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# Development of audio-guided deep breathing and auditory Go/No-Go task on evaluating its impact on the wellness of young adults: a pilot study

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**Abstract**

**Objectives:** Numerous studies indicate that deep breathing (DB) enhances wellbeing. Multiple deep breathing methods exist, but few employ audio to reach similar results. This study developed audio-guided DB and evaluated its immediate impacts on healthy population via self-created auditory Go/No-Go task, tidal volume changes, and psychological measures.
**Methods:** Audio-guided DB with natural sounds to guide the DB was developed. Meanwhile, audio-based Go/No-Go paradigm with Arduino was built to measure the attention level. Thirty-two healthy young adults (n=32) were recruited. Psychological questionnaires (Rosenberg's Self-Esteem Scale (RSES), Cognitive and Affective Mindfulness Scale-Revised (CAMS-R), Perceived Stress Scale (PSS)), objective measurements with tidal volume and attention level with auditory Go/No-Go task were conducted before and after 5 min of DB.
**Results:** Results showed a significant increment in tidal volume and task reaction time from baseline (p=0.003 and p=0.033, respectively). Significant correlations were acquired between (1) task accuracy with commission error (r=−0.905), (2) CAMS-R with task accuracy (r=−0.425), commission error (r=0.53), omission error (r=0.395) and PSS (r=−0.477), and (3) RSES with task reaction time (r=−0.47), task accuracy (r=−0.362), PSS (r=−0.552) and CAMS-R (r=0.591).
**Conclusions:** This pilot study suggests a link between it and young adults' wellbeing and proposes auditory Go/No-Go task for assessing attention across various groups while maintaining physical and mental wellness.

**Keywords:** attention level; audio guided deep breathing; auditory Go/No-Go task; tidal volume; wellness; young adults

## Introduction

The period of young adulthood grants a golden opportunity to implement health and wellness promotion strategies before any critical life transition moment along their journey [1]. For instance, it was observed that the quality of the diet and level of physical activity declined particularly in the transition from adolescence to young adulthood [2, 3]. Likewise, the initiation of a new career, marriage and family is probable to take place during young adulthood [4], all of these events impact their long-term health and well-being significantly. Furthermore, the consequences of the COVID-19 pandemic have introduced profound and longitudinal impacts on life satisfaction, stressor and mental well-being of young adults [5], as well as presented with poorer mental health (18–34 years old) compared to older adults [6]. With this, the world health organization has been progressing to improve young adults' well-being measures through policy development and close collaboration globally [7]. However, the programs and policies are frequently lacking coordination and disjointed [8]. Contrastingly, non-pharmacological methods such as relaxation techniques have gained attention, in specific, deep breathing is an easy, effective and affordable approach to enhance health wellness in the present fast-moving lifestyle of young adults.

Deep breathing (DB) refers to voluntary respiration involving deep inhalation and exhalation followed by abdominal expansion and diaphragm contraction [9]. DB indirectly induces changes in the autonomic nervous system that optimize the dynamic interaction between the sympathetic circuit, associated with the "fight or flight" response and the parasympathetic circuit, linked to the "rest and digest" function [10]. Continuous breathing stimulates vagal flow and shifts to parasympathetic outflow, maximizing physiological relaxation and its outcome was revealed positively in young adults as well

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[11–13]. Prior research also showed stress reduction and mindfulness improvement in young adults [14]. These dimensions are particularly important for maintaining the wellness of young adults to cope with various life transitions.

In terms of physiological impact, studies also showed that DB led to an improvement in respiratory function, including increased tidal volume, which is crucial for optimal gas exchange [15–17]. Persistent low levels of physical activity, poor nutrient intake and elevated stress experienced by young adults could reduce pulmonary performance [18] and increase the risk of early cardiopulmonary mortality [19]. While there is no standardized tidal volume for young adults, the average tidal volume of a healthy adult typically falls within 400–500 mL per breath [20], but it is varied among individuals based on their conditions such as gender and body mass. Yokogawa et al. [16] showed there was a statistically significant instant increment of tidal volume after the 5 min of DB by healthy young adults with a mean age of 21.6 years. A recent study by Courtois et al. [15] indicated that DB improved instant tidal volume significantly compared to natural-paced breathing among healthy adults with a mean age of 21.75 years. Moreover, Gholamrezaei et al. [17] reported that practising DB increased tidal volume instantaneously and significantly in the healthy adult with a mean age of 21.7 years together with the improvement in obtaining an increment of respiratory sinus arrhythmia and regulation of the autonomic nervous system. Undoubtedly, DB played a crucial role in improving instant respiratory health, especially in the young adult population.

