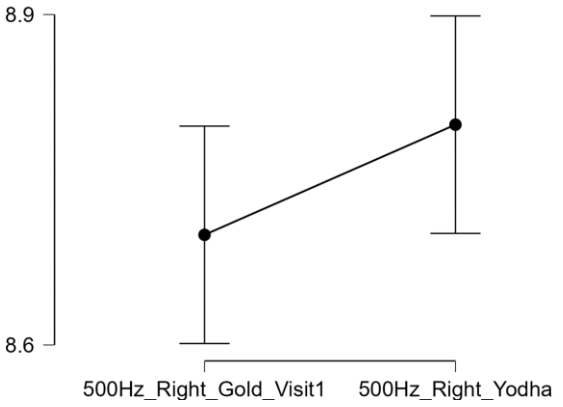
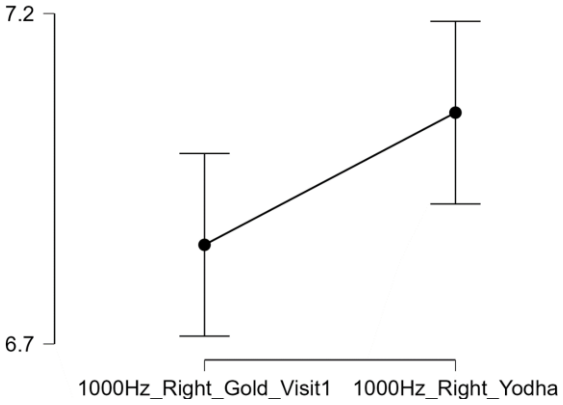


1000Hz_Right_Gold_Visit1 - 1000Hz_Right_Yodha



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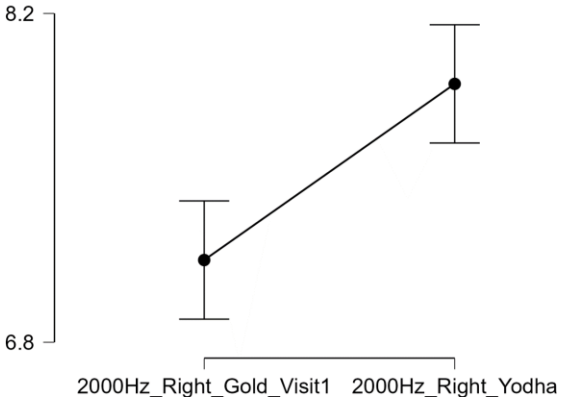
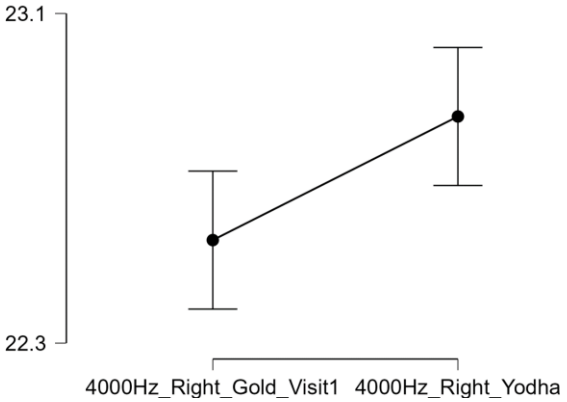


4000Hz_Right_Gold_Visit1 - 4000Hz_Right_Yodha



6000Hz_Right_Gold_Visit1 - 6000Hz_Right_Yodha

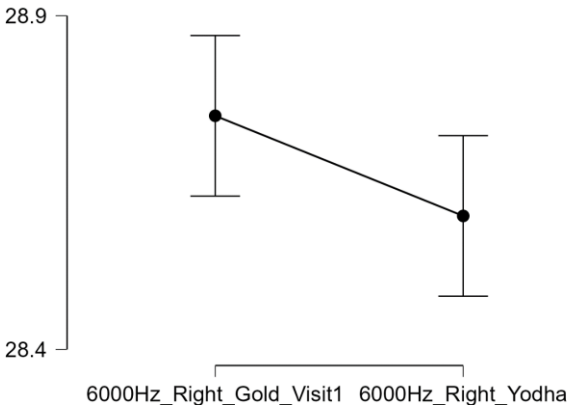
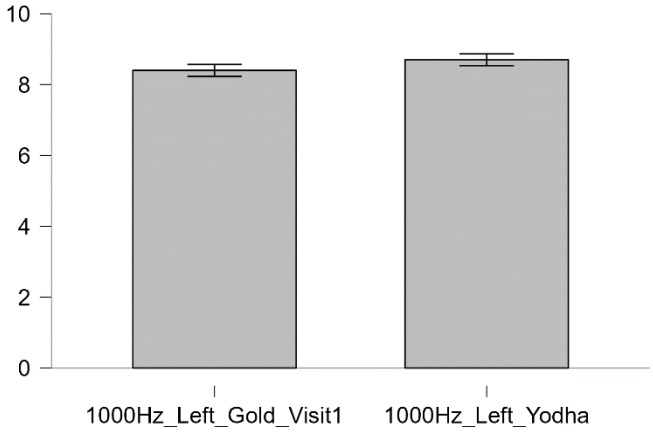
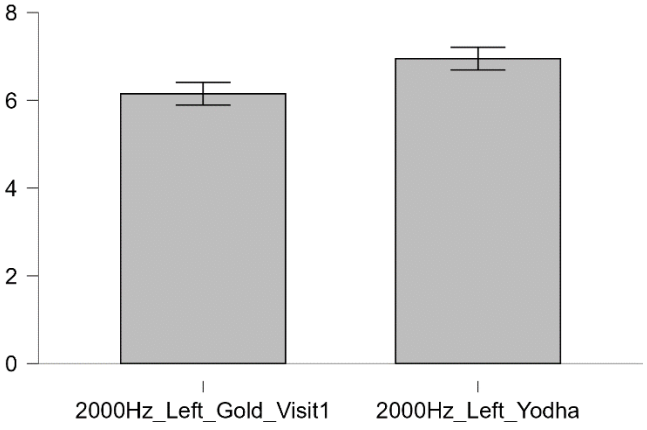


Figure 6: Bar Plots

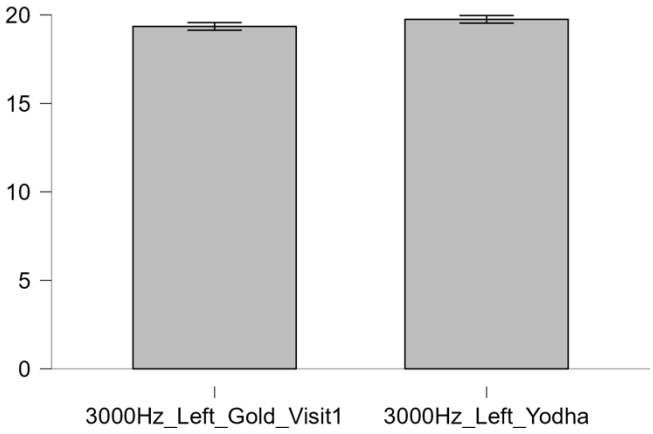
1000Hz_Left_Gold_Visit1 - 1000Hz_Left_Yodha



2000Hz_Left_Gold_Visit1 - 2000Hz_Left_Yodha



3000Hz_Left_Gold_Visit1 - 3000Hz_Left_Yodha



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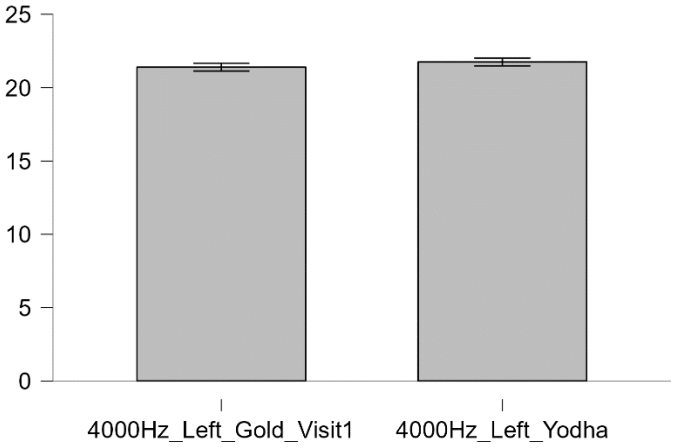

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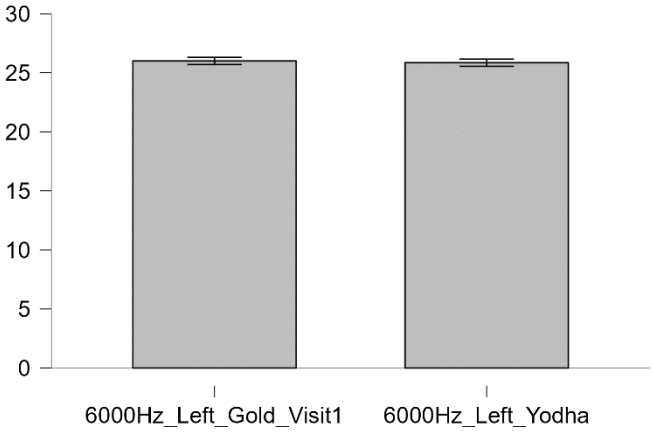
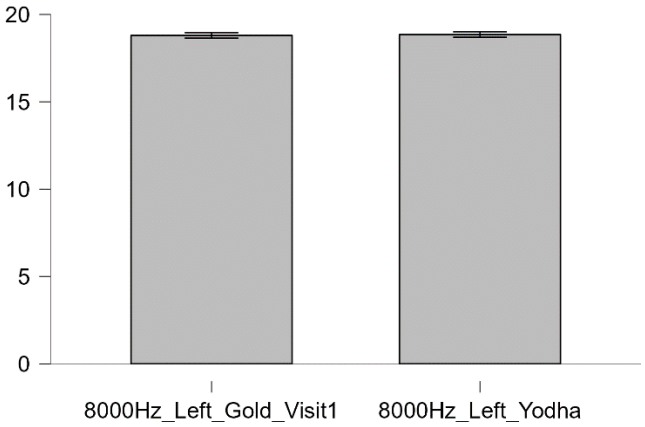
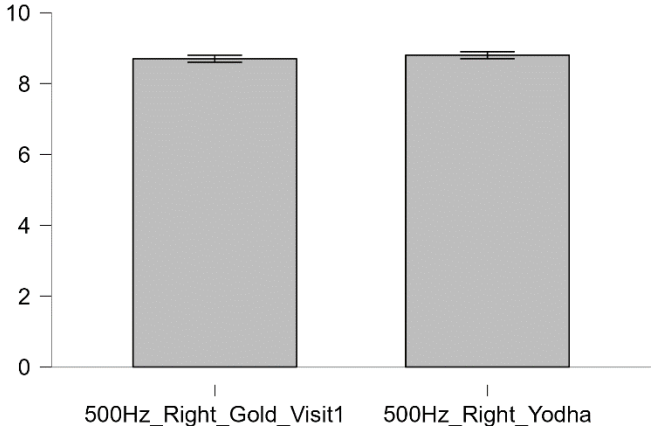


