VOL. 24, NO. 3, 2025, 230-236
elektrika.utm.my
ISSN 0128-4428

ELEKTRIKA
Journal of Electrical Engineering

Preliminary Findings on Effect of Stress on Breathing Sound Signal

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Abstract: On the onset of the Covid-19 pandemic, announced by WHO on March 2020, the global prevalence estimates for stress were 37%. Extreme stress causes psychological problems in workers such as anxiety and depression, burnout, and decreased productivity. The research among healthy adults has shown that slow breathing significantly reduces psychological stress. However, the breath ratios of inhale versus exhale do not have a significant differential effect on stress reduction. The goal of this study was to quantify sound power of the breathing sound signals of adults, induced by stressful mental workload. Eighteen adults participated in the study. Thirty-six samples of breathing sound signals were captured for normal breathing, and after the participants had undergone three Stressors - Stroop, Trail Marking, and Mental Arithmetic tests. The acquired breathing sound signals were then analysed to obtain power spectral density (PSD). From PSD, the magnitude and the frequency of sound power of the breathing signals were determined. For normal breathings, the magnitude of sound power of male and female participants decreases the same pattern as the frequency of the breathing sound signal increases. However, after they had undergone the Stressors, the magnitude of sound power of the breathing signals of the female participants spikes between frequency 1200 Hz and 2000 Hz. In conclusion, the male participants are indifference to the stressful mental workload imposed to them, while the female participants were susceptible to stress at higher frequency.

Keywords: Breathing Signal, Power Spectral Density, Psychological Test, Signal Processing, Stress Test

Article History: received 25 September 2024; accepted 9 September 2025; published 22 December 2025
Digital Object Identifier 10.11113/elektrika.v24n3.620

1. INTRODUCTION

After the onset of COVID-19 pandemic, declared by the WHO on March 11, 2020, the global prevalence estimates for psychological distress, stress, and depression were approximately 50%, 37% and 28% respectively [1].

Stress is our body's response to the pressure of life situations or events. If we are experiencing something new or in a situation that is threatening our sense of self, the pressure can build up. We often have no control over it in either case, and we do not know the best way of dealing with it. That pressure can be temporary enough to vanish in a few moments. Certain pressures, which may influence our sleep, memory retention and eating habits, could last a long time [2].

Generally, there are four types of stresses – physical, mental, behavioral and emotional. However, mental, behavioral and emotional stress can be classified as psychological. Therefore, it leaves us with two main category or types of stress – physical and psychological stress.

Stress is associated with detrimental physical symptoms such as hypertension, coronary artery disease and congestive heart failure. Stress also contributes to psychological disorders such as anxiety, depression, acute or chronic pain. The stressful states can be classified in terms of two outputs. It is either hindering or challenging.

Because it can cause medical issues, employee burnout, and harm to a person's personal needs, hindering stress is a phenomenon that needs to be recognized and dealt with the soonest. When a person begins to feel emotionally exhausted and cynical as a result of emotionally intense experiences, they are hindered. A hindering stress can cause burnout in a person or employee and be detrimental to that person's needs on a personal level. Employee well-being and progress toward work goals are diminished. Thus, all these symptoms will lead to decreased production and losses at work or inside an organization [3].

In a study by [4] and [5], they have shown that anger has correlated well with the decline of lung function in older men, and the cardiovascular disease. In [4] the researchers have gone more detailed to show that the ‘‘fight’’ component in the fight-flight reflex, the psychophysiology of anger overlaps with that of stress. According to [6], stress appears particularly related to the occurrence and severity of asthma. Asthma exacerbations have been linked to the occurrence of life stressors.

Albeit its common occurrence, psychological stress is hard to diagnose. The diagnosis of stress can be done through questionnaires, biochemical measures and physiologic measures. Biochemical measures of diagnosing stress are quite complicated and exposed to high variation in results. The examples of general procedures of diagnosing stress are tabulated in Table 1.