In addition to physiological benefits, DB has been linked to the improvement of cognitive function and attention level bidirectionally among young adults [21]. A growing number of studies have suggested that controlled breathing served as a complementary skill for enhancing attention [9, 22, 23]. For instance, Ma et al. [9] investigated the effect of DB on the attention level among adults with a mean age of 30.16 years in a controlled study and the improvement was significant. Indeed, attention level is assessed via Go/No-Go task, which typically consists of two stimuli: “Go” signals indicating that a response is required and “NoGo” signals indicating that a response is not needed [24]. It uses response time, accuracy, and task error as dependent variables for evaluation to identify any attention changes [24]. The incorporation of the Go/No-Go task with DB practice has been explored in the neurophysiological study conducted by Cheng et al. [21] on young adults but the association between DB and attention level was not established and the study of this response task on DB is limited, creating a gap in understanding the potential impact of DB on attention level in depth. Recently, an alternative solution has been proposed for effective assessment in the form of an equiprobable auditory Go/No-Go paradigm, which has been gaining attention due to its evocation of event-related potential that activates attention engagement [25]. Despite existing research that has used this auditory response tool on healthy young adults [25], a further question is whether an equiprobable task paradigm can assess attention in healthy young adults following DB.

Widely considered DB improved psychological, and physiological wellness and attention, however, it is challenging for young adults to follow the correct DB protocol independently, especially in this fast-paced environment. Poor cardiorespiratory synchronization may prevent incorrect DB technique from maximizing the physiological benefits while regular adaption to DB for 5 min at 6 breaths per minute was found to be optimum [26]. Considering commercially available guided DB may be pricy for young adults, audio-guided DB was developed in this study as an accessible and inexpensive alternative while providing real-time guidance. Therefore, by developing audio-guided DB and integrating it with auditory Go/No-Go task, the combination approach can provide a comprehensive measurement of the potential impact of DB on attention thoroughly.

The development and design of an audio-guided DB, which uses a software-produced audio clip to instruct the user on how to carry out DB correctly, was done in this study. As a novel application with audio-guided DB, the auditory Go/No-Go task was also implemented to gauge the level of attention. One group pretest-posttest design, inspired by the earlier studies, was used. The primary goal is to investigate the immediate effects of the audio-guided DB tool on tidal volume and attention level while the exploratory goal is to investigate the psychological changes in healthy young adults. It was anticipated that audio-guided DB would have a significant positive impact on tidal volume, attention level, stress regulation, self-esteem, and mindful abilities.

## Materials and methods

### Development of audio-guided deep breathing

The audio clip consists of birds chirping sounds which prompt participants to breathe in and stream-flowing sound which prompts them to breathe out. The natural sounds were obtained from royalty-free media clips [27, 28] and the selection was adopted by Kow et al. [29]. When participants heard bird chirping sound, they inhaled deeply and slowly; When participants heard a stream-flowing sound, they exhaled deeply and slowly. The DB clip is 5 min with a respiratory rate of 6 breaths per minute as is shown in Figure 1, edited using Audacity® Cross-Platform Sound Editor, version 2.4.2. The duration set is supported by the study reporting that this rate can regulate physiological function due to the induction of coherent and resonance effects of neuro-mechanical interactions [26]. The audio clip is provided in Online Resource 2.

### Tidal volume

An automatic electronic spirometer, model item SY-8888 (Hangzhou Panhong Sports Goods Co., Ltd.) was used to measure the participants’ tidal

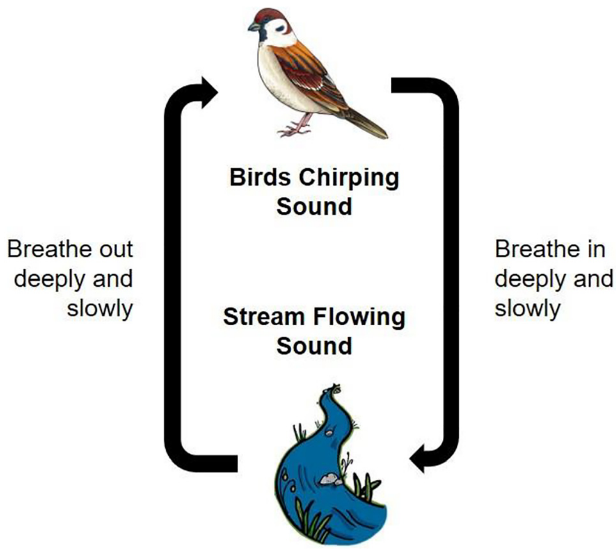


**Figure 1:** The flow diagram of the audio-guided DB clip.

volume before and after audio-guided DB. The participant was requested to exhale through a one-way valve disposable mouthpiece attached to the respirometer of which the displayed reading was recorded manually. The participant was invited to repeat the steps three times and the largest value among the three readings was taken as the outcome. Before the next measurement, a new one-way valve disposable mouthpiece was installed back on the device for the next participant.