8000Hz_Left_Gold_Visit1 - 8000Hz_Left_Yodha



500Hz_Right_Gold_Visit1 - 500Hz_Right_Yodha



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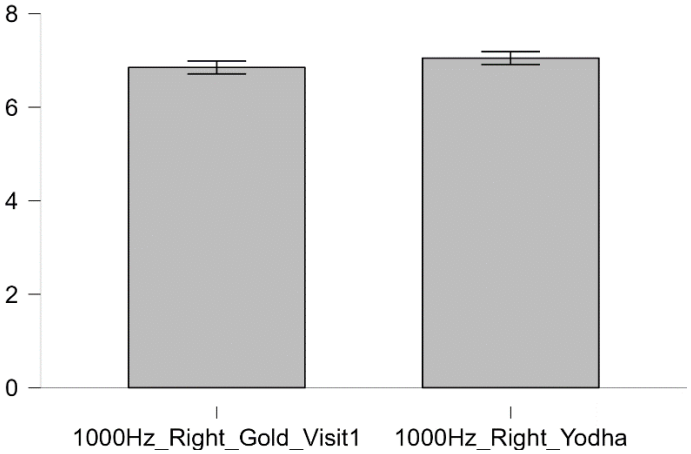
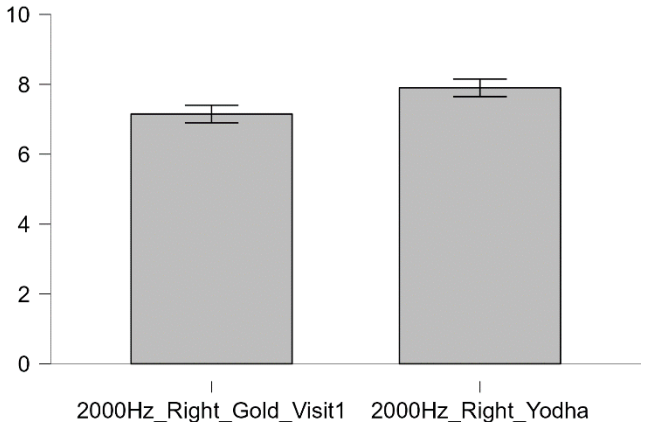
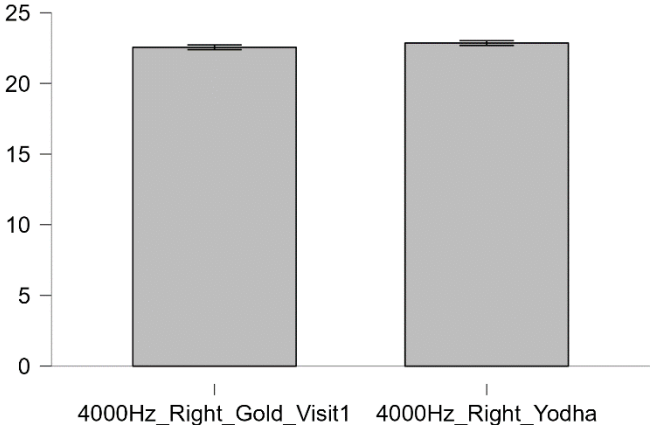


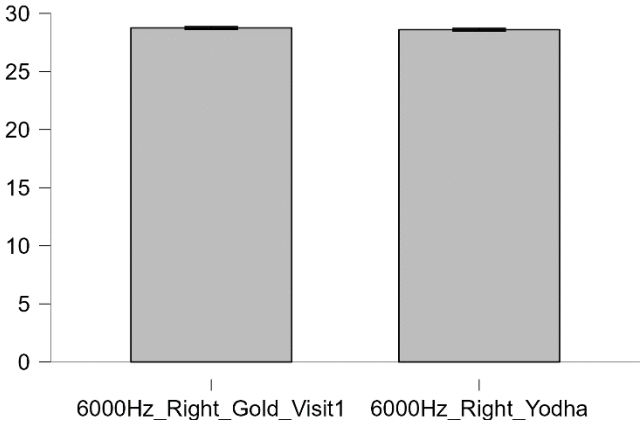
2000Hz_Right_Gold_Visit1 - 2000Hz_Right_Yodha



4000Hz_Right_Gold_Visit1 - 4000Hz_Right_Yodha



6000Hz_Right_Gold_Visit1 - 6000Hz_Right_Yodha



Comparative Analysis of Spirometry Measures between Mirobank and YODHA Devices

The descriptive statistics for spirometry measures between Mirobank and YODHA indicate some differences in pulmonary function test results (see Tables 6,7,8; Figures 7,8 for details). For FVC, the mean for Mirobank was 4.705 L (SD = 1.289), with an IQR of 1.557 L. The range spanned from 0.750 L to 7.290 L, with the 25th percentile at 4.058 L, the median at 4.430 L, and the 75th percentile at 5.615

L. YODHA's FVC had a slightly higher mean of 4.836 L (SD = 1.327), an IQR of 1.656 L, and a range from 0.767 L to 7.592 L. The 25th percentile for YODHA FVC was 4.144 L, the median 4.483 L, and the 75th percentile 5.801 L. Both distributions exhibited significant deviations from normality, as indicated by Shapiro-Wilk test results ($W = 0.941$, $p < 0.001$).

For FEV1, the mean for Mirobank was 3.762 L (SD = 1.056), with an IQR of 1.630 L. The FEV1 values ranged from 0.750 L to 5.670 L, with the 25th percentile at 3.132 L, the median at 3.560 L, and the 75th percentile at 4.763 L. YODHA's FEV1 mean was slightly higher at 3.867 L (SD = 1.087), with an IQR of 1.682 L, and a range from 0.767 L to 5.800 L. The 25th percentile for YODHA FEV1 was 3.225 L, the median 3.682 L, and the 75th percentile 4.907 L. FEV1 distributions also showed significant deviations from normality ($W = 0.937$, $p < 0.001$ for Mirobank; $W = 0.937$, $p < 0.001$ for YODHA).

Additionally, PEF had a mean of 8.194 L/min (SD = 2.695) for Mirobank, with an IQR of 2.443 L/min and a range from 2.080 L/min to 13.790 L/min. The 25th percentile was 7.025 L/min, the median 7.985 L/min, and the 75th percentile 9.468 L/min. YODHA's PEF mean was 8.425 L/min (SD = 2.775), with an IQR of 2.618 L/min, and a range from 2.149 L/min to 14.245 L/min. The 25th percentile for YODHA PEF was 7.067 L/min, the median 8.258 L/min, and the 75th percentile 9.685 L/min. Both PEF distributions deviated significantly from normality ($W = 0.959$, $p = 0.004$ for Mirobank; $W = 0.962$, $p = 0.006$ for YODHA).

Moreover, FEV1/FVC ratio also displayed differences, with Mirobank having a mean of 80.206 (SD = 7.764) and YODHA having a higher mean of 82.992 (SD = 3.526). The IQR for Mirobank was 7.450, while for YODHA it was 3.100. The range for Mirobank's FEV1/FVC was from 50.900 to 100.000, and for YODHA from 72.200 to 93.200. Both ratios deviated significantly from normality ($W = 0.914$, $p < 0.001$ for Mirobank; $W = 0.947$, $p < 0.001$ for YODHA). Additionally, the variance in the difference between Mirobank and YODHA for both predicted FVC and predicted FEV1 is equal to zero, suggesting no variability in the observed differences between the two visits.

Table 6: Descriptive Statistics Spirometry

Descriptive Statistics

	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum	25th percentile	50th percentile	75th percentile
Mirobank FVC	4.705	1.289	1.557	0.956	0.002	6.540	0.750	7.290	4.058	4.430	5.615
YODHA FVC	4.836	1.327	1.656	0.960	0.004	6.824	0.767	7.592	4.144	4.483	5.801
Mirobank FEV1	3.762	1.056	1.630	0.957	0.002	4.920	0.750	5.670	3.132	3.560	4.763
YODHA FEV1	3.867	1.087	1.682	0.958	0.003	5.033	0.767	5.800	3.225	3.682	4.907
Mirobank PEF	8.194	2.695	2.443	0.959	0.004	11.710	2.080	13.790	7.025	7.985	9.468

Descriptive Statistics

	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum	25th percentile	50th percentile	75th percentile
YODHA PEF	8.425	2.775	2.618	0.962	0.006	12.096	2.149	14.245	7.067	8.258	9.685
Mirobank FEV1/FVC	80.206	7.764	7.450	0.914	< .001	49.100	50.900	100.000	76.900	81.700	84.350
YODHA Pred FEV1/FVC	82.992	3.526	3.100	0.947	< .001	21.000	72.200	93.200	81.200	82.700	84.300

Table 7: Assumption Checks Spirometry

Test of Normality (Shapiro-Wilk)

			W	p
Mirobank FVC	-	YODHA FVC	0.941	< .001
Mirobank FEV1	-	YODHA FEV1	0.937	< .001
Mirobank Pred FEV1	-	YODHA FEV1	0.934	< .001
Mirobank PEF	-	YODHA PEF	0.930	< .001
Mirobank Pred PEF	-	YODHA Pred FEV1	0.853	< .001
Mirobank FEV1/FVC	-	YODHA FEV1/FVC	0.923	< .001

Note. Significant results suggest a deviation from normality.