Stress is not a distinct medical diagnosis and there is no single, specific treatment for it. Treatment for stress focuses on changing the situation, developing stress coping skills, implementing relaxation techniques, and treating symptoms or conditions that may have been caused by chronic stress [7].

Breathing, on the other hand, is thought as an efficient stress buster. The types of breathing that diminishes stress is inhaled for 4 seconds, 6 breaths in a minute, to create slow breathing, and it is pushed deliberately further to induce long exhalation – about 6 seconds. It is called diaphragmatic breathing through which the lungs are expanded by expanding the abdomen which the breathing is conducted the entire exercise should last around 5 minutes [1]. This beneficial breathing technique is achieved also in certain mind-body exercises such as t'ai chi, qi gong, and yoga [8].

The production of breath or respiratory sounds is the result of the exertion and exhaustion of the human lungs. Adult takes approximately 12-20 breaths per minute [9]. Respiratory sounds may be influenced by various demographic characteristics, such as age, gender and employment. When measuring the normal breathing sounds between 60 Hz and 600 Hz bands, there were significant differences between the average frequency values of male and female, regardless of the inspiration or exhaustion of the breathing activity [10]. In [11] studied 40 participants who had undergone strenuous exercise and found that women were less prone to diaphragmatic fatigue than men due to exercise. These results suggest that women have more reliant muscle for the extra diaphragmatic respiratory.

Despite numerous known detrimental effects of hindering stress to a person, the sufferer does not really know his body is dealing with it. Therefore, this study had attempted to quantify the existence of stress in persons by employing stressful mental workload tests, and thus analyzing the stressed breathing sound signal, in terms the magnitude of sound power and frequency of the signal.

Table 1. Measures for diagnosis of stress [7]

No.	Measures	Description
1	Questionnaires	- Appear to correlate well with clinical findings of Life Style Inventory (LSI) and Perceived Stress Scale (PSS) - Social Readjustment Rating Scale (SRRS), Traumatic Stress Symptoms Checklist (TSSC) and Profile Moods Survey (POMS)
2	Biochemical	- Cortisol from corticosteroid hormones found in blood, saliva and urine (the best to analyze). Normal – 25 mg/dl, and can go up to 300 mg/dl. The procedure is hard to administer. The result is hard to interpret due to variation – peak, trough and some point in between - Plasma catecholamine levels in a 15 minutes supine. Normal – 20 to 60 pg/ml, 1000 - 2000 pg/ml when the patient is stressful - Interventions - therapy, medication, and complementary and alternative medicine (CAM).
3	Physiologic	- Heart rate - Heart rate variation - Blood pressure - Heart rate-blood pressure product - Electrodermal activity (Galvanic skin resistance)

2. METHODOLOGY

This paper reports a preliminary finding of the bigger part of the project, which is to quantify stress with respect to mental workloads. Figure 1 shows the procedure of running this project. Real-wave analyser (RWA) was used to record the breathing sound signal in an audiometry room. The calibration of anechoic room had been taken beforehand to ensure microphone working according to the standardized value.

Thirty-six breathing signal samples in *.wav* file (two samples from each participant – normal breathing, and after three Stressors had been the one conducted. Microphone was placed 2 cm from their nasal cavity for 40 seconds to take the readings. For the stress test, a simulated computer task involving different levels of difficulty in Stroop, Trail-Making, and Mental Arithmetic tests had been conducted as described in Section 2.1. The data had been simulated in Matlab to obtain PSD using FFT and Welch methods.

The power spectral density (PSD) provides huge advantage in signal processing by revealing how power of a signal is distributed across different frequencies. Unlike time domain representation, PSD can provide information such as dominant frequencies, bandwidth, and noise properties.