## Development of an auditory Go/No-Go task

**System design:** For the purpose to measure the attention level changes after a single session of DB, audio go/no-go task was developed. Visual Go/No-Go task was more commonly used in previous studies. Since audio-guided DB was used in this study, an audio Go/No-Go task was designed for the purpose. The block diagram of the proposed system is illustrated in Figure 2(A). The system was designed to measure the Go/No-Go task performance such as go response time, task accuracy and error comparison of the user. The system consists of three major components: (a) press button to serve as the input, (b) buzzer to generate Go/No-Go tone and (c) light emitting diode (LED) to reflect the response.

**Circuit design and protocol:** The proposed circuit of the system (see Figure 2(B)) was built on an Arduino Uno (R3). The advantages of Arduino Uno are the system is relatively affordable, less bulky, and has sufficient space included for this low-load study. The paradigm and the flow diagram of the system is shown in Supplementary Figure 1 and Supplementary Figure 3 (Online Resource 3) respectively in the appendices. Each of the tones has a duration of 50 ms with a fixed stimulus onset asynchrony of 1100 ms, following the specifications in the previous study [30]. Before the task, the press button must be pressed to initiate the task. The first tone will be played randomly while the system will wait for any input from the user via the press button. When the button state is high, the Go reaction time will be computed, and LED will turn on. Conversely, the low button state will turn the LED off directly since no active response is involved. The entire cycle will repeat until 150 tones have been delivered. The task accuracy rate, commission error and omission error (see Supplementary Figure 2 in Online Resource 3) were computed using the percentage relative to the total stimuli received. Online Resource 1 provided the Arduino code for the development.

**Instruments for psychological measurement:** Three types of psychological questionnaires were administered in the current study.

**Perceived Stress Scale (PSS):** Perceived stress scale is a psychological assessment widely adopted to measure one's perception of stress associated with event control and life changes [31]. The PSS-10 has a ten-item scale that is presented in five-point Likert-type scales from 0 (never) to 4 (very often) which require participants to rate how they feel in a certain way (e.g., "In the last month, how often have you felt that things were going your way?"). A higher sum of scores reflects a higher level of perceived stress experienced by the participant. This measure has demonstrated a good psychometric property whereby the test-retest reliability of the PSS-10 is over 0.70 in 4 studies and Cronbach's alpha with over 0.70 in 12 studies as well [32], suggesting PSS-10 as measures selected compared to PSS-14 and PSS-4.

**Cognitive and Affective Mindfulness Scale-revised (CAMS-R):** Cognitive and Affective Mindfulness Scale–Revised is a revised version based on the original Cognitive and Affective Mindfulness Scale and it is designed to measure one's mindfulness approach to relate their feeling, emotion and thought [33]. CAMS-R consists of a twelve-item scale that is presented in four-point Likert-type scales from 1 (Rarely/Not at all) to 4 (Almost always) which require participants to rate how applicable each item is to them (e.g., "I can tolerate emotional pain"), with a higher total sum of score indicates a higher level of mindfulness. It presents a stable internal consistency between 0.55 and 0.78 as well as established discriminant and convergent validity [34].

**Rosenberg's Self-Esteem Scale (RSES):** Rosenberg's Self-Esteem Scale is developed by Rosenberg [35] and designed to measure self-esteem using a 10-item self-reported on a four-point Likert-type scale from 4 (Strongly

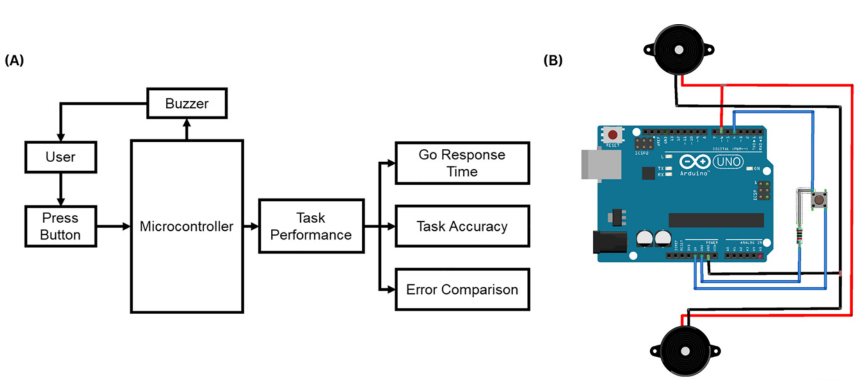


**Figure 2:** The (A) circuit block diagram and (B) circuit connection and its components of the auditory Go/No-Go paradigm.

agree) to 1 (Strongly disagree). Half of the questions consist of positive statements (e.g., "I am able to do things as well as most other people") and negative statements another half (e.g., "I certainly feel useless at times") with a higher score indicating a higher level of self-esteem. Prior studies showed that reasonable Cronbach's alpha internal consistency was obtained (from 0.77 to 0.88) and test-retest reliability ranged from 0.82 to 0.88 [35, 36].

