

Immediate effects of structured and natural deep breathing on heart rate variability and blood pressure in community-dwelling older adults

Ting-Ting Yeh^{a,b,*}, Yi-Chieh Ho^a

^a Master Degree Program in Health and Long-term Care Industry, College of Medicine, Chang Gung University, Taoyuan, Taiwan

^b Division of Endocrinology and Metabolism, Chang Gung Memorial Hospital at Linkou, Taoyuan, Taiwan

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ABSTRACT

Background: This study investigated the immediate effects of structured deep breathing (SDB) and natural deep breathing (NDB) on heart rate variability (HRV) and blood pressure (BP) in community-dwelling older adults.

Methods: Twenty-six participants were randomly assigned to SDB ($n = 14$) or NDB ($n = 12$) groups. HRV parameters (time domain: standard deviation of normal-to-normal intervals [SDNN], root mean square of successive differences [RMSSD]; frequency domain: low frequency [LF], high frequency [HF], LF/HF ratio, total power [TP], normalized low frequency [LFnu], normalized high frequency [HFnu]) and BP were assessed during spontaneous breathing, DB, and post DB.

Results: Both groups showed significant increases during DB in SDNN ($p < 0.001$), RMSSD ($p = 0.021$), LF power ($p < 0.001$), LFnu ($p < 0.001$), TP ($p < 0.001$), and LF/HF ratio ($p < 0.001$). HFnu decreased significantly during DB ($p < 0.001$) with no group differences. HF power showed no significant effect in group and time. BP remained stable throughout the protocol, with no significant changes in either systolic or diastolic BP across time points or between groups.

Conclusions: This first direct comparison of structured versus natural DB in healthy older adults demonstrates that both approaches effectively enhance parasympathetic activity. These findings support DB as a cost-effective, accessible intervention for promoting autonomic balance in healthy aging, without requiring specialized equipment or instruction.

1. Background

The global population is aging rapidly, with adults aged 65 and older projected to double by 2050 (WHO, 2021). This demographic shift brings increased focus on age-related physiological changes, particularly in autonomic nervous system (ANS) function. Aging is associated with progressive decline in ANS regulation, characterized by reduced parasympathetic activity and increased sympathetic dominance (Mancia and Grassi, 2014; Hotta and Uchida, 2017). These alterations can lead to decreased cardiovascular adaptability and increased health risks in older adults (Thayer et al., 2020).

Heart rate variability (HRV), which measures beat-to-beat variations in heart rhythm, serves as a reliable, non-invasive indicator of autonomic function (Shaffer and Ginsberg, 2017). Reduced HRV reflects autonomic imbalance and is associated with increased cardiovascular morbidity and mortality in aging populations (McCraty and Shaffer,

2015). Both time-domain measures (such as root mean square of successive differences) and frequency-domain parameters (including high frequency power) provide valuable insights into vagal modulation of cardiac function (Laborde et al., 2017). Similarly, blood pressure (BP) regulation, which depends heavily on proper autonomic function, often becomes impaired with age, leading to increased cardiovascular risk (Monahan, 2007).

Deep breathing (DB) exercises have emerged as a promising intervention for enhancing autonomic function. The physiological basis lies in respiratory sinus arrhythmia (RSA) and baroreflex mechanisms, where controlled breathing can modulate cardiovascular dynamics (Gerritsen and Band, 2018). Breathing at approximately 6 cycles per minute (0.1 Hz) corresponds to the resonance frequency of the cardiovascular system, potentially optimizing HRV and BP control (Lehrer and Gevirtz, 2014; Russo et al., 2017). This resonance effect occurs through synchronization of respiratory and cardiovascular rhythms, enhancing

* Corresponding author at: Master Degree Program in Health and Long-term Care Industry, Chang Gung University, No.259, Wenhua 1st Rd., Guishan Dist., Taoyuan City 33302, Taiwan.