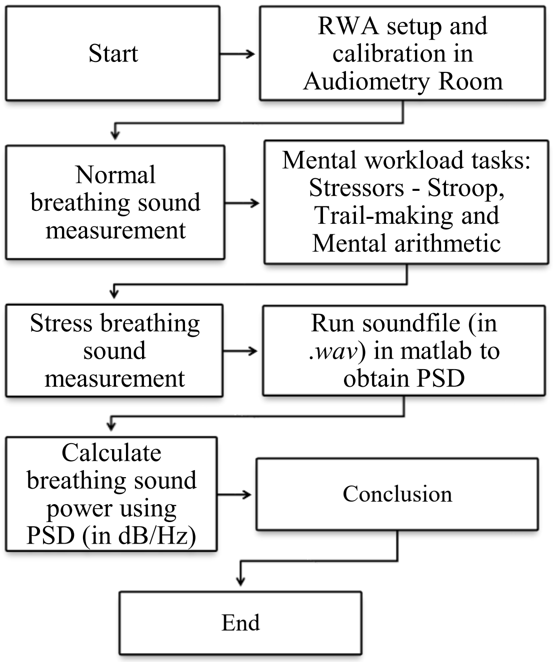


Figure 1. Flowchart of methodology

2.1 Stress Test

A total of 18 healthy individuals consist of nine males and nine females were recruited, with age range between 20–25-year-old, with no history of mental illness. All participants filled in the consent form beforehand. The stress assessments were conducted using Stroop, Trail-Making and Mental Arithmetic test. The tests were conducted using iPad.

2.1.1 Stroop test

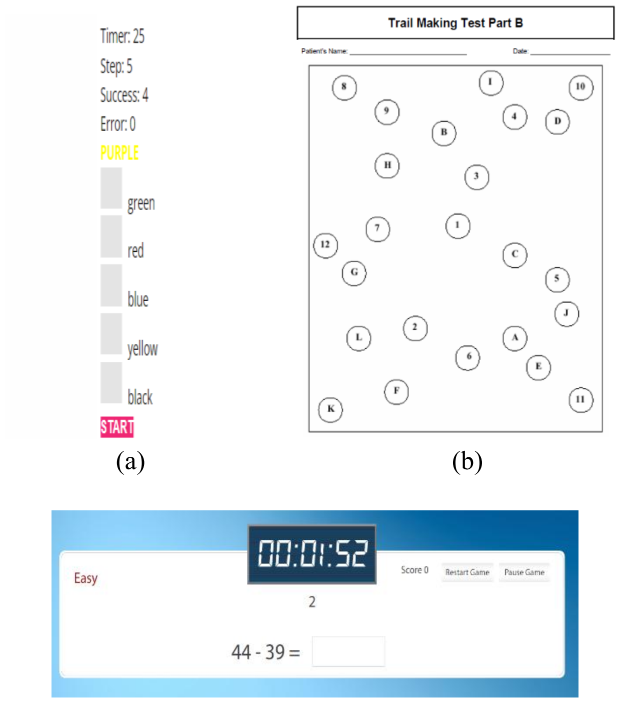
Stroop test is a neuropsychological test published by an American psychologist named John Ridley Stroop in 1935 [12]. Based on the theory, our brain conserves resources and instinctively recognizes familiar words. Consequently, individuals who were proficient in the language will analyse the color based on the words, and not the color of the word displayed. For this project, the participants were given one minute to achieve the correct answers of three levels which are 30, 40 and 50. The test will be repeated until they completed all three level. Figure 2(a) displays the Stroop test conducted in the website of [12]. The participants need to choose the color of the words to get the right answer. On average, each participant took 15 minutes to complete this test.

2.1.2 Trail-making test

Trail-making test is a neuropsychological test requires visual scanning and working memory. It comprises of two parts, part A and B. In every part, the participant is instructed to connect a line between 24 successive circles placed randomly on a sheet of paper. Part A exclusively employs numbers 1-24, while part B combines numbers and letters 1-24 and A-L, necessitating the test subject to shift between numbers and letters in sequence. To complete the test, the participants are required to finish each part within 30, 45 and 60 seconds. The test will be repeated until they achieve all the time target. Figure 2(b) shows the Trail-making test for part B taken from [13]. On average, 15 minutes were taken by the participants to complete the test.