**Participants:** The research procedures have been approved by the university's Scientific and Ethical Review Committee. A total of 32 participants with ages ranged from 19 to 31 years old were recruited from University Campus and the public through the distribution of flyers. The sample size was determined using the rule of thumb proposed by Julious [37] as the minimum sample size with 10 % withdrawal rate required for the pilot study is 13. Two exclusion criteria were adopted in this study: (1) those who could not perform DB after more than 5 min, and (2) those who was having any medical condition. All participants were able to communicate in English. Among the 32 participants (see Supplementary Table 1 in Online Resource 3), 68.75 % of the participants were identified as male whereas 31.25 % as female. Ethnic distribution of participants – Chinese: 96.88 %; Malay: 3.13 %. More than half of the participants were university students (59.38 %) whereas employed adults accounted for 40.63 % of the total number of participants.

**Procedures:** Figure 3 summarizes the overall experimental process. At least two fluorescent lamps were used to provide adequate lighting for the experiment to be conducted in a room or open area. Prior to the experiment, informed consent was obtained from each participant. First, the participants were instructed to take a 5-min break while sitting upright in their chairs to relax their psychological and physiological states. The participants also had to use Google Forms to complete the psychological questionnaires. The participant was then instructed to measure the tidal volume under the guidance of the researcher. Immediately after the recording, the participants were given an auditory Go/No-Go task to complete while keeping their eyes closed, under the investigator's supervision, to get a baseline task performance. Following the test, the participant began to complete a 5-min audio-guided DB. Tidal volume measurements, an auditory Go/No-Go task, and psychological questionnaires were repeated after the DB period to collect data for the post-intervention.

**Statistical analysis:** The data were analyzed using IBM SPSS (Statistical Package for the Social Sciences), version 25. The significant level was set at 0.05 and the confidence interval (CI) was defined as 95 %. Shapiro-Wilk test was used to test the normality of the data. The mean and standard deviation were used to describe parametric data, whereas the median and interquartile range were used in non-parametric data. Paired sample t-test and Wilcoxon signed-rank test were employed to test the difference of each variable before and after DB. Finally, Pearson's correlation analysis was applied to test the correlation between each variable, and a heatmap was generated.

# Results

## Descriptive statistics and significant difference

The Shapiro-Wilk test demonstrated that tidal volume and all performance indicators of the auditory Go/No-Go task were found to be non-parametric ($p>0.05$), while responses to the psychological measurement were parametric ($p<0.05$). Correspondingly, the Wilcoxon signed-rank test and paired sample t-test were used to analyze the data. Tidal volume was one of the study's dependent variables. Employing the non-parametric Wilcoxon signed-rank test, it aimed to study whether there is any presence of statistically significant difference in tidal volume and performance indicator of auditory Go/No-Go task before and after the DB. As shown in Figure 4, the mean tidal volume presented after the DB (M=514.13 mL, SD=197.66 mL) was higher than the mean volume displayed before the DB (M=435.33 mL, SD=154.58 mL).