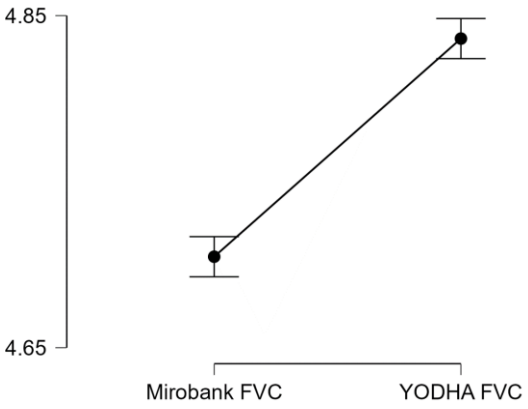
Table 8: Descriptives Spirometry Data

Descriptives

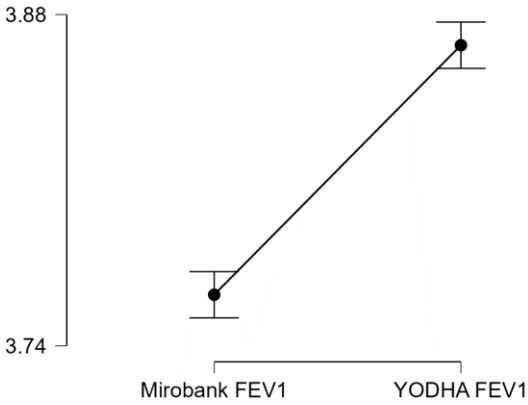
	N	Mean	SD	SE	Coefficient of variation
Mirobank FVC	100	4.705	1.289	0.129	0.274
YODHA FVC	100	4.836	1.327	0.133	0.274
Mirobank FEV1	100	3.762	1.056	0.106	0.281
YODHA FEV1	100	3.867	1.087	0.109	0.281
Mirobank Pred FEV1	100	4.313	0.640	0.064	0.148
Mirobank PEF	100	8.194	2.695	0.269	0.329
YODHA PEF	100	8.425	2.775	0.277	0.329
Mirobank Pred PEF	100	9.261	1.264	0.126	0.137
YODHA Pred FEV1	100	4.313	0.640	0.064	0.148
Mirobank FEV1/FVC	100	80.206	7.764	0.776	0.097
YODHA FEV1/FVC	100	82.465	8.216	0.822	0.100

Figure 7: Descriptives Plots

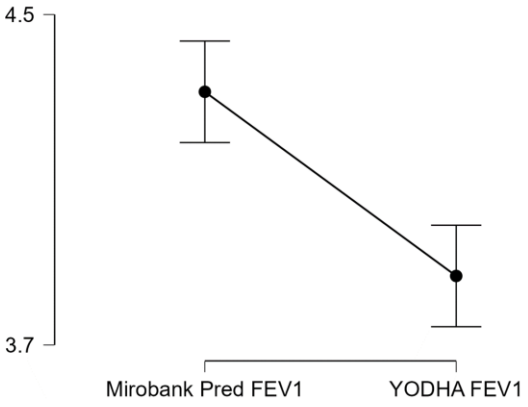
Mirobank FVC - YODHA FVC



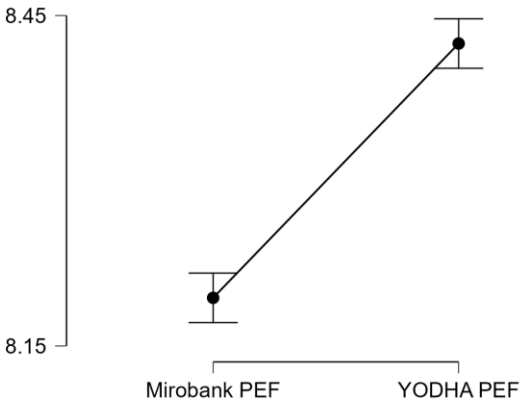
Mirobank FEV1 - YODHA FEV1



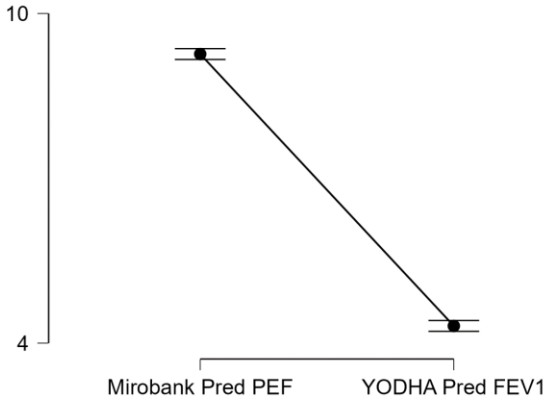
Mirobank Pred FEV1 - YODHA FEV1



Mirobank PEF - YODHA PEF



Mirobank Pred PEF - YODHA Pred FEV1



Mirobank FEV1/FVC - YODHA FEV1/FVC

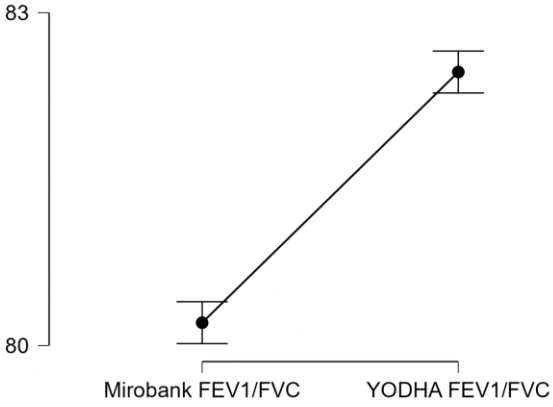
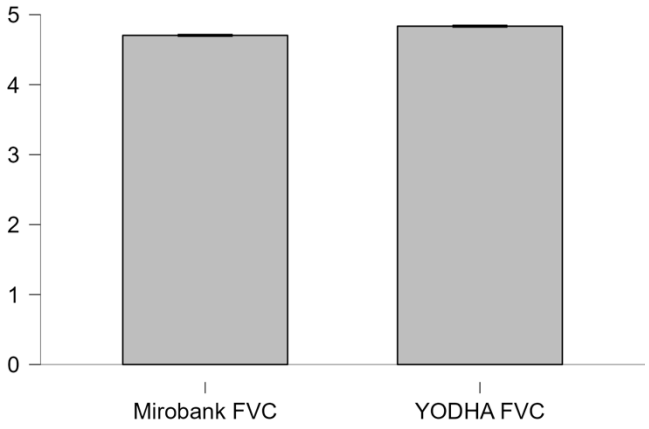
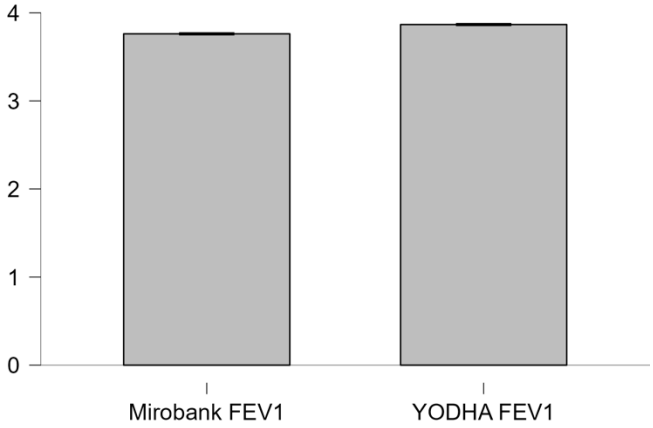