2.1.3 Mental arithmetic test

An arithmetic test assesses one's understanding and capacity to interpret and resolve mathematical problems, which involve fundamental operations like addition, subtraction, division, and multiplication in a variety of problem formats. For this purpose, calculators are not allowed. The participants are required to get 10 correct answers for each level of difficulties, easy, normal and advanced for two minutes each. It will be repeated until all the level are passed. The test was done in website [14] as in Figure 2(c). It is an automated computer test and took each participant, on average, 15 minutes to complete

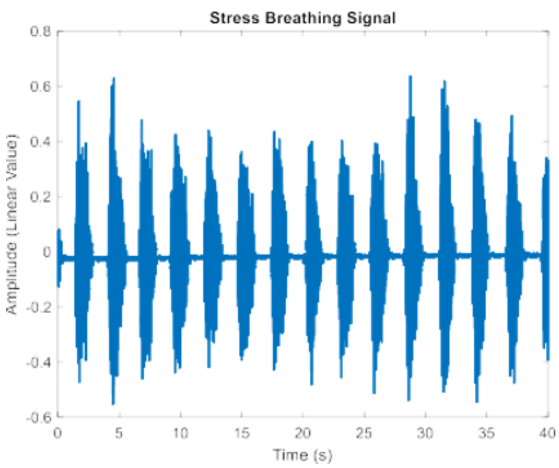


(c)

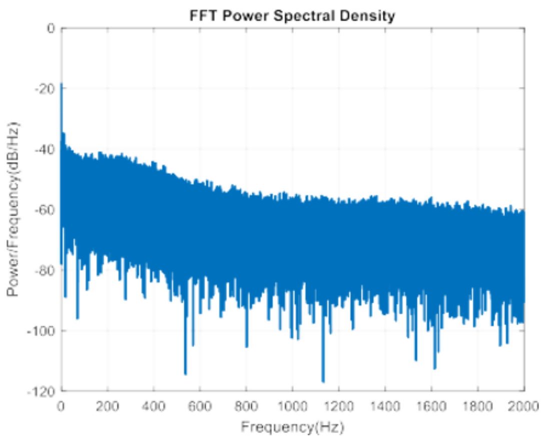
Figure 2. Stress test (a) Stroop [12], (b) Trail-making [13], (c) Mental arithmetic [14] test

2.2 Signal Processing

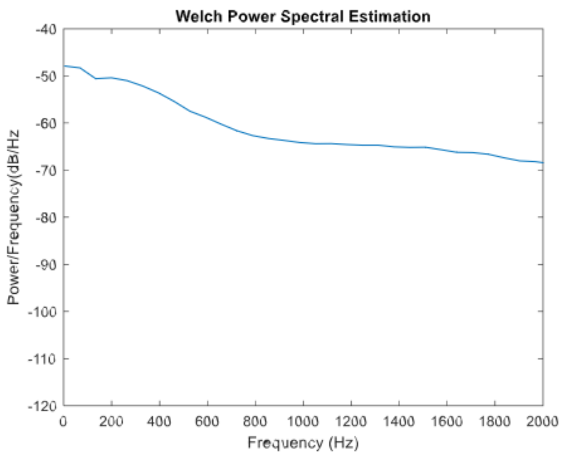
Figure 3 dictates the sequential of processing raw signal (normal/stress breathing sound signal) into PSD. Firstly, the breathing sound raw signals in time-domain (in *.wav* file) were converted into frequency-domain signal using FFT. It is required to change the breathing sound signal in time-domain into the frequency-domain because the analysis must be done at certain frequencies. Then, FFT was converted into PSD using Welch method. These operations were simulated in Matlab. It is used to analyse and characterize the signals at the amplitude with respect to its respective frequency - to extract the signal's underlying power spectrum.