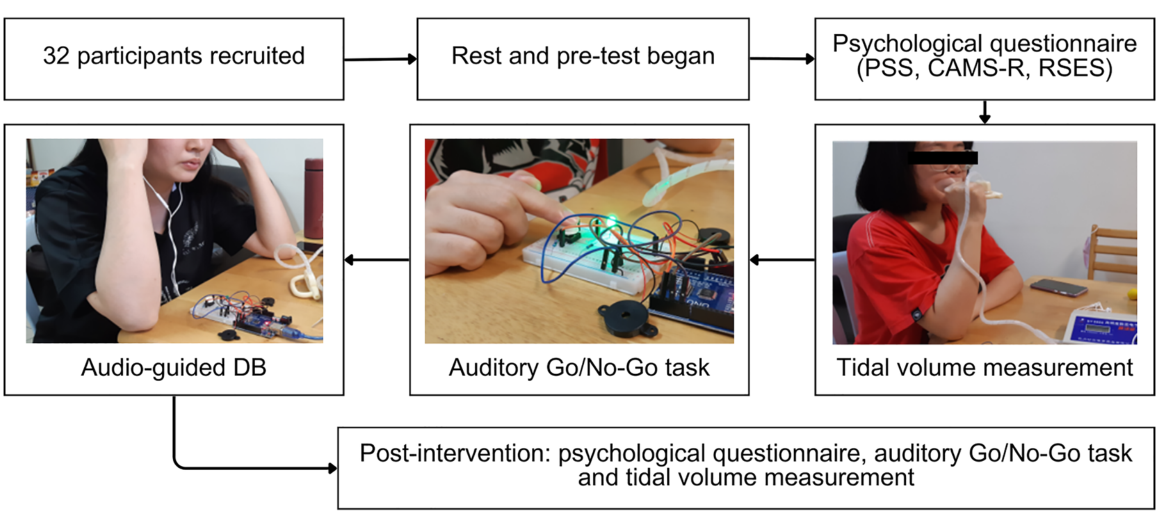


**Figure 3:** The whole experiment which consisted of tidal volume measurement, auditory Go/No-Go task and psychological assessments to be performed before and after the audio-guided DB.

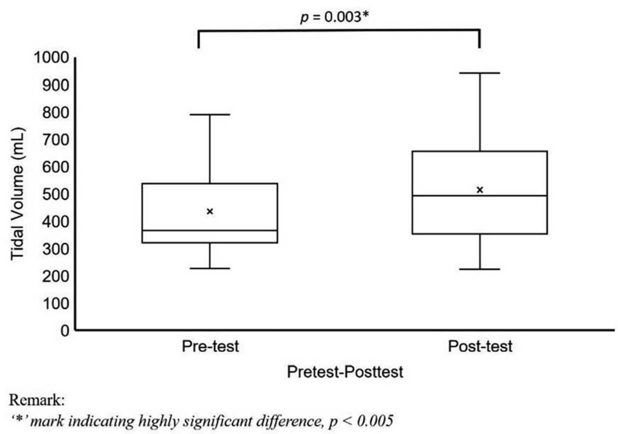


**Figure 4:** Boxplots showing the changes in tidal volume for pre-test and post-test for a single session of audio-guided DB.

The displayed mean difference of 78.80 mL was a highly statistically significant difference ($p<0.005$, $Z=-3.017$).

Based on the findings resulting from the auditory Go/No-Go task displayed in Figure 5, the Wilcoxon signed-rank test was used to analyse the data, which revealed no statistically significant difference in mean task response accuracy before (M=98.31 %, SD=1.73 %) and after (M=98.84 %, SD=1.14 %) the application of DB, as determined by a p-value larger than 0.05 and a Z-score of −1.009. Additionally, from auditory Go/No-Go task, the findings of Wilcoxon signed-rank test from Table 1 also revealed no statistically significant differences in mean task commission error before the DB (M=1.20 %, SD=1.70 %) and after the DB (M=0.93 %, SD=1.23 %), with a p-value larger than 0.05 and a Z-score of −0.144. Similarly, there were no statistically significant differences in mean task omission error before the DB (M=0.29 %, SD=0.49 %) and after the DB (M=0.24 %, SD=0.42 %), with a p-value larger than 0.05 and a Z-score of −0.181.

The paired sample t-test was subsequently conducted to study whether there are statistical significance changes on the psychological measures specifically PSS, CAMS-R and RSES. The findings indicated the mean PSS score after the DB (M=18.34, SD=4.75) was slightly reduced compared to the mean PSS score before the DB (M=18.75, SD=5.28), and the observed means change were −0.41, with a 95 % CI of [−2.088, 2.901]. Similarly, the mean CAMS-R score after the DB (M=33.03, SD=4.23) was slightly higher than the mean CAMS-R score before the DB (M=32.97, SD=3.90), and the observed mean changes were 0.06, with a 95 % CI of [−1.859, 1.734]. Finally, the mean RSES score after the DB (M=29.06, SD=4.88) was slightly increased compared to the mean RSES score before the DB (M=28.38, SD=4.16). The observed mean changes were 0.68 with 95 % CI of [−2.761, 1.386]. Overall, there is no significant difference found in PSS, CAMS-R and RSES as $p>0.05$. The details of the analysis are presented in Table 1.

**Table 1:** Paired Samples Test and Wilcoxon signed-rank test comparing the task performance and psychological changes before and after the intervention.

| | Paired samples test | | | Wilcoxon signed-rank test | |
|---|---|---|---|---|---|
| | p-Value | (95 % CI) | | p-Value | Z-Score |
| | | Lower | Upper | | |
| **Auditory Go/No-Go task** | | | | | |
| Go reaction time, ms | – | – | – | **0.033**[a] | −2.132 |
| Task accuracy, % | – | – | – | 0.313 | −1.009 |
| Commission error, % | – | – | – | 0.885 | −0.144 |
| Omission error, % | – | – | – | 0.856 | −0.181 |
| **Psychological changes (sum of score)** | | | | | |
| PSS | 0.742 | −2.088 | 2.901 | – | – |
| CAMS-R | 0.944 | −1.859 | 1.734 | – | – |
| RSES | 0.504 | −2.761 | 1.386 | – | – |
| Significance marker: [a]p<0.05 | | | | | |

[a]Significance marker, p<0.05. CI, confidence interval; RSES, Rosenberg's self-esteem scale; CAMS-R, cognitive and affective mindfulness scale-revised; PSS, perceived stress scale.