E-mail address: tingtingyeh@cgu.edu.tw (T.-T. Yeh).

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baroreflex gain and autonomic regulation (Vaschillo et al., 2011). The relationship between breathing patterns and autonomic activity is phase-dependent: while inhalation is associated with temporary vagal withdrawal, it is the prolonged exhalation phase that promotes enhanced parasympathetic activity (Van Diest et al., 2014; Lehrer et al., 2020). The prolonged exhalation period stimulates the Hering-Breuer reflex, which activates the parasympathetic vagus nerve and inhibits sympathetic outflow (Gerritsen and Band, 2018). This shift towards parasympathetic dominance is reflected in increased HRV, particularly in the high-frequency (HF) band, as well as reductions in BP.

Various approaches to DB exist, ranging from structured protocols with device guidance to natural breathing techniques (Brown and Gerbarg, 2009). While device-guided breathing has shown efficacy in clinical settings (Wang et al., 2019), the necessity of specialized equipment may limit accessibility and widespread adoption. Natural breathing techniques, which require minimal resources, might offer a more practical alternative for community-based interventions (Ma et al., 2017).

Despite extensive research on breathing interventions in clinical populations with conditions such as hypertension (Wang et al., 2019) and COPD (Ubolnuar et al., 2019), several important gaps remain in our understanding. First, studies examining immediate autonomic responses to different breathing protocols in healthy older adults are limited. Second, the comparative effectiveness of structured versus natural DB approaches in this population remains unknown. Third, the time course of acute autonomic responses to breathing interventions in older adults needs clarification. These gaps are particularly significant given the growing need for accessible, non-pharmacological interventions to support healthy aging.

This study therefore aimed to compare the immediate effects of structured and natural DB on HRV and BP in community-dwelling older adults. We hypothesized that both approaches would enhance parasympathetic activity, with potential differences in the magnitude or time course of effects. Understanding these responses could inform the development of practical, cost-effective interventions for maintaining autonomic health in aging populations, particularly in community settings where specialized equipment or extensive training may not be available.

2. Methods

2.1. Study design

This study employed a quasi-experimental intervention design with a one-group time-series approach. Participants were recruited from a senior club in New Taipei City, Taiwan, between May 29, 2023, and June 30, 2023. Informed and signed consent was obtained from all participants. The study protocol was approved by the Chang Gung Memorial Hospital (IRB number 202300650B0).

2.2. Participants

Eligibility criteria included individuals aged 65 years or older who were able to sign a written informed consent form. Exclusion criteria encompassed a diagnosis of dementia, the presence of an implanted cardiac pacemaker, regular engagement in mind-body exercises such as meditation, participation in nail art, communication barriers with researchers, and concurrent participation in other studies.

2.3. Sample sizes

Sample size estimation was performed using G*Power 3.1, with the effect size set at 0.25 for this pilot study. The significance level was set at $\alpha < 0.05$, and the power ($1-\beta$) was 0.8, accounting for an anticipated dropout rate of approximately 8 % (Landman et al., 2013; Liu et al., 2021). The target enrollment was 30 participants.

2.4. Interventions

Participants were randomly assigned to either the structured (SDB) or natural deep breathing (NDB) group using a simple randomization method. The randomization was conducted using sequentially numbered opaque envelopes containing colored cards that designated group assignment. Each participant selected an envelope in numerical order, and the color of their card determined their group allocation. To minimize bias, the randomization process, outcome measurements, and data analysis were conducted by an independent researcher who was not involved in delivering the interventions.