Figure 8: Bar Plots

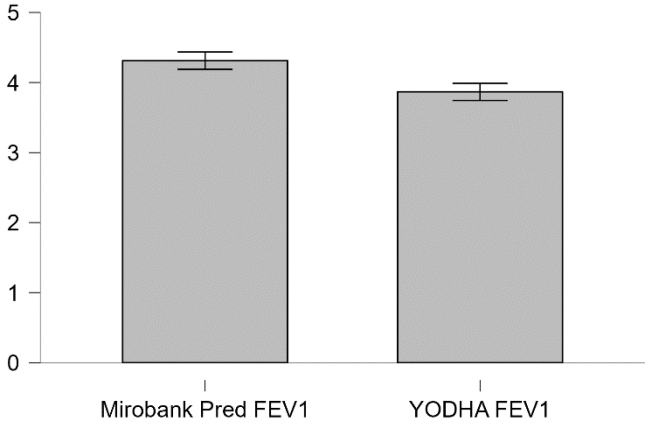
Mirobank FVC - YODHA FVC



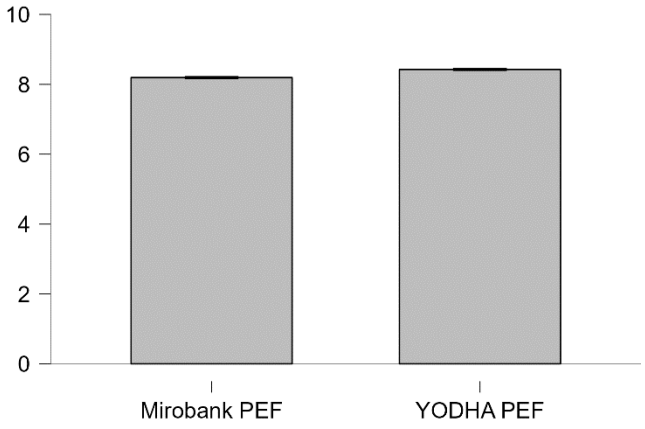
Mirobank FEV1 - YODHA FEV1



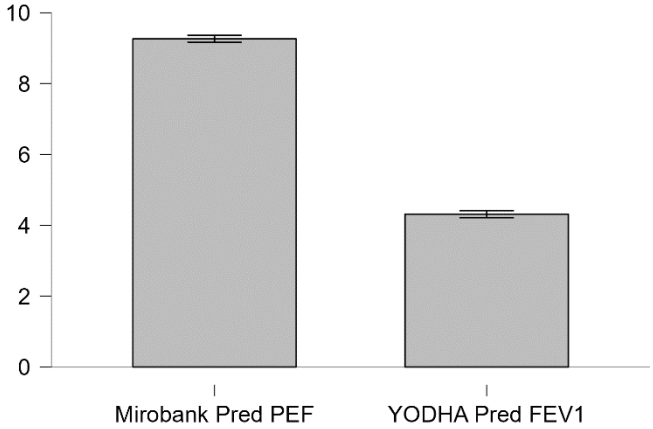
Mirobank Pred FEV1 - YODHA FEV1



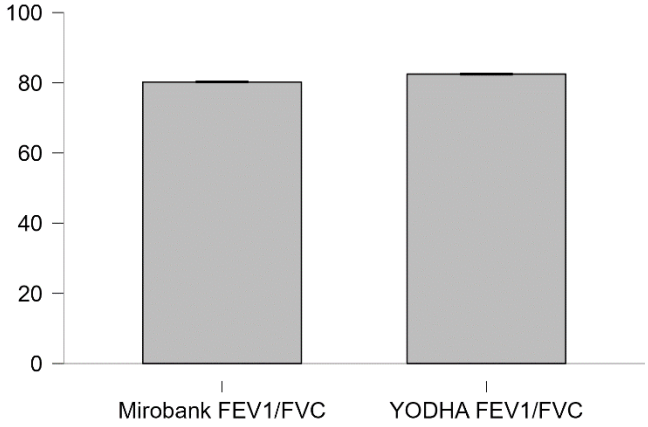
Mirobank PEF - YODHA PEF



Mirobank Pred PEF - YODHA Pred FEV1



Mirobank FEV1/FVC - YODHA FEV1/FVC



Comparative Analysis of Blood Pressure and Pulse Rate Measurements between Omron and YODHA Devices

The Omron and YODHA devices show similarities and differences in blood pressure measurements (see Tables 10, 11, 12; Figures 9,10 for details), with Omron having a mode of 148.000 and YODHA slightly

lower at 139.200. However, the median and mean values for both devices are quite close, with Omron having a mean of 135.000 and YODHA 135.240. The SD for both is also similar, with Omron at 13.581 and YODHA at 13.802. The IQR is comparable as well, with Omron at 21.250 and YODHA at 20.857. However, while the Shapiro-Wilk test indicates significant deviations from normality for both devices (W = 0.933, p < .001 for Omron; W = 0.980, p = .124 for YODHA), the range of systolic blood pressure values is wider for YODHA (ranging from 109.312 to 168.000) compared to Omron (ranging from 110.000 to 160.000).

Both Omron and YODHA devices show similar median and mean values for diastolic blood pressure, with Omron at 82,000 and YODHA at 82.110. The SD for diastolic pressure is comparable as well, with Omron at 8.540 and YODHA at 8.893. However, the mode for Omron is 78.000, slightly lower than YODHA's mode of 76.128. Both devices display significant deviations from normality according to the Shapiro-Wilk test (W = 0.931, p < .001 for Omron; W = 0.983, p = .230 for YODHA).

The mean pulse rate for Omron is 79.500, with a SD of 14.107, while for YODHA it is 79.737, slightly higher than the SD of 14.332. The Shapiro-Wilk test indicates significant deviations from normality for both devices (W = 0.945, p < .001 for Omron; W = 0.983, p = .233 for YODHA). Both devices exhibit similar patterns in terms of mean, SD, and normality of pulse rate measurements.

Table 9: Descriptive Statistics Blood Pressure

Descriptive Statistics

	Mode	Median	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum	25th percentile	50th percentile	75th percentile
Omron BP Systolic	148.000[a]	135.000	134.190	13.581	21.250	0.970	0.024	50.000	110.000	160.000	124.000	135.000	145.250
YODHA BP Systolic	139.200[a]	135.240	134.736	13.802	20.857	0.980	0.124	58.688	109.312	168.000	123.300	135.240	144.157
Omron BP Diastolic	78.000[a]	82.000	81.850	8.540	12.250	0.986	0.363	36.000	63.000	99.000	75.750	82.000	88.000
YODHA BP Diastolic	76.128[a]	82.110	82.215	8.893	11.752	0.983	0.230	39.540	63.360	102.900	76.363	82.110	88.115
Omron BP Pulse	89.000[a]	79.500	79.580	14.107	20.250	0.978	0.089	57.000	50.000	107.000	70.000	79.500	90.250
YODHA BP Pulse	72.633[a]	79.737	79.931	14.332	17.399	0.983	0.233	60.465	48.000	108.465	72.135	79.737	89.534

[a] The mode is computed assuming that variables are discreet.

Table 10: Paired Samples T-Test Blood Pressure

Paired Samples T-Test

Measure 1		Measure 2	t	df	p
Omron BP Systolic	-	YODHA BP Systolic	-1.319	99	0.190
Omron BP Diastolic	-	YODHA BP Diastolic	-1.447	99	0.151
Omron BP Pulse	-	YODHA BP Pulse	-1.412	99	0.161

Note. Student's t-test.

Table 11: Assumption Checks

Test of Normality (Shapiro-Wilk)

			W	p
Omron BP Systolic	-	YODHA BP Systolic	0.933	< .001
Omron BP Diastolic	-	YODHA BP Diastolic	0.931	< .001
Omron BP Pulse	-	YODHA BP Pulse	0.945	< .001

Note. Significant results suggest a deviation from normality.

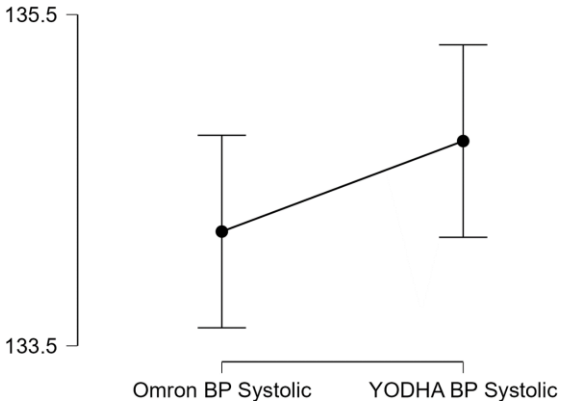
Table 12: Descriptives

Descriptives

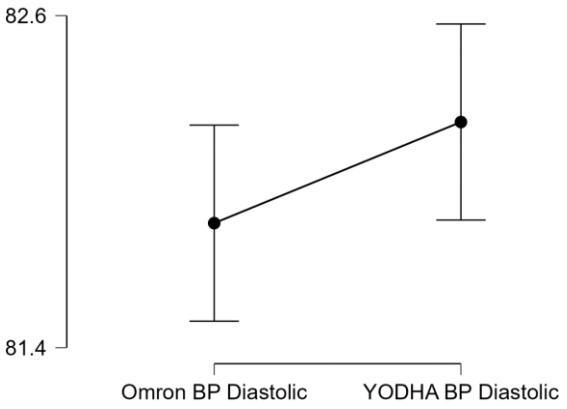
	N	Mean	SD	SE	Coefficient of variation
Omron BP Systolic	100	134.190	13.581	1.358	0.101
YODHA BP Systolic	100	134.736	13.802	1.380	0.102
Omron BP Diastolic	100	81.850	8.540	0.854	0.104
YODHA BP Diastolic	100	82.215	8.893	0.889	0.108
Omron BP Pulse	100	79.580	14.107	1.411	0.177
YODHA BP Pulse	100	79.931	14.332	1.433	0.179

Figure 9: Descriptives Plots

Omron BP Systolic - YODHA BP Systolic



Omron BP Diastolic - YODHA BP Diastolic



Omron BP Pulse - YODHA BP Pulse

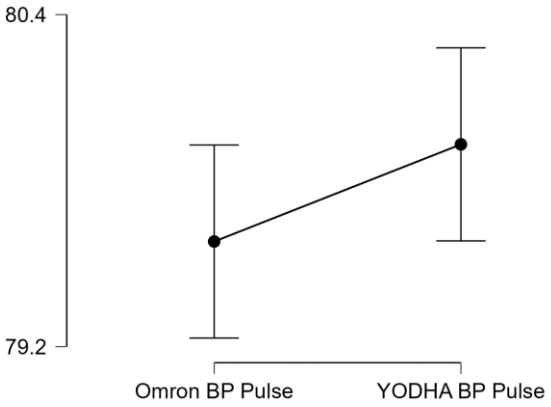
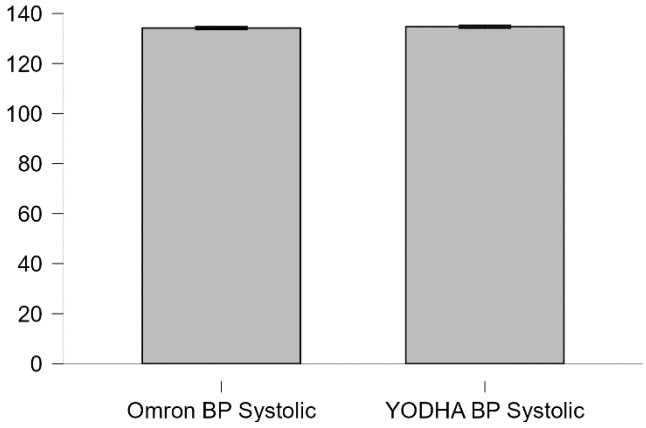
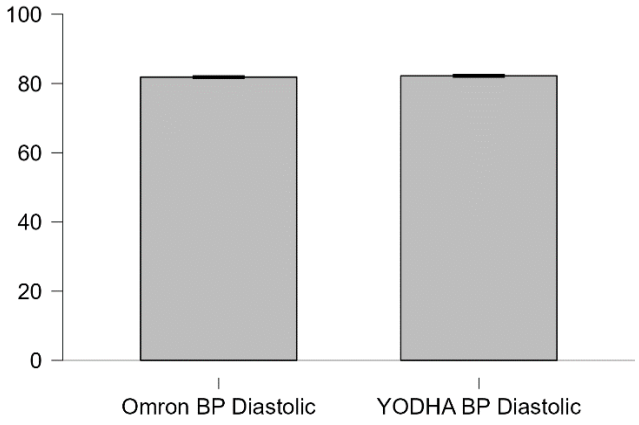