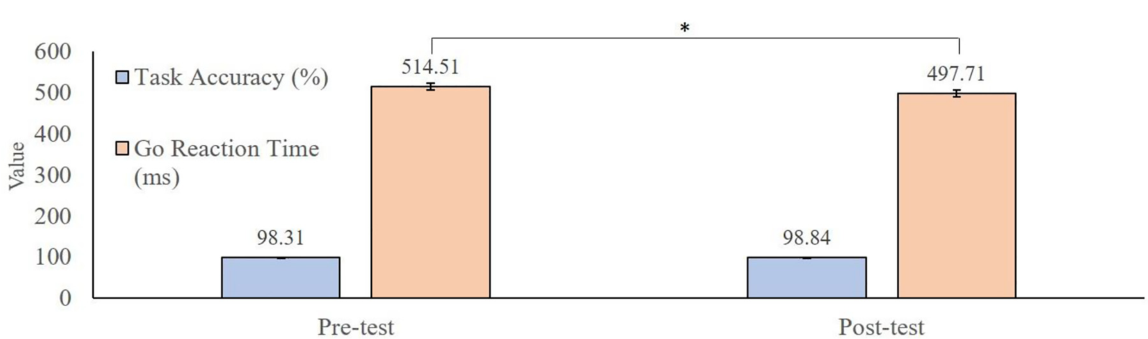


**Figure 5:** Bar charts showing the changes in the Go reaction time and task accuracy before and after the DB. Error bars represent the standard error. *, p<0.05.

## Pearson's correlation analysis

The Person's correlation analysis was applied to examine the correlation between variable changes in this study. These correlations offered an additional insight into the possible significant relationship between the tidal volume, attention level and psychological changes that arose in the health populations due to the implementation of the audio-guided DB, thereby strengthen the evaluation of the effectiveness of the DB intervention. Analyses revealed a statistically significant correlation between response accuracy and task commission error, $r=-0.905$, $p<0.01$. The size of this correlation is a large effect, $r=\pm0.50$ and it was a negative correlation. Similarly, the correlation between task response accuracy and CAMS-R score was statistically significant, $r=-0.425$, $p<0.05$. The size of this correlation is a medium effect, $r=\pm0.30$ and it was a negative correlation. Furthermore, a large significant positive correlation was identified between CAMS-R score and task commission error, $r=0.53$, $r=\pm0.50$, $p<0.01$. Besides, the correlation between task commission error and CAMS-R score was statistically significant, $r=0.395$, $p<0.05$. The size of this correlation is a medium effect, $r=\pm0.30$ and it was a positive correlation. There was a statistically significant negative correlation found between CAMS-R score and PSS score with $r=-0.477$, $p<0.01$. The correlation between RSES scores and Go reaction time was statistically significant, $r=-0.47$, $p<0.01$. The size of this correlation is a medium effect, $r=\pm0.30$ and it was a negative correlation. There was a statistically significant negative correlation found between RSES score and task accuracy with $r=-0.362$, $p<0.05$ as well. Finally, the correlation between RSES scores and PSS score and CAMS-R score were statistically significant, $r=-0.552$, $p<0.01$ and $r=0.591$, $p<0.01$, respectively. The size of both correlations is large effect, $r=\pm0.50$ and they were negative and positive correlations, respectively. These outcomes are illustrated in the Pearson's correlation heatmap as shown in Figure 6.

# Discussion

The goal of the study is to determine whether an audio-guided DB design can have a short-term beneficial effect on healthy young adults by measuring tidal volume changes, self-created auditory Go/No-Go task performance, and psychological screening. The study's findings showed unmistakable evidence of the improvement, especially in changes to tidal volume and Go response times. A further encouraging result was the significant correlation between the auditory Go/No-Go task performance, PSS, CAMS-R, and RSES that was also found in this study.