(a)



(b)



(c)

Figure 3. Signal processing (a) Breathing sound signal in *.wav* file (b) Power spectrum of breathing sound – PSD via FFT (c) Power spectrum of breathing sound – PSD via Welch

3. RESULT AND ANALYSIS

The PSD graphs obtained from Welch method as in Figure 3(c) had been inserted numerically in terms of amplitude (dB) and frequency (Hz) in Table 2 and Table 3. The investigated frequencies for the study are five bands - 400 Hz, 800 Hz, 1200 Hz, 1600 Hz and 2000 Hz. Table 2 and Table 3 show PSD of normal (a) and stress (b) breathing sound signals of male and female participants, respectively.

Also, in Table 2 and Table 3, average PSD value from the nine participants, of male and female respectively, are shown with respect to its frequency. PSD amplitude, then, were converted to sound power. Using reference sound power of 1pW, the magnitude of sound power with respect to its frequency, of the breathing sound signal of male and female participants were obtained. For both normal and stressed breathing sound signals of male and female participants, they are in the range of zepto (1 x 10^{-21}) Watts only.

These results are correct since the obtained PSD values are all -dB (negative Decibel), conforming that the breathing signals are all below the reference sound power, which is 1 pW (1 x 10^{-12} Watts).

In Figure 4, for both male and female participants, it has been found that the magnitude of sound power of normal breathing signal decrease steadily, as the frequency of the sound increases. As the magnitude of normal breathing sound power decrease steadily, it is implied that the acquisition of breathing sound signal for this study had been conducted correctly. This is because the equal loudness contour of natural sound phenomena such whistling, snoring, and the sound of falling leaf – exhibits that the magnitude of sound power decreases as the frequency increases. It is noted that the magnitude of normal breathing signal of male participants are all higher than the females', over the selected frequencies ranging from 400 Hz to 2000 Hz. The difference in normal breathing sound signal is the highest at frequency 400 Hz, which is 23 zW, while the difference is the lowest at frequency 1200 Hz, which is 0.7 zW.

The changes to a higher level in sound power magnitudes, above, indicate higher manifestation of stress. According to [15] and [16], any changes to a higher level of the variables under test indicates the increase of the stress level in the participants. In [15], the breathing level of the driver increases when there was no help of Haptic breathing guidance. In the work of [16], standard deviation of the state-anxiety scores of the participants increase when the pace of the task was increased.

In Figure 5, the magnitude of sound power of the stressed breathing sound of the male participant also decreases characteristically, like the decreasing pattern of the normal breathing sound signal. Albeit, the magnitude of sound power of the stressed breathing sound signal of the male participants is higher than the normal's. However, for the female participants, the magnitude of sound power of their stressed breathing signals spikes uncharacteristically at the frequencies 1600 Hz and 2000 Hz.

The authors have run a check of the study data as shown in Table 4 using analysis of first order statistics – to check for there was any unintentional thumping or screeching sound signal during the experiment. The stressed breathing sound signals of nine female participants data look good since the Standard deviation of sound power of normal and stressed breathing sound signals does not change much, at 1600 Hz and 2000 Hz are 7.71 zW and 7.69 zW, and 6.10 zW and 7.04 zW, respectively.

Comparison of the magnitude of sound power of female breathing sound signals shows that the skewness and kurtosis of the data go positive for normal breathing, while they are negative for stressed breathing sound signals. It means, for females' normal beathing sound signals, the outliers of the data are mostly found in the lower frequency bands, while for the stressed breathing sound signals, the outlier are mostly found on the higher frequency bands. Therefore, the normal and stressed breathing sound signals of female participants are independent of one another.

The finding in Figure 5 indicates contrast to the study by [17] and [11]. In [17] has found out that the men are more susceptible to stress – on the study of perceived job insecurity for temporary agency workers. The data for study were acquired using the questionnaires. On the other hand, the work of [11] has revealed that women are more resilient physical stress because they have greater reliance on the extra-diaphragmatic inspiratory muscles that their tendency to experience diaphragmatic fatigue is minimized.