Figure 10: Bar Plots

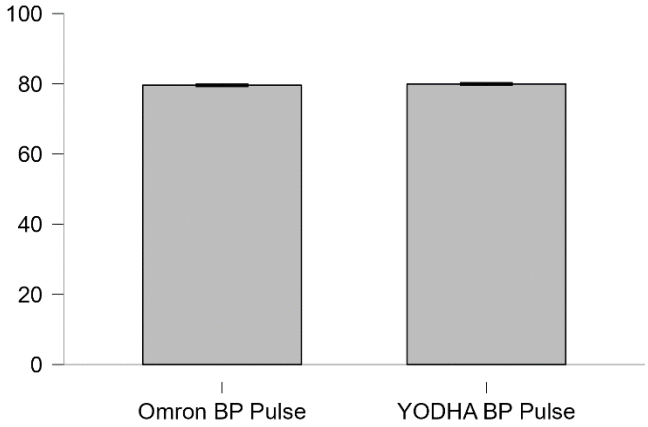
Omron BP Systolic - YODHA BP Systolic



Omron BP Diastolic - YODHA BP Diastolic



Omron BP Pulse - YODHA BP Pulse



Comparative Analysis of Hearing Test Results between Gold standard in person testing and YODHA Devices across Various Frequencies

The Spearman's correlation coefficients indicate significant associations between the hearing test results obtained from gold standard in person testing and YODHA devices across various frequencies (see details for each frequency in Table 13). At 500Hz in the left ear, there was a perfect positive correlation (Spearman's rho = 1.000, $p < .001$), suggesting a strong agreement between the measurements from both devices at this frequency. Similar strong positive correlations were observed at 1000Hz (Spearman's rho = 0.958, $p < .001$), 2000Hz (Spearman's rho = 0.939, $p < .001$), 3000Hz (Spearman's rho = 0.990, $p < .001$), 4000Hz (Spearman's rho = 0.990, $p < .001$), 6000Hz (Spearman's rho = 0.991, $p < .001$), and 8000Hz (Spearman's rho = 0.989, $p < .001$) in the left ear, indicating consistent correlation patterns across these frequencies.

In the right ear, similar strong positive correlations were observed at all frequencies tested: 500Hz (Spearman's rho = 0.998, $p < .001$), 1000Hz (Spearman's rho = 0.991, $p < .001$), 2000Hz (Spearman's rho = 0.973, $p < .001$), 3000Hz (Spearman's rho = 0.967, $p < .001$), 4000Hz (Spearman's rho = 0.996, $p < .001$), 6000Hz (Spearman's rho = 0.997, $p < .001$), and 8000Hz (Spearman's rho = 1.000, $p < .001$).

Table 13: Hearing Correlation

Spearman's Correlations

Variable		500Hz_Left_Gold_Visit1	500Hz_Left_ YODHA_Visit2
1. 500Hz_Left_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 500Hz_Left_ YODHA_Visit2	Spearman's rho	1.000 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		1000Hz_Left_Gold_Visit1	1000Hz_Left_ YODHA_Visit2
1. 1000Hz_Left_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 1000Hz_Left_ YODHA_Visit2	Spearman's rho	0.958 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		2000Hz_Left_Gold_Visit1	2000Hz_Left_ YODHA_Visit2
1. 2000Hz_Left_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 2000Hz_Left_ YODHA_Visit2	Spearman's rho	0.939 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		3000Hz_Left_Gold_Visit1	3000Hz_Left_ YODHA_Visit2
1. 3000Hz_Left_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 3000Hz_Left_ YODHA_Visit2	Spearman's rho	0.990 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		4000Hz_Left_Gold_Visit1	4000Hz_Left_ YODHA_Visit2
1. 4000Hz_Left_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 4000Hz_Left_ YODHA_Visit2	Spearman's rho	0.990 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		6000Hz_Left_Gold_Visit1	6000Hz_Left_ YODHA_Visit2
1. 6000Hz_Left_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 6000Hz_Left_ YODHA_Visit2	Spearman's rho	0.991 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		8000Hz_Left_Gold_Visit1	8000Hz_Left_ YODHA_Visit2
1. 8000Hz_Left_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 8000Hz_Left_ YODHA_Visit2	Spearman's rho	0.989 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		500Hz_Right_Gold_Visit1	500Hz_Right_ YODHA_Visit2
1. 500Hz_Right_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 500Hz_Right_ YODHA_Visit2	Spearman's rho	0.998 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		1000Hz_Right_Gold_Visit1	1000Hz_Right_ YODHA_Visit2
1. 1000Hz_Right_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 1000Hz_Right_ YODHA_Visit2	Spearman's rho	0.991 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		2000Hz_Right_Gold_Visit1	2000Hz_Right_ YODHA_Visit2
1. 2000Hz_Right_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 2000Hz_Right_ YODHA_Visit2	Spearman's rho	0.973 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		3000Hz_Right_Gold_Visit1	3000Hz_Right_ YODHA_Visit2
1. 3000Hz_Right_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 3000Hz_Right_ YODHA_Visit2	Spearman's rho	0.967 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		4000Hz_Right_Gold_Visit1	4000Hz_Right_ YODHA_Visit2
1. 4000Hz_Right_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 4000Hz_Right_ YODHA_Visit2	Spearman's rho	0.996 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		6000Hz_Right_Gold_Visit1	6000Hz_Right_ YODHA_Visit2
1. 6000Hz_Right_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 6000Hz_Right_ YODHA_Visit2	Spearman's rho	0.997 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		8000Hz_Right_Gold_Visit1	8000Hz_Right_ YODHA_Visit2
1. 8000Hz_Right_Gold_Visit1	Spearman's rho	—	
	p-value	—	
2. 8000Hz_Right_ YODHA_Visit2	Spearman's rho	1.000 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Comparative Analysis of Spirometry Measurements between Mirobank and YODHA Devices

Spearman's correlation coefficients show significant associations between spirometry measurements from Mirobank and YODHA devices (see details in Table 14). For FVC, there is a strong positive correlation between Mirobank and YODHA measurements (Spearman's rho = 0.994, p < .001), indicating consistent FVC values between the two devices. Similarly, a perfect positive correlation exists between predicted FVC values obtained from Mirobank and YODHA devices (Spearman's rho = 1.000, p < .001), confirming precise predicted FVC outcomes.

Regarding FEV1, a strong positive correlation is evident between Mirobank and YODHA measurements (Spearman's rho = 0.995, p < .001), ensuring reliable FEV1 values. The correlation between predicted FEV1 values obtained from Mirobank and YODHA devices was also perfect, with a Spearman's rho of 1.000 (p < .001), also indicating complete agreement in the predicted FEV1 outcomes.

However, for PEF, while a significant correlation was observed between Mirobank and YODHA measurements (Spearman's rho = 0.628, p < .001), the correlation coefficient suggests a moderate level of agreement between the two devices for PEF values. Similarly, there is a perfect positive correlation between predicted PEF values obtained from Mirobank and YODHA devices (Spearman's rho = 1.000, p < .001), ensuring exact predicted PEF outcomes. Regarding the FEV1/FVC ratio, a strong positive correlation exists between Mirobank and YODHA measurements (Spearman's rho = 0.966, p < .001), demonstrating consistent FEV1/FVC ratios. The correlation between predicted FEV1/FVC ratios from Mirobank and YODHA devices is perfect (Spearman's rho = 1.000, p < .001), confirming precise predicted FEV1/FVC ratio outcomes.

Table 14: Spirometry Correlation

Spearman's Correlations

Variable		Mirobank FVC	YODHA FVC
1. Mirobank FVC	Spearman's rho	—	
	p-value	—	
2. YODHA FVC	Spearman's rho	0.994 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Mirobank Pred FVC	YODHA Pred FVC
1. Mirobank Pred FVC	Spearman's rho	—	
	p-value	—	
2. YODHA Pred FVC	Spearman's rho	1.000 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Mirobank FEV1	YODHA FEV1
1. Mirobank FEV1	Spearman's rho	—	
	p-value	—	
2. YODHA FEV1	Spearman's rho	0.995 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Mirobank Pred FEV1	YODHA Pred FEV1
1. Mirobank Pred FEV1	Spearman's rho	—	
	p-value	—	
2. YODHA Pred FEV1	Spearman's rho	1.000 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Mirobank PEF	YODHA Pred PEF
1. Mirobank PEF	Spearman's rho	—	
	p-value	—	
2. YODHA Pred PEF	Spearman's rho	0.628 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Mirobank Pred PEF	YODHA Pred PEF
1. Mirobank Pred PEF	Spearman's rho	—	
	p-value	—	
2. YODHA Pred PEF	Spearman's rho	1.000 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Mirobank FEV1/FVC	YODHA FEV1/FVC
1. Mirobank FEV1/FVC	Spearman's rho	—	
	p-value	—	
2. YODHA FEV1/FVC	Spearman's rho	0.966 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Mirobank Pred FEV1/FVC	YODHA Pred FEV1/FVC
1. Mirobank Pred FEV1/FVC	Spearman's rho	—	
	p-value	—	
2. YODHA Pred FEV1/FVC	Spearman's rho	1.000 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Correlations Between Omron and YODHA Devices for Blood Pressure Measurements

Spearman's correlation coefficients indicate strong associations between Omron and YODHA devices (see details in Table 15), with a high positive correlation for systolic blood pressure (Spearman's rho = 0.956, p < .001), indicating consistent readings. Diastolic blood pressure measurements also show a strong correlation (Spearman's rho = 0.957, p < .001), confirming agreement between the two devices. Pulse rate values display an even higher correlation (Spearman's rho = 0.983, p < .001), further demonstrating consistency.