Tidal volume changes for 5 min DB in this research produced the significant result which is aligned with the hypothesis. These results are consistent with those investigation of DB on respiratory tidal volume performance among young adults [15–17]. For instance, one study compared the effect of different DB technique on psychophysiological variables in a healthy group and found that tidal volume also improved significantly in DB at 0.1 Hz [15]. Throughout deep breathing, the breathing

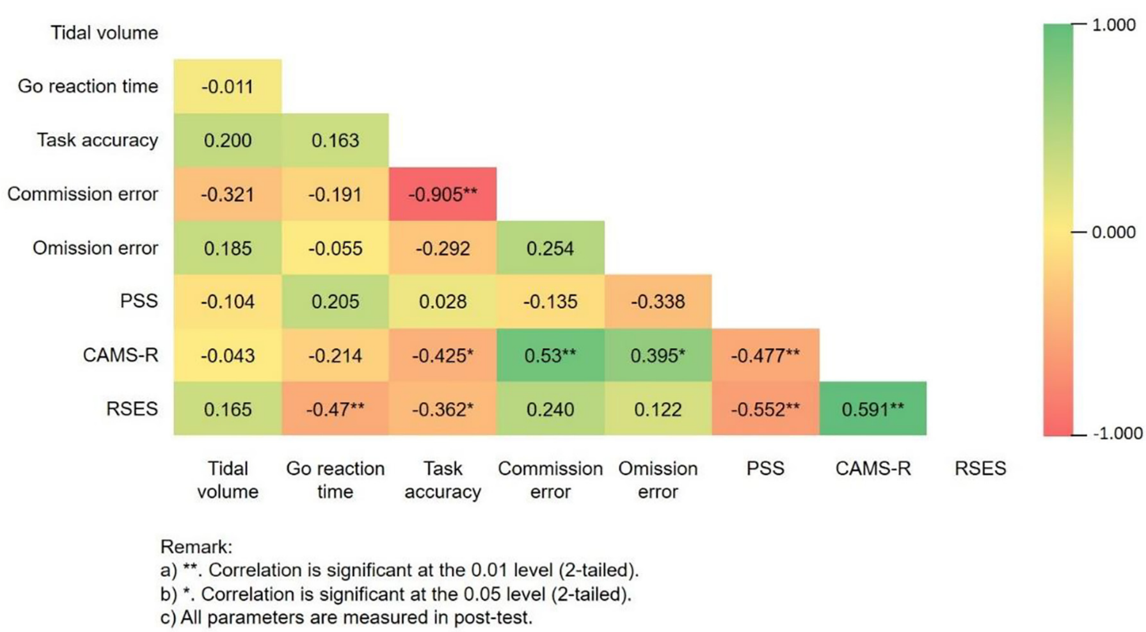


**Figure 6:** Pearson correlation heatmap for all variables after DB.

action will increase the alveolar pressure and air velocity flow, thus increasing pressure difference between atmospheric pressure and lung pressure to allow greater air intake into the lung [38]. Despite the alveolar pressure was not measured directly in this study, it is presumed that the tidal volume was increased due to the lung pressure change. It is important to note that increased tidal volume in young adults implied improvement of alveolar ventilation [20]. The strengthening could help to prevent pulmonary diseases development and associated mortality [19] as part of well-being strategies.

The assessment of attention level is the study's second finding. The findings indicate that the difference in Go reaction time before and after DB is statistically significant. This outcome fits the earlier research quite well [39]. After 5 min of slow DB, there was a significant decrease in reaction time, suggesting increased alertness and less distractibility [40]. Under certain assumption, it can be construed larger contemplation in recognizing the suitable response in this current response task. However, no significant difference was identified in the omission error, commission error as well as their result on accuracy in response to audio-guided DB. It implied that the less time spent on response task did not compromise the task accuracy, which also means that the significant speed-accuracy trade off was not identified [41]. Compared to another study, although Cheng et al. [21] found that attention was less associated with DB which is opposing to the outcome in this study, they used non-equiprobable Go/No-Go paradigm which might be less assessable compare to equiprobable response paradigm [25]. The current study shows that the task reaction time reduced through experimental Go/No-Go task and the attention resulted by parasynaptic activation via DB can be observed in auditory Go/No-Go task even though the neuromechanics of how the DB regulates the autonomic nervous system physiologically leads to an improvement in attention level is still unclear [9].

According to Pearson's correlation analysis, task accuracy and commission errors had a significant negative correlation even though other performance indicators for the task did not demonstrate any notable results. This suggests that concentration is possible with fewer incorrect responses. Importantly, the task's strongest negative correlation can be found in the commission error. As stated, commission errors happen more frequently than omission errors [42]. While these two different errors are resulted from different neural processing which revealed specific neurocognitive behaviour [42]. Although the further interpretation is outside of the study scope, it showed consistent evidence that can provide a foundation for future investigation.