Table 2. PSD and sound power of male: (a) normal (b) stressed breathing sound

Frequency (Hz)/ Sample	PSD (dB/Hz)									
	400		800		1200		1600		2000	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
M1	-71.38	-46.18	-78.10	-50.92	-89.19	-54.95	-95.72	-57.68	-96.85	-59.7
M2	-60.44	-53.65	-70.14	-62.74	-72.52	-64.56	-76.88	-65.85	-82.33	-68.43
M3	-50.94	-50.85	-52.84	-63.13	-56.77	-74.11	-61.47	-80.96	-65.96	-85.65
M4	-79.85	-83.13	-88.54	-91.75	-92.41	-98.30	-100.47	-103.09	-105.85	-106.77
M5	-75.65	-78.64	-89.93	-89.63	-96.49	-98.03	-100.98	-102.95	-103.64	-105.65
M6	-89.66	-89.29	-96.85	-95.17	-100.19	-97.83	-102.44	-99.69	-104.22	-104.68
M7	-77.64	-73.92	-94.37	-87.48	-100.20	-93.22	-103.89	-98.88	-105.94	-101.77
M8	-95.42	-94.01	-104.6	-99.29	-107.61	-100.39	-108.95	-101.47	-110.42	-102.24
M9	-51.62	-47.58	-56.00	-51.12	-66.35	-60.05	-72.76	-65.87	-77.11	-70.24
Ave PSD	-72.51	-68.58	-81.27	-76.80	-86.86	-82.38	-91.51	-86.27	-94.70	-89.46
SWL (dB)	-73	-69	-81	-77	-87	-82	-92	-86	-95	-89
Sound power (zW)	56.09	140.00	7.50	21.00	2.10	5.80	0.71	2.40	0.34	1.10

Table 3. PSD and sound power of female: (a) normal (b) stressed breathing signal

Frequency (Hz)/ Sample	PSD (dB/Hz)									
	400		800		1200		1600		2000	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
F1	-71.53	-73.14	-77.68	-76.13	-81.88	-75.70	-86.66	-82.56	-93.40	-90.80
F2	-69.12	-69.1	-77.60	-79.17	-83.65	-87.00	-90.25	-94.5	-97.30	-101.01
F3	-86.17	-74.19	-86.8	-87.85	-100.86	-95.43	-107.61	-102.41	-110.80	-106.98
F4	-88.29	-74.26	-89.49	-78.46	-94.35	-85.77	-96.68	-89.33	-98.37	-90.50
F5	-68.82	-70.57	-78.10	-84.86	-84.25	-91.33	-88.18	-94.67	-90.55	-93.28
F6	-65.17	-69.93	-77.90	-80.95	-82.10	-80.94	-84.02	-92.22	-88.82	-98.28
F7	-78.38	-61.00	-79.2	-65.43	-82.04	-67.95	-87.54	-73.79	-89.93	-78.71
F8	-75.20	-74.47	-92.25	-82.48	-101.63	-93.35	-107.91	-100.12	-108.29	-102.76
F9	-69.65	-66.00	-79.70	-75.69	-85.98	-82.91	-92.25	-86.98	-98.88	-90.71
Ave PSD	-74.81	-70.30	-82.08	-79.00	-88.53	-84.49	-93.46	-70.24	-97.37	-72.94
SWL (dB)	-75	-70	-82	-79	-89	-84	-93	-70	-97	-73
Sound power (zW)	33.00	93.40	6.20	12.60	1.40	3.56	0.45	94.70	0.18	50.80

Table 4. Power spectrum and first order statistics of female: (a) normal (b) stressed breathing sound