Table 15: Blood Pressure Correlation

Spearman's Correlations

Variable		Omron BP Systolic	YODHA BP Systolic
1. Omron BP Systolic	Spearman's rho	—	
	p-value	—	
2. YODHA BP Systolic	Spearman's rho	0.956 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Omron BP Diastolic	YODHA BP Diastolic
1. Omron BP Diastolic	Spearman's rho	—	
	p-value	—	
2. YODHA BP Diastolic	Spearman's rho	0.957 ***	—
	p-value	< .001	—

* p < .05, ** p < .01, *** p < .001

Spearman's Correlations

Variable		Omron BP Pulse	YODHA BP Pulse
1. Omron BP Pulse	Spearman's rho	—	
	p-value	—	
2. YODHA BP Pulse	Spearman's rho	0.983 ***	—
	p-value	< .001	—

Spearman's Correlations

Variable	Omron BP Pulse	YODHA BP Pulse

* p < .05, ** p < .01, *** p < .001

Gender Differences in Auditory Thresholds Across Frequencies and Visits

Gender differences in auditory thresholds reveal nuanced variations across frequencies and visits (see details in Table 16). For instance, at 500Hz during the gold standard in person testing, males displayed a mean threshold of 9.521 dB (SD = 8.214 dB), slightly lower than females with a mean threshold of 9.815 dB (SD = 8.932 dB). Similarly, at 1000Hz, males showed a mean threshold of 8.493 dB (SD = 7.532 dB), while females had a mean threshold of 8.148 dB (SD = 7.740 dB). The trend indicates that males generally have slightly lower mean thresholds than females, but this difference varies across frequency bands. Gender differences in mean thresholds vary at different frequencies, with males showing marginally lower thresholds at 500Hz and 1000Hz, and more pronounced at 3000Hz and 4000Hz.

Table 16: Gender Differences Descriptive Statistics

Descriptive Statistics

		Valid	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum
500Hz_Left_Gold_Visit1	1	73	9.521	8.214	10.000	0.780	< .001	35.000	0.000	35.000
500Hz_Left_Gold_Visit1	2	27	9.815	8.932	10.000	0.796	< .001	35.000	0.000	35.000
1000Hz_Left_Gold_Visit1	1	73	8.493	7.532	10.000	0.757	< .001	30.000	0.000	30.000
1000Hz_Left_Gold_Visit1	2	27	8.148	7.740	5.000	0.756	< .001	30.000	0.000	30.000
2000Hz_Left_Gold_Visit1	1	73	6.096	7.784	5.000	0.736	< .001	35.000	-5.000	30.000
2000Hz_Left_Gold_Visit1	2	27	6.296	8.615	5.000	0.801	< .001	35.000	-5.000	30.000
3000Hz_Left_Gold_Visit1	1	73	19.589	16.827	20.000	0.842	< .001	55.000	0.000	55.000
3000Hz_Left_Gold_Visit1	2	27	18.704	17.845	20.000	0.825	< .001	55.000	0.000	55.000
4000Hz_Left_Gold_Visit1	1	73	21.575	14.479	15.000	0.852	< .001	45.000	5.000	50.000
4000Hz_Left_Gold_Visit1	2	27	20.926	15.002	15.000	0.833	< .001	45.000	5.000	50.000
6000Hz_Left_Gold_Visit1	1	73	26.027	11.606	15.000	0.905	< .001	40.000	10.000	50.000
6000Hz_Left_Gold_Visit1	2	27	25.926	11.354	12.500	0.914	0.028	40.000	10.000	50.000
8000Hz_Left_Gold_Visit1	1	73	18.425	9.856	10.000	0.824	< .001	40.000	5.000	45.000
8000Hz_Left_Gold_Visit1	2	27	19.815	11.307	5.000	0.869	0.003	40.000	5.000	45.000
500Hz_Right_Gold_Visit1	1	73	8.356	8.419	10.000	0.931	< .001	30.000	-5.000	25.000
500Hz_Right_Gold_Visit1	2	27	9.630	9.700	17.500	0.910	0.023	30.000	-5.000	25.000
1000Hz_Right_Gold_Visit1	1	73	6.781	8.595	5.000	0.825	< .001	35.000	-5.000	30.000
1000Hz_Right_Gold_Visit1	2	27	7.037	7.998	5.000	0.734	< .001	35.000	-5.000	30.000
2000Hz_Right_Gold_Visit1	1	73	6.438	12.061	15.000	0.818	< .001	45.000	-5.000	40.000
2000Hz_Right_Gold_Visit1	2	27	9.074	11.851	15.000	0.869	0.003	45.000	-5.000	40.000
3000Hz_Right_Gold_Visit1	1	73	18.219	15.509	20.000	0.800	< .001	55.000	5.000	60.000
3000Hz_Right_Gold_Visit1	2	27	17.593	16.015	20.000	0.780	< .001	55.000	5.000	60.000
4000Hz_Right_Gold_Visit1	1	73	22.534	16.732	30.000	0.914	< .001	55.000	0.000	55.000
4000Hz_Right_Gold_Visit1	2	27	22.593	15.403	20.000	0.933	0.080	55.000	0.000	55.000
6000Hz_Right_Gold_Visit1	1	73	28.151	13.681	20.000	0.850	< .001	50.000	10.000	60.000
6000Hz_Right_Gold_Visit1	2	27	30.370	15.746	22.500	0.878	0.004	50.000	10.000	60.000
8000Hz_Right_Gold_Visit1	1	73	22.192	9.574	15.000	0.903	< .001	30.000	10.000	40.000
8000Hz_Right_Gold_Visit1	2	27	22.778	10.316	15.000	0.851	0.001	30.000	10.000	40.000

Descriptive Statistics

		Valid	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum
500Hz_ Left_YODHA_Visit2	1	73	9.521	8.214	10.000	0.780	< .001	35.000	0.000	35.000
500Hz_ Left_YODHA_Visit2	2	27	9.815	8.932	10.000	0.796	< .001	35.000	0.000	35.000
1000Hz_ Left_YODHA_Visit2	1	73	8.836	7.337	10.000	0.747	< .001	30.000	0.000	30.000
1000Hz_ Left_YODHA_Visit2	2	27	8.333	7.596	5.000	0.737	< .001	30.000	0.000	30.000
2000Hz_ Left_YODHA_Visit2	1	73	6.986	8.154	5.000	0.753	< .001	40.000	-5.000	35.000
2000Hz_ Left_YODHA_Visit2	2	27	6.852	8.221	5.000	0.803	< .001	35.000	-5.000	30.000
3000Hz_ Left_YODHA_Visit2	1	73	20.000	16.667	20.000	0.855	< .001	60.000	0.000	60.000
3000Hz_ Left_YODHA_Visit2	2	27	19.074	17.815	20.000	0.831	< .001	55.000	0.000	55.000
4000Hz_ Left_YODHA_Visit2	1	73	21.781	14.822	15.000	0.857	< .001	55.000	5.000	60.000
4000Hz_ Left_YODHA_Visit2	2	27	21.667	15.628	15.000	0.848	0.001	50.000	5.000	55.000
6000Hz_ Left_YODHA_Visit2	1	73	26.164	11.563	15.000	0.904	< .001	40.000	10.000	50.000
6000Hz_ Left_YODHA_Visit2	2	27	25.000	10.470	15.000	0.922	0.043	40.000	10.000	50.000
8000Hz_ Left_YODHA_Visit2	1	73	18.493	9.884	5.000	0.833	< .001	40.000	5.000	45.000
8000Hz_ Left_YODHA_Visit2	2	27	19.815	11.392	5.000	0.884	0.006	45.000	0.000	45.000
500Hz_Right_Yodha	1	73	8.493	8.236	10.000	0.927	< .001	30.000	-5.000	25.000
500Hz_ Right_YODHA_Visit2	2	27	9.630	9.700	17.500	0.910	0.023	30.000	-5.000	25.000
1000Hz_ Right_YODHA_Visit2	1	73	7.055	8.613	5.000	0.837	< .001	35.000	-5.000	30.000
1000Hz_ Right_YODHA_Visit2	2	27	7.037	7.998	5.000	0.734	< .001	35.000	-5.000	30.000
2000Hz_ Right_YODHA_Visit2	1	73	7.192	11.726	10.000	0.832	< .001	45.000	-5.000	40.000
2000Hz_ Right_YODHA_Visit2	2	27	9.815	11.476	15.000	0.871	0.003	45.000	-5.000	40.000
3000Hz_ Right_YODHA_Visit2	1	73	18.767	14.925	20.000	0.824	< .001	55.000	5.000	60.000
3000Hz_ Right_YODHA_Visit2	2	27	19.074	17.155	20.000	0.778	< .001	65.000	5.000	70.000
4000Hz_ Right_YODHA_Visit2	1	73	22.808	16.562	30.000	0.920	< .001	55.000	0.000	55.000
4000Hz_ Right_YODHA_Visit2	2	27	22.963	15.582	20.000	0.933	0.081	60.000	0.000	60.000
6000Hz_ Right_YODHA_Visit2	1	73	28.014	13.610	20.000	0.863	< .001	50.000	10.000	60.000
6000Hz_ Right_YODHA_Visit2	2	27	30.185	15.657	20.000	0.872	0.003	50.000	10.000	60.000
8000Hz_ Right_YODHA_Visit2	1	73	22.192	9.574	15.000	0.903	< .001	30.000	10.000	40.000

Descriptive Statistics

	Valid	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum
8000Hz_ Right_YODHA_Visit2	2	27 22.778	10.316	15.000	0.851	0.001	30.000	10.000	40.000

Pulmonary Function Measures: A Comparative Analysis between Mirobank and YODHA Groups

The Mirobank group had a FVC mean was 4.797 L (SD = 1.282) for male participants and 4.456 L (SD = 1.300) for female participants (see details in Table 17). Similarly, the predicted FVC mean was 5.295 L (SD = 0.719) for males and 4.964 L (SD = 0.869) for females. Interestingly, a slight decrease in mean values for FVC and predicted FVC was observed from Visit 1 to Visit 2, although the SDs remained relatively consistent. Moreover, a similar trend was observed for FEV1 and PEF measures.