On the other hand, surprisingly, the results indicate negligible variations in PSS, CAMS-R, and RSES before and after a single session of a 5-min DB even though marginal improvement was observed. Contrary to the previous studies, they showed that stress reduced significantly among young adults after DB exercise [14, 43, 44], however, in a duration of weeks to months. Interestingly, when instant stress change was measured following DB, the findings were consistent but majority of the studies employed blood pressure and heart rate variability as a physiological mean to assess stress level [45, 46]. It is speculated that the divergent findings due to the psychological measures which relied on personal subjective perception. Conversely, the change of heart rate variability induced by the autonomic interaction could indicate improvement of cardiorespiratory synchronization given 5 min of DB at once [26]. This new perspective on the brief DB has no effects on modifications of psychological screening among healthy young adults, which increases the significance of including physical measurement in brief interventions. Similar to mindfulness measured by CAMS-R, one of the fewer studies has demonstrated that mindful qualities improved following longer period of DB among young adults using psychological assessment [14] whereas change in self-esteem failed to be addressed by the past studies. Prior studies have frequently explored the impact of combined methods on mindfulness and self-esteem such as DB with meditation, progressive muscle relaxation and yoga [14, 47–49]. Although improvement was observed, it unable to identify the specific component contributing to the aspects.

In terms of the psychological evaluation, there was no discernible difference between the pre- and post-scores on the PSS, CAMS-R, and RSES. However, there were numerous strong correlations between auditory Go/No-Go task performance and psychological tests. Surprisingly, the findings showed that the higher the mindful qualities of the person, the lower the task performance of the individual (task accuracy reduced and task error increased). The conclusion, however, conflicts with one of the limited findings which found no conclusive link between mindful characteristics and all task performances including reaction time after relaxation among young adults [50]. It is unclear to identify the exact factor contributed to this inconsistency but the probable justification is that different Go/No-Go paradigms and mindfulness rating scales, where the irregularities of the methodologies can be used to explain why there was a discrepancy. Besides, the relationship between stress and mindfulness should then be noted. The ability to be mindful declined as perceived stress rose. In the prior study, which found that mindfulness is strongly negatively correlated with stress, a similar pattern of results was attained based on larger sample of young adults' population [51]. Strengthening the study with the PSS, the strong negative correlation also showed by Zollars, Poirier and Pailden [52] in their mindful practice with larger correlation ($r=-0.61$) compared to the current study (r=−0.477). Hence, it showed that mindfulness are closely associated with attention level and stress among young adults after mindful breathing.

Furthermore, task accuracy and Go reaction time have a positive correlation with self-esteem, suggesting that sense of self-esteem impacts the attention level. Low attention is a result of low self-esteem, according to the similar findings by Brockner and Hulton [26]. Particularly reaction time are associated with the index of self-esteem as reproduced by the event-related potential [53]. Hence, it is probable that neurological mechanism governing the linkage between self-esteem and attention. Although it does appear to increase attention span, the extent to which self-esteem was responsible for this is still unknown given the paucity of prior research on DB and thus required additional extensive research. Results showed that this is not always the case. According to the findings of the correlation study between self-esteem and stress, stress decreased as self-esteem rose. These findings are consistent with other studies [54, 55] that discovered a negative relationship between stress and self-esteem among universities' student. It has been suggested that the self-esteem led to sense of worth that help to limit the negative effect of the stress [56]. An effective way to reduce stress is to encourage coping skills that are brought on by higher self-esteem. Finally, it was suggested that mindfulness skills are positively correlated with self-esteem. The results are in line with the earlier investigation that revealed this beneficial relationship among young adults [57, 58]. Being mindful can help one focus on their objectives, thoughts, and feelings while also preventing self-critical thoughts that can undermine one's self-esteem [59]. These findings are suggestive to young adults where mindful breathing improve mindfulness, self-esteem and attention level in response to each other similar to the young adult's population with social anxiety [60].

Based on the results, the present findings demonstrate its strength in the development of audio-guided deep breathing and auditory Go/No-Go task in providing insightful combined approach in assessing wellness of young adults. Besides its potential, it can be concluded that the sample size is suitable for the investigation of tidal volume and attention level changes, which is the main objective of the study. The findings, however, indicate that larger sample sizes are needed for correlation analysis and psychological measurements in the future research. If there is a large enough sample size, this could change or improve the outcome. Another major source of limitation is the lack of control arm, only pre-and post-intervention analysis were conducted and the positive changes may be due to the placebo effect. Therefore, future study is required to get a more reliable conclusion in a controlled study setting and improve its generalizability. For instance, DB and regular breathing at normal frequency.

## Conclusions

The findings show that audio-guided DB has a significant effect on tidal volume and response time in healthy young adults. Additionally, experimental data show a significant correlation between the performance indicators of the auditory Go/No-Go task, PSS, CAMS-R, and RSES. However, the results also showed that the task accuracy, commission error, omission error, PSS, CAMS-R, and RSES were all affected in a negligible way. These preliminary findings may be confirmed by future research that enlarges the sample size and conducts multiple DB sessions. It offers a foundation for the intervention by delivering the immediate effects of audio-guided DB and suggesting tidal volume and attention level among healthy young adults.

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