Frequency (Hz)/ Sample	PSD (dB/Hz)									
	400		800		1200		1600		2000	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Ave PSD	-74.8	-70.3	-82.1	-79.00	-88.5	-84.5	-93.5	-70.2	-97.4	-72.9
SWL (dB)	-75	-70	-82	-79	-89	-84	-93	-70	-97	-73
Sound power (zW)	33.00	93.40	6.20	12.60	1.40	3.56	0.45	94.70	0.18	50.80
Median (dB)	-71.5	-70.6	-79.2	-79.2	-84.3	-85.8	-90.3	-92.2	-97.3	-93.3
Median (zW)	70.3	87.7	0.12	0.12	3.8	2.6	0.94	0.6	0.19	0.47
Mode	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SD (dB)	8.1	4.5	5.8	6.4	8.2	8.8	8.9	8.8	7.9	8.5
SD (pW)	6.42	2.83	3.78	4.41	6.55	7.58	7.71	7.69	6.10	7.04
Skewness	-0.8	1.2	-1.0	1.0	-1.0	0.7	-1.0	0.7	-0.8	0.5
Kurtosis	-0.6	1.0	-0.8	1.9	-1.0	0.1	-0.4	0.4	-0.5	0.4

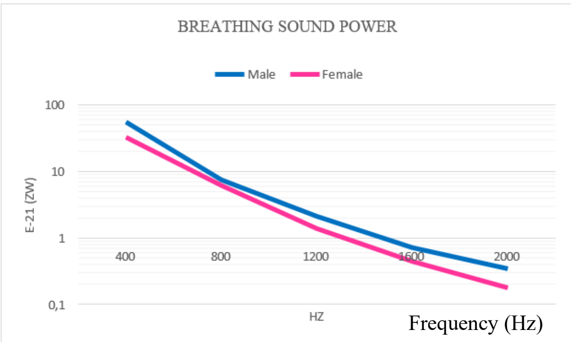


Figure 4. Sound power for normal breathing signal of the participants

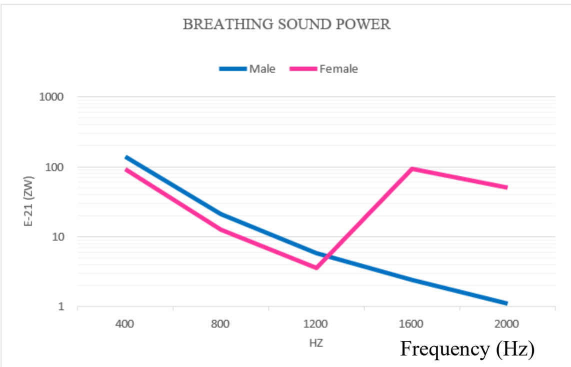


Figure 5. Sound power for stress breathing signal of the participants

4. CONCLUSION

The data acquisition method and the analysis of data for this study is verified because the finding has shown that the sound power of normal breathing signals for both male and female participants, have shown similar decreasing patterns, with the amplitude of sound power in men is about 30-40 percent higher compared to the women', over the five investigated frequency bands.

The Stressors employed for this study – Stroop, Trail Making and Mental Arithmetic tests have not been able to detect any element of stress in male participants. During the study, some participants have reported some kind of excitement and fun that the tests had given positive challenges for them to do more.

The methods used to induce stress, in this study, have been able to show that the sound power of the stressed breathing sound signals of female participants spikes at the frequencies 1600 Hz and 2000 Hz. This finding, however, is contrary to two previous study that show women are more resilient to physical stress, compared to men.

ACKNOWLEDGMENT

The authors would like to thank all those who have contributed toward making this research paper successful. The authors wish to express their gratitude to funder by the Ministry of Higher Education under FRGS, Registration Proposal No: FRGS/1/2021/TK0/UTM/02/97.

REFERENCES

[1] R. J. Kulchar and M.-B. Haddad, "Preventing burnout and substance use disorder among healthcare professionals through breathing exercises, emotion identification, and writing activities," *Journal of Interprofessional Education & Practice*, vol. 29, p. 100570, December 2022, doi: 10.1016/j.xjep.2022.100570.

[2] Mental Health Foundation 2021, "Stress," mentalhealth.org.uk, September 2021.