Comparatively, the YODHA group exhibited similar patterns in pulmonary function measures across visits, albeit with some variations. For example, the FVC mean for male participants was 4.950 L (SD = 1.324) and for female participants was 4.527 L (SD = 1.308). Likewise, the predicted FVC mean was 5.295 L (SD = 0.719) for males and 4.964 L (SD = 0.869) for females. Despite these similarities, subtle differences in mean values between the Mirobank and YODHA groups were noted, suggesting potential group-specific differences in pulmonary function. Additionally, the FEV1/FVC ratio showed consistent trends across visits, with slightly higher mean values in the YODHA group compared to the Mirobank group, indicating potential differences in airway obstruction or pulmonary restriction between the two groups.

Table 17: Descriptive Statistics on Pulmonary Function

Descriptive Statistics

	Valid	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum
Mirobank FVC	1	73 4.797	1.282	1.690	0.961	0.022	6.540	0.750	7.290
Mirobank FVC	2	27 4.456	1.300	0.670	0.919	0.037	5.730	1.390	7.120
Mirobank Pred FVC	1	73 5.295	0.719	0.920	0.914	< .001	3.480	2.800	6.280
Mirobank Pred FVC	2	27 4.964	0.869	0.845	0.879	0.005	4.140	2.100	6.240
Mirobank FEV1	1	73 3.840	1.043	1.540	0.950	0.006	4.840	0.750	5.590
Mirobank FEV1	2	27 3.549	1.081	0.800	0.949	0.208	4.670	1.000	5.670
Mirobank Pred FEV1	1	73 4.386	0.598	0.670	0.863	< .001	2.910	2.350	5.260
Mirobank Pred FEV1	2	27 4.116	0.718	0.310	0.819	< .001	3.060	1.920	4.980
Mirobank PEF	1	73 8.342	2.743	2.610	0.954	0.010	11.080	2.710	13.790
Mirobank PEF	2	27 7.794	2.565	2.295	0.970	0.593	11.270	2.080	13.350
Mirobank Pred PEF	1	73 9.374	1.175	1.070	0.807	< .001	5.700	5.190	10.890
Mirobank Pred PEF	2	27 8.956	1.460	0.855	0.805	< .001	5.650	5.240	10.890
Mirobank FEV1/FVC	1	73 80.505	8.267	7.300	0.914	< .001	49.100	50.900	100.000
Mirobank FEV1/FVC	2	27 79.396	6.269	7.450	0.883	0.005	27.700	59.200	86.900

Descriptive Statistics

		Valid	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum
Mirobank Pred FEV1/FVC	1	73	83.473	3.584	3.200	0.939	0.002	21.000	72.200	93.200
Mirobank Pred FEV1/FVC	2	27	81.693	3.060	4.050	0.927	0.060	14.500	76.400	90.900
YODHA FVC	1	73	4.950	1.324	1.703	0.961	0.023	6.824	0.767	7.592
YODHA FVC	2	27	4.527	1.308	0.778	0.932	0.078	5.727	1.436	7.163
YODHA Pred FVC	1	73	5.295	0.719	0.920	0.914	< .001	3.480	2.800	6.280
YODHA Pred FVC	2	27	4.964	0.869	0.845	0.879	0.005	4.140	2.100	6.240
YODHA FEV1	1	73	3.963	1.076	1.623	0.951	0.006	4.987	0.767	5.754
YODHA FEV1	2	27	3.606	1.092	0.967	0.961	0.395	4.767	1.033	5.800
YODHA Pred FEV1	1	73	4.386	0.598	0.670	0.863	< .001	2.910	2.350	5.260
YODHA Pred FEV1	2	27	4.116	0.718	0.310	0.819	< .001	3.060	1.920	4.980
YODHA PEF	1	73	8.611	2.832	3.008	0.957	0.015	11.473	2.772	14.245
YODHA PEF	2	27	7.920	2.596	2.397	0.973	0.679	11.508	2.149	13.657
YODHA Pred PEF	1	73	9.374	1.175	1.070	0.807	< .001	5.700	5.190	10.890
YODHA Pred PEF	2	27	8.956	1.460	0.855	0.805	< .001	5.650	5.240	10.890
YODHA FEV1/FVC	1	73	83.106	8.685	7.517	0.915	< .001	52.929	52.071	105.000
YODHA FEV1/FVC	2	27	80.730	6.626	7.450	0.903	0.016	29.695	59.555	89.250
YODHA Pred FEV1/FVC	1	73	83.473	3.584	3.200	0.939	0.002	21.000	72.200	93.200
YODHA Pred FEV1/FVC	2	27	81.693	3.060	4.050	0.927	0.060	14.500	76.400	90.900

Gender-Specific Blood Pressure Measurements: A Comparative Analysis between Omron and YODHA Devices

The descriptive statistics offer valuable insights into the blood pressure measurements recorded using Omron and YODHA devices, with distinct patterns observed between male and female participants (see details in Table 18). In terms of systolic blood pressure measured by Omron devices, male participants exhibited a slightly higher mean of 134.877 mmHg (SD = 13.559) compared to female participants, who had a mean of 132.333 mmHg (SD = 13.720). Similarly, for diastolic blood pressure measured by Omron, males had a mean of 82.000 mmHg (SD = 8.342), slightly higher than females with a mean of 81.444 mmHg (SD = 9.208). However, when examining pulse rate, females showed a slightly higher mean of 81.630 bpm (SD = 11.610) compared to males with a mean of 78.822 bpm (SD = 14.927).

Contrastingly, the YODHA group displayed comparable patterns in blood pressure measures between male and female participants. For systolic blood pressure, males had a mean of 135.133 mmHg (SD = 13.857) and females had a mean of 133.664 mmHg (SD = 13.854). Likewise, diastolic blood pressure showed similar trends, with males exhibiting a mean of 82.187 mmHg (SD = 8.726) and females with a mean of 82.293 mmHg (SD = 9.502). Interestingly, the pulse rate among YODHA participants showed a slightly higher mean for females, with 82.493 bpm (SD = 12.105), compared to males with 78.984 bpm (SD = 15.039).

Table 18: Descriptive Statistics on Blood Pressure Measurements

Descriptive Statistics

		Valid	Mean	Std. Deviation	IQR	Shapiro-Wilk	P-value of Shapiro-Wilk	Range	Minimum	Maximum
Omron BP Systolic	M	73	134.877	13.559	23.000	0.968	0.059	50.000	110.000	160.000
Omron BP Systolic	F	27	132.333	13.720	19.500	0.961	0.394	49.000	110.000	159.000
Omron BP Diastolic	M	73	82.000	8.342	12.000	0.985	0.556	36.000	63.000	99.000
Omron BP Diastolic	F	27	81.444	9.208	11.500	0.957	0.323	33.000	65.000	98.000
Omron BP Pulse	M	73	78.822	14.927	24.000	0.967	0.053	57.000	50.000	107.000
Omron BP Pulse	F	27	81.630	11.610	15.500	0.969	0.571	44.000	61.000	105.000
YODHA BP Systolic	M	73	135.133	13.857	19.704	0.981	0.350	58.688	109.312	168.000
YODHA BP Systolic	F	27	133.664	13.854	19.554	0.972	0.647	52.983	111.264	164.247
YODHA BP Diastolic	M	73	82.187	8.726	11.536	0.973	0.117	37.917	63.360	101.277
YODHA BP Diastolic	F	27	82.293	9.502	11.307	0.972	0.651	35.755	67.145	102.900
YODHA BP Pulse	M	73	78.984	15.039	19.290	0.971	0.088	56.860	48.000	104.860
YODHA BP Pulse	F	27	82.493	12.105	14.016	0.966	0.510	46.977	61.488	108.465

Discussion

Exploring the Potential of Remote Health Assessment Technologies: A Comparative Analysis and Demographic Considerations

Recent research by Semaan et al. (2023) and Bardram (2023) highlights the promising accuracy of remote health assessment technologies, such as remote photoplethysmography imaging and telemedicine, which rival traditional in-person methods for measuring vital signs and conducting physical examinations. Specifically, Semaan et al. (2023) demonstrated excellent agreement between remote and standard measurements for vital signs like respiratory rate, while Bardram (2023) found telemedicine to be effective in children for various examinations, including otoscopy and lung auscultations. Moreover, Wagner et al. (2023) found that digital applications have facilitated accurate remote hearing assessments, supporting decentralised hearing services. These findings underscore the potential of remote health assessment technologies to enhance employee wellbeing by providing reliable measurements of blood pressure, hearing, and lung function, thus offering a viable alternative to traditional in-person methods.

However, it's noteworthy that the sample in the study displayed a notable skew towards older ages, with a quarter falling between 52 and 67 years old. This suggests potential demographic trends or sampling biases within the study. This demographic variability is critical, as age and gender can influence health parameters such as auditory and pulmonary function (Ftouh et al., 2018; World Health Organisation, 2020). Thus, the comparison of automated health monitoring technologies with

traditional in-person methods entails significant methodological considerations, especially given the predominantly male sample (73%) with a diverse age range (mean age 39.7 years, SD = 14.2).

Comparative Analysis of Hearing Test Results: Evaluating Variations Between Gold standard in person testing and YODHA Assessments

Examining the Paired Samples T-Test results for the hearing test between gold standard in person testing and YODHA reveals significant differences at specific frequencies, such as 1000Hz and 2000Hz in the left ear, and 4000Hz in the right ear, indicating variations in hearing thresholds between the two visits. Conversely, several frequencies, including 6000Hz and 8000Hz in the left ear, and 500Hz and 6000Hz in the right ear, showed no significant differences, suggesting consistent hearing thresholds and stable auditory performance for these frequencies between the two testing conditions. Additionally, the inability to perform comparisons at 500Hz in the left ear and 8000Hz in the right ear due to zero variance highlights specific issues in variability that should be further investigated.

Thus, the study identified significant differences in hearing thresholds between the two visits, highlighting potential variability in remote hearing tests and challenges in maintaining consistent noise levels (Füllgrabe et al., 2015). Despite these differences, strong positive correlations across all tested frequencies suggest that the relative ranking of individuals remains stable, indicating crucial monitoring over time. Furthermore, considering the limitations of standard audiometry protocols, such as the standard 7029:2017, which does not adequately address variations across individual sexes and age groups, there is a need for extended high-frequency audiometry to ensure comprehensive hearing assessment (Škerková et al., 2022). Additionally, the reliability of alternative methods, such as the Amplivox hearing test, especially in assessing hearing status through distortion-product otoacoustic emission measurements, underscores the importance of exploring diverse assessment approaches. These approaches can provide more accurate and detailed insights into auditory function, as evidenced in our study comparing gold standard in-person testing and YODHA results (Burke et al., 2010).