The SDB group watched a customized video with audio and visual cues that guided their breathing at a pace of 6 breaths/min, with an inhale-exhale ratio of 1:1 (Sevoz-Couche and Laborde, 2022). We selected this specific breathing pattern because it optimizes respiratory sinus arrhythmia (RSA) amplitude at the resonant frequency (~ 0.1 Hz). This frequency is achieved through the 6 breaths/min pace with equal inspiration and expiration phases. The equal ratio is particularly important as it creates optimal conditions for vagal activation through two key mechanisms. First, this pattern maximizes vagal activity by optimizing the timing of acetylcholine (ACh) release and hydrolysis at the sinoatrial node. Second, it promotes temporal coherence between respiratory, blood pressure, and cardiac phases, leading to enhanced baroreflex function (Sevoz-Couche and Laborde, 2022).

The NDB group listened to the same background music as the SDB group and viewed scenic images, but without any guiding cues. Before data collection, both groups were instructed by a registered respiratory therapist on how to perform the DB properly.

2.5. Outcome measures

The outcome measures of this study were HRV and BP. Our HRV analysis strictly adhered to the guidelines established by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996), as implemented in the SA-3000P Clinical Manual (ver. 3.0). We also incorporated more recent recommendations for HRV data analysis and reporting (Laborde et al., 2017, 2022; Shaffer et al., 2014; Shaffer and Ginsberg, 2017).

For time-domain metrics, we analyzed mean heart rate, the standard deviation of normal-to-normal intervals (SDNN), and the root mean square of successive differences (RMSSD). SDNN, measured in milliseconds, represents the standard deviation of normal sinus-initiated interbeat intervals and reflects total variability from both sympathetic and parasympathetic cardiac contributions. SDNN has prognostic value, as low age-adjusted values predict morbidity and mortality, while higher SDNN categories correlate with improved survival probability (Shaffer et al., 2014). RMSSD specifically estimates vagally-mediated changes in HRV by measuring beat-to-beat variance in heart rate.

For frequency-domain analysis, we examined metrics in both absolute and relative terms. Absolute power was calculated as ms^2 divided by cycles per second (ms^2/Hz), while relative power was expressed as either a percentage of total HRV power or in normalized units (nu). The frequency bands were defined as follows: low-frequency (LF) at 0.04–0.15 Hz and high-frequency (HF) at 0.15–0.40 Hz. The physiological significance of these bands varies with breathing frequency: LF reflects both sympathetic and parasympathetic contributions when breathing exceeds 9 cycles per minute (cpm), but primarily indicates cardiac vagal activity below 9 cpm (Laborde et al., 2022). HF predominantly reflects parasympathetic activity when breathing frequency falls between 9 and 24 cpm (Laborde et al., 2017). Total power (TP) represents the sum of energy across very low frequency, LF, and HF bands during our short-term recordings. The LF/HF ratio provides an estimate of sympathetic-parasympathetic balance under controlled conditions (Shaffer and Ginsberg, 2017). All HRV analyses were performed using the SA-3000P software, which implements standardized filtering and artifact correction procedures according to Task Force

Table 1

Time points of breathing mode and measurement.

Time point	T1	T2	T3	Practice	T4	T5
Timeline	5th min	10th min	15th min	20th min	25th min	30th min
Breathing mode	Spon	Spon	Spon	Practice DB	SDB	Spon
Measurement	HRV	HRV RR	HRV BP	None	HRV RR	HRV BP

Spon: spontaneous breathing; DB: deep breathing; SDB: structured deep breathing; NDB: natural deep breathing; HRV: heart rate variability; BP: blood pressure; RR: respiratory rate.

recommendations. Detailed specifications of these procedures are available in the SA-3000P Clinical Manual (ver. 3.0).

BP was measured using the HBP-9020 tunnel-type monitor (Omron healthcare Co., Ltd., Taiwan). Participants rested in a seated position for 5 min, after which BP was measured three times on the right upper arm. The mean value of these three readings was used to determine systolic blood pressure (SBP) and diastolic blood pressure (DBP). The respiratory rate (RR) was monitored to ensure accurate performance of both DB and spontaneous breathing and adherence to the guided breathing protocol. RR was recorded concurrently with HRV measurements, with the average rate (breaths per minute) calculated over a 5-minute period. Measurement reliability was validated by having two researchers independently count breaths during both breathing sessions, resulting in a Cronbach's α of 0.99.

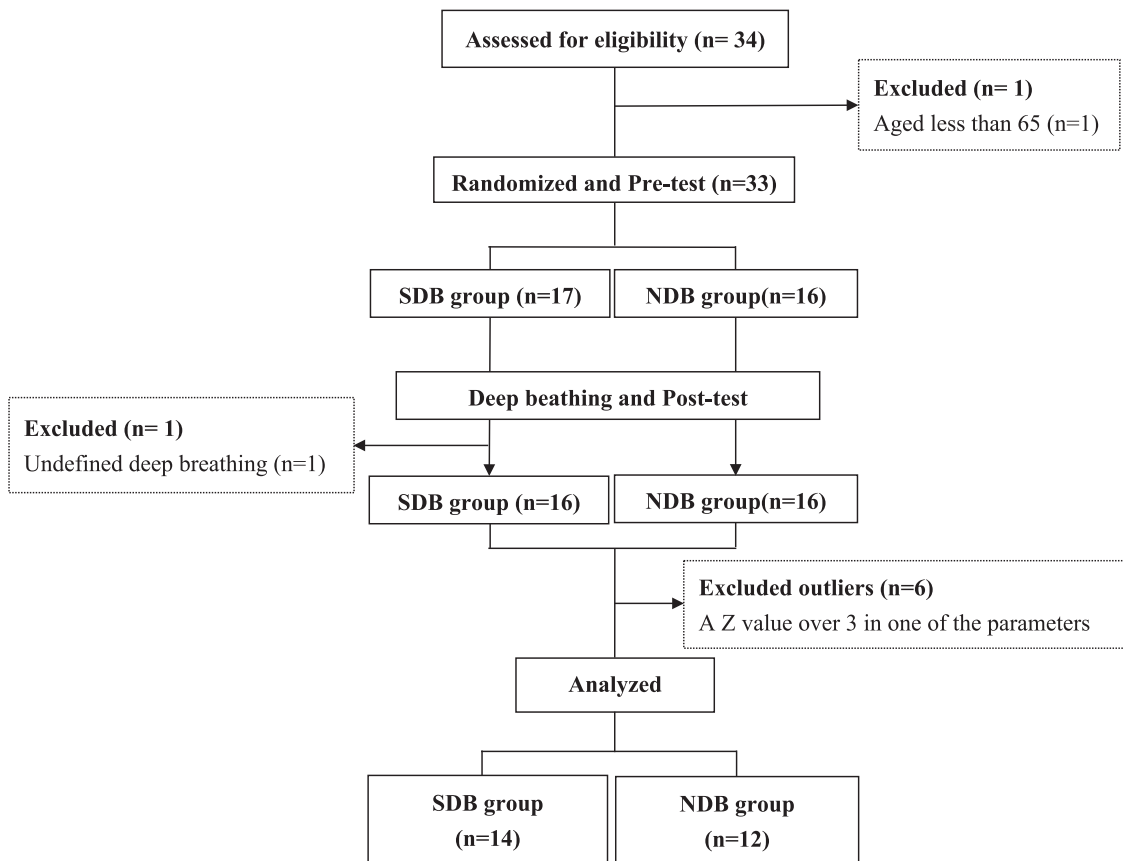
Data collection occurred at five distinct time points to assess HRV and BP in relation to DB. Measurements at the 5th minute (T1), 10th

minute (T2), and 15th minute (T3) captured pre-test data during spontaneous breathing. Among these, T2 was used as the baseline for spontaneous breathing. Before the DB intervention, participants underwent a 5-minute instructional session, followed by 5 min of guided DB. Measurements at the 25th minute (T4) corresponded to the active phase of DB, while those at the 30th minute (T5) represented the immediate post-intervention period. HRV parameters were recorded consistently at all five time points, whereas BP measurements were taken only at T3 (before DB) and T5 (immediately after DB). The data collection process and timeline are detailed in Table 1.

All testing sessions were conducted in a dedicated, quiet laboratory room. The physical environment was strictly controlled, with room temperature maintained at 23–26 °C using central air conditioning and relative humidity kept between 45 and 55 %. Lighting was standardized using overhead LED lighting at 500 lx. To minimize external noise, all measurements were conducted in a sound-attenuated room, and “Testing in Progress” signs were posted to prevent interruptions. Testing was consistently performed during the morning hours (9:00–11:00 AM) to control for diurnal variations. Additionally, participants were given specific pre-testing instructions to ensure reliable measurements: they were asked to avoid caffeine, alcohol, and heavy meals for at least 3 h before testing; maintain their regular sleep schedule the night before; and avoid strenuous exercise for 24 h prior to testing.

2.6. Statistical analysis

Data were analyzed using SPSS version 25.0, with participant identities anonymized using research codes. Statistical analyses were conducted with a significance level set at $\alpha < 0.05$. Demographic variables



SDB=Structured deep breathing; NDB=Natural deep breathing

Fig. 1. Flowchart of participants.

Table 2
Baseline characteristics of the participants.

	SDB group (n = 14)	NDB group (n = 12)	p-Value
Age [Mean $\pm$ SD]	70.36 $\pm$ 6.76	71.25 $\pm$ 5.66	0.717
Gender [n, (%)]			0.596
Male	3 (21.4)	3 (25.0)	
Lifestyle [n, (%)]			
Smoking	0	1 (8.3)	0.462
Alcohol	0	1 (8.3)	0.462
Exercising	4 (28.6)	7 (58.3)	0.129
Disease [n, (%)]			
Hypertension	3 (21.4)	4 (33.3)	0.404
Heart diseases	3 (21.4)	2 (16.7)	0.568
Diabetes	2 (14.3)	3 (25.0)	0.422
Hyperlipidemia	4 (28.6)	0	0.067
Stroke	1 (7.1)	0	0.538
Cancer	1 (7.1)	0	0.538
Respiratory rate (bpm)			
Spontaneous breathing	17.59 $\pm$ 5.26	19.83 $\pm$ 2.68	0.194
Deep breathing	6.09 $\pm$ 0.22	5.67 $\pm$ 2.7	0.602
Heart rate (bpm)	75.21 $\pm$ 10.31	73.83 $\pm$ 7.9	0.709

Abbreviations: n: number of cases; SDB: structured deep breathing; NDB: natural deep breathing; Spon: spontaneous breathing; DB: deep breathing; bpm: beats per minute; SD: standard deviation.

for both groups were presented as frequencies (percentages) for categorical variables and as mean $\pm$ standard deviation (SD) for numerical variables. Differences in demographics between the groups were assessed using independent samples *t*-tests for numerical variables and χ^2 or Fisher's exact tests for categorical variables. The effects of DB on HRV and BP were evaluated using a 3 $\times$ 2 mixed ANOVA, which analyzed within-group (three time points: T2, T4 and T5) and between-group differences (SDB and NDB).

3. Results

3.1. Participant characteristics

Of the 34 older adults initially recruited, 26 participants completed the study and were included in the final analysis (SDB: *n* = 14; NDB: *n* = 12; see Fig. 1 for participant flow). Baseline characteristics showed no significant differences between groups in age, gender, or other variables (all *p*'s > 0.05; detailed characteristics in Table 2).

Table 3
Heart rate variability parameters and blood pressure during different breathing phases in SDB and NDB groups.

	SDB (n = 14)			NDB (n = 12)		
	Spon (T2)	DB (T4)	Post DB (T5)	Spon (T2)	DB (T4)	Post DB (T5)
HRV						
Time domain						
SDNN (ms)	21.27 $\pm$ 9.57	36.95 $\pm$ 17.23	30.41 $\pm$ 13.89	25.55 $\pm$ 7.46	37.55 $\pm$ 9.68	31.82 $\pm$ 13.21
RMSSD (ms)	16.81 $\pm$ 6.54	22.76 $\pm$ 7.39	22.60 $\pm$ 18.35	24.11 $\pm$ 9.88	24.83 $\pm$ 11.37	27.07 $\pm$ 15.58
Frequency domain						
LF (ms ²)	105.59 $\pm$ 223.41	582.84 $\pm$ 603.52	138.42 $\pm$ 167.61	81.69 $\pm$ 99.03	554.71 $\pm$ 528.07	224.74 $\pm$ 280.86
LFnu (%)	45.23 $\pm$ 21.40	80.75 $\pm$ 15.62	62.25 $\pm$ 15.45	40.60 $\pm$ 19.59	80.76 $\pm$ 13.77	53.50 $\pm$ 22.30
HF (ms ²)	73.10 $\pm$ 66.39	61.55 $\pm$ 45.43	69.33 $\pm$ 80.97	108.38 $\pm$ 86.10	106.83 $\pm$ 84.62	127.97 $\pm$ 103.40
HFnu (%)	54.77 $\pm$ 21.40	19.25 $\pm$ 15.61	37.75 $\pm$ 15.45	59.40 $\pm$ 19.59	19.24 $\pm$ 13.77	46.50 $\pm$ 22.30
LF/HF	1.23 $\pm$ 1.27	8.45 $\pm$ 5.56	3.10 $\pm$ 3.46	0.95 $\pm$ 0.91	5.24 $\pm$ 3.40	2.00 $\pm$ 2.33
TP (ms ²)	377.44 $\pm$ 384.05	944.59 $\pm$ 847.05	577.21 $\pm$ 439.16	400.80 $\pm$ 275.84	1040.96 $\pm$ 589.53	788.93 $\pm$ 658.85
BP						
SBP (mmHg)	127.86 $\pm$ 16.34	Not measured	129.38 $\pm$ 17.05	133.75 $\pm$ 13.34	Not measured	132.44 $\pm$ 16.58
DBP (mmHg)	68.40 $\pm$ 10.20		67.88 $\pm$ 10.92	71.56 $\pm$ 6.13		71.36 $\pm$ 8.37

Values are presented as mean $\pm$ standard deviation. SDB group (*n* = 14); NDB group (*n* = 12). Blood pressure was not measured during deep breathing (T4).

Abbreviations: SDB: structured deep breathing; NDB: natural deep breathing; SDNN: standard deviation of normal RR intervals; RMSSD: root mean square of successive differences; LF: low-frequency HRV; HF: high-frequency HRV; LFnu: normalized low-frequency HRV; HFnu: normalized high-frequency HRV; LF/HF: low-frequency to high-frequency ratio; TP: total power; SBP: systolic blood pressure; DBP: diastolic blood pressure; ms: milliseconds.

3.2. RR outcomes

During spontaneous breathing (T2), both groups demonstrated similar respiratory rates (SDB: 17.59 $\pm$ 5.26 breaths/min; NDB: 19.83 $\pm$ 2.68 breaths/min, *p* > 0.05). During the DB intervention (T4), the SDB group maintained consistent breathing rates close to the target (6.09 $\pm$ 0.22 breaths/min; range: 5.8–6.2), while the NDB group showed greater variability (5.67 $\pm$ 2.7 breaths/min; range: 2–10.2). Despite this variability, no significant differences in respiratory rates were observed between groups during either spontaneous or DB phases (*p* > 0.05).

3.3. HRV parameters

The HRV parameters and BP data are shown in Table 3. Analysis revealed no significant group $\times$ time interactions for all HRV parameters throughout the protocol (all *p* > 0.05). While there was no main effect of group, both groups demonstrated significant within-group changes during DB compared to baseline (T