[3] R. T. Borst and R. Blom, "Stressed out public servants? Testing the stress appraisal of psychological and emotional stressors on stress reactions through psychological capital," *International Journal of Public Sector Management*, vol. 35, no. 2, pp. 113–132, February 2022, doi: 10.1108/IJPSM-02-2021-0030.

[4] J. K. Kiecolt-Glaser, L. McGuire, T. F. Robles, and R. Glaser, "Psychoneuroimmunology: Psychological influences on immune function and health.," *Journal of Consulting and Clinical Psychology*, vol. 70, no.

3, pp. 537–547, January 2002, doi: 10.1037//0022-006x.70.3.537.
[5] L. D. Kubzansky, “Angry breathing: a prospective study of hostility and lung function in the Normative Aging Study,” *Thorax*, vol. 61, no. 10, pp. 863–868, October 2006, doi: 10.1136%2Fthx.2005.050971.
[6] R. J. Wright, R. T. Cohen, and S. Cohen, “The impact of stress on the development and expression of atopy,” *Current Opinion in Allergy and Clinical Immunology*, vol. 5, no. 1, pp. 23–29, February 2005, doi: 10.1097/00130832-200502000-00006.
[7] E. Scott, “What is Stress,” verywellmind.com, November 2022.
[8] G. Birdee, K. Nelson, K. Wallston, N. Hui, A. Diedrich, S. Paranjape, R. Abraham, A. Gamboa, “Slow breathing for reducing stress: The effect of extending exhale,” *Complementary Therapies in Medicine*, vol. 73, p. 102937, May 2023, doi: 10.1016/j.ctim.2023.102937.
[9] J. Chauhan, Y. Hu, S. Seneviratne, A. Misra, A. Seneviratne, and Y. Lee, “BreathPrint: Breathing Acoustics-based user authentication,” in *MobiSys ’17: Proceeding of the 15th Annual International Conference on Mobil Systems Applications and Services*, pp. 278–291. June 2017, doi: 10.1145/3081333.3081355.
[10] V. Gross, A. Dittmar, T. Penzel, F. Schüttler, and P. V. Wichert, “The Relationship between Normal Lung Sounds, Age, and Gender,” *American Journal of Respiratory and Critical Care Medicine*, vol. 162, no. 3, pp. 905–909, September 2000, doi: 10.1164/ajrccm.162.3.9905104.
[11] R. A. Mitchell, M. R. Schaeffer, A. H. Ramsook, S. S. Wilkie, and J. A. Guenette, “Sex differences in respiratory muscle activation patterns during high-intensity exercise in healthy humans,” *Respiratory Physiology & Neurobiology*, vol. 247, pp. 57–60, January 2018, doi: 10.1016/j.resp.2017.09.002.
[12] Psycho test, Psychotests.com, https://psycho-tests.com/test/stroop-test, 2019-2023.
[13] Trail making test (TMP) Parts A & B EatSpeakThink.com, https://eatspeakthink.com/wp-content/uploads/2018/06/IowaTrailMaking.pdf.
[14] Mental math rankyourbrain.com https://rankyourbrain.com/mental-math/mental-math-test-normal.
[15] X. Zhou, G. He, H. Zhu, Y. Wang, and W. Zhang, “Evaluation of driver stress intervention with guided breathing and positive comments,” Applied Ergonomics, vol. 114, p. 104144, Sep. 2023, doi: 10.1016/j.apergo.2023.104144.
[16] P. Renaud and J.-P. Blondin, “The stress of Stroop performance: physiological and emotional responses to color–word interference, task pacing, and pacing speed,” *International Journal of Psychophysiology*, vol. 27, no. 2, pp. 87–97, Sep. 1997, doi: 10.1016/s0167-8760(97)00049-4.
[17] M. Giunchi, F. Emanuel, M. J. Chambel, and C. Ghislieri, “Job insecurity, workload and job exhaustion in temporary agency workers (TAWs),” *Career Development International*, vol. 21, no. 1, pp. 3–18, February 2016, doi: 10.1108/CDI-07-2015-0103.