Comparative Analysis of Spirometry Results Between Mirobank and YODHA Devices: Insights into Pulmonary Function Assessment

Comparing spirometry results between Mirobank and YODHA reveals slight differences, with YODHA generally showing slightly higher mean values for FVC, FEV1, and PEF. However, both sets of measures exhibit significant deviations from normality, consistent with prior research highlighting variability in spirometry measures due to factors such as user proficiency and environmental conditions (Miller, 2005). The FEV1/FVC ratio suggests a potential improvement in pulmonary function with YODHA measurements. The lack of variability in predicted FVC and FEV1 between Mirobank and YODHA

suggests the need for further investigation into comparability issues, especially in women and patients with less severe airflow limitations (Aggarwal et al., 2006).

Notably, spirometers are considered the gold standard for COPD diagnosis, yet technical factors can lead to inaccuracies, especially in outpatient settings (Fan et al., 2020). Moreover, although our study did not directly assess sensitivity and specificity, the notable distinctions observed between gold standard in person testing and YODHA imply efficacy in detecting alterations in hearing thresholds. This aligns with the documented high accuracy rates of hearing screeners like pure-tone screening and HearCheck, which exhibited a sensitivity of at least 89% and specificity of at least 78% (Fortnum et al., 2016). Additionally, Barth et al. (2024) found reasonable concordance between clinic and home spirometry in patients with interstitial lung disease, confirming the reliability of remote spirometry measurements and endorsing their potential for accurate health monitoring. This further supports the conclusions drawn from our study.

Consistency of Blood Pressure Measurements Between Omron and YODHA Devices: Implications for Clinical Monitoring

Our investigation into the correlation of blood pressure data between Omron and YODHA devices revealed robust positive correlations for systolic (Spearman's rho = 0.956, $p < .001$), diastolic (Spearman's rho = 0.957, $p < .001$), and pulse rate (Spearman's rho = 0.983, $p < .001$), indicating a high level of consistency between the devices. The significant deviations from normality observed in both devices align with previous research suggesting that blood pressure measurements may vary due to factors such as cuff placement, user technique, and device calibration (Parati et al., 2014). In contrast, a study by Juraschek et al. (2023) examining device agreement for home and office blood pressure measurements using the Omron HEM-907XL found a failure rate of 22.4%, with Omron devices exhibiting a failure rate of 19.1% compared to 27.6% for non-Omron devices. This study underscores that more than one-fifth of home devices failed to meet the accuracy protocol set by the American Medical Association, underscoring the importance of office-based comparisons to ensure the accuracy of home devices. The high correlation coefficients (Spearman's rho > 0.95) suggest that YODHA can deliver reliable blood pressure readings comparable to conventional methods, which is essential for monitoring chronic diseases (O'Brien et al., 2013) and may potentially meet the accuracy standards observed in clinical settings, alike the reliable performance of Omron devices (Juraschek et al., 2023).

Gender-Specific Variations in Auditory Thresholds Across Frequencies and Visits: Implications for Auditory Sensitivity Assessment

Gender differences in auditory thresholds manifest as nuanced variations across frequencies and visits, with males generally exhibiting slightly lower mean thresholds than females, particularly at higher frequencies. These findings underscore the intricate interplay between gender and auditory sensitivity, hinting at frequency-specific factors influencing these disparities. Further investigation is warranted to unravel the underlying mechanisms driving these differences.

Supporting our observations, previous research by Von Gablenz et al. (2020) highlights the variability of gender differences in auditory thresholds across studies and regions. For instance, German studies revealed that 15.5% of participants had a pure-tone average exceeding 25 dB HL at 0.5, 1, 2, and 4 kHz in the better ear, with 8.6% exhibiting a PTA of at least 35 dB HL. Comparisons with Dutch and Swedish studies generally corroborated our findings, although some disparities were evident. Notably, discrepancies emerged when comparing with US-American results, indicating regional disparities in age-related hearing impairment. Specifically, there was less pronounced age-related hearing impairment in Europe compared to the US, potentially attributable to lower rates of hearing impairment in males as observed in European studies.

Gender-Specific Analysis of Spirometry Measurements and Implications for Pulmonary Function Assessment

The study findings reveal a high level of agreement in spirometry measurements across male and female participants, particularly for FVC and FEV1. However, measurements of PEF exhibit a moderate level of consistency. Both genders demonstrate similar levels of reliability in spirometry measurements across both Mirobank and YODHA devices. Male participants exhibit more consistent results across visits compared to female participants in both groups. Despite subtle variations between the two groups, trends in pulmonary function measures remain relatively consistent, with slight decreases in mean values observed from Visit 1 to Visit 2.

The results on spirometry from the Mirobank and YODHA groups aligns with existing research by Li et al. (2023) on pulmonary function in patients with chronic obstructive pulmonary disease (COPD). Consistent with prior findings, disparities in lung function measures are observed between male and female participants. Males generally exhibit higher mean FVC and predicted FVC values compared to females in both groups. Interestingly, a slight decline in these mean values is noted from Visit 1 to Visit 2, despite consistent standard deviations. While our study primarily focuses on pulmonary function measures across visits, Li et al. (2023) have explored differences in COPD-related comorbidities and all-cause mortality between men and women. Although not directly examined in our study, these previous findings highlight the broader context of sex-based disparities in COPD outcomes.

In terms of spirometry, the YODHA group demonstrates similar trends to the Mirobank group, suggesting comparable patterns in lung function measures. However, subtle variations in mean values between the two groups imply potential differences in disease severity or progression. Furthermore, consistent trends in the FEV1/FVC ratio across visits, with slightly higher mean values in the YODHA group, may indicate distinctions in airway obstruction or pulmonary restriction between the two groups. These findings underscore the significance of sex-based differences in pulmonary function measures and emphasise the need for further investigation into their clinical implications.

Gender-Specific Analysis of Blood Pressure Correlations and Implications for Clinical Interpretation

The analysis demonstrates strong correlations between Omron and YODHA devices across all blood pressure metrics, indicating consistent results. Notably, there are no significant differences in consistency observed between male and female participants. While both devices provide valuable insights into blood pressure measurements, the YODHA group shows greater consistency between male and female participants across visits, whereas the Omron group displays slightly more variability. These findings emphasise the need to consider device-specific factors and potential gender biases when interpreting blood pressure measurements for clinical assessment and intervention strategies. Further research is necessary to elucidate the underlying mechanisms contributing to gender-specific variations in blood pressure measurements recorded by different devices.

This study's findings on gender-specific patterns in blood pressure measurements align with the research by Kiss et al. (2024), which identified differences in cardiovascular risk factors between men and women. While our study focuses on blood pressure measurements obtained using Omron and YODHA devices, Kiss et al. (2024) highlighted disparities in the measurement and management of cardiovascular risk factors. Specifically, they noted that among individuals with elevated blood pressure, women were less likely than men to receive lipid-lowering medications (RR 0.87, 95% CI: 0.79-0.95) but more likely to achieve adequate blood pressure control with treatment (RR 1.17, 95% CI: 1.09-1.25). These findings underscore the importance of considering gender differences in cardiovascular health management, which complements our investigation into gender-specific variations in blood pressure measurements.

Implications for Occupational Health Surveillance

The use of remote health monitoring technology, such as the YODHA mobile screening kit, can significantly enhance accessibility to occupational health services, particularly in industries with dispersed or remotely located workers. This technology allows employees to perform health

assessments at their convenience, reducing the need for travel and minimising work schedule disruptions. Remote health technologies also facilitate continuous and real-time monitoring of workers' health, enabling early detection of health issues, prompt interventions, and better overall management of occupational health risks (Khanijahani et al., 2022). Although the study identifies some discrepancies between new and traditional technologies, the strong positive correlations across various health metrics indicate that remote monitoring can provide reliable data, essential for long-term health monitoring and informed decision-making regarding workplace safety and employee health. Furthermore, remote assessments yielding comparable results to in-person evaluations can reduce the need for physical appointments, saving time and resources and minimising human error and bias associated with technician-administered tests.

Limitations and Future Directions

The study identified significant differences in hearing thresholds and spirometry measures between traditional methods and the YODHA system at certain frequencies and metrics, indicating the need for further refinement and calibration of remote health technologies to match the precision of gold standard devices. Although instructions and video tutorials were provided for using the YODHA device, the reliability of self-administered tests depends on the user's ability to follow instructions correctly. Future research should focus on improving the user interface and providing comprehensive training to ensure consistent and accurate data collection by non-professionals. Additionally, maintaining consistent conditions for remote health assessments, such as controlling ambient noise levels during audiometric testing, poses potential challenges. Future studies should explore ways to mitigate environmental variables that could impact the accuracy of remote health measurements. The sample in the study was predominantly male and had a diverse age range, but it did not reflect an even gender distribution. Future research should aim to include a more balanced demographic representation to ensure that the findings are generalisable across different populations. Longitudinal studies are necessary to fully understand the long-term implications of remote health monitoring, tracking health outcomes over extended periods to assess the effectiveness and reliability of remote technologies in maintaining occupational health standards. Furthermore, the successful implementation of remote health monitoring requires seamless integration with existing occupational health systems. Future research should explore how these technologies can be integrated with current health records, data management systems, and compliance frameworks to enhance overall efficiency and efficacy.

In conclusion, the study demonstrates the potential of remote health monitoring technologies, such as the YODHA mobile screening kit, to enhance occupational health surveillance by improving accessibility,

enabling continuous monitoring, and providing reliable data. Despite the identified challenges related to technological variability, user training, environmental factors, demographic considerations, and integration with existing health systems, the findings underscore the need for ongoing refinement and comprehensive longitudinal research. Addressing these issues will be crucial to fully harness the benefits of remote health monitoring and ensure its effective implementation in diverse occupational settings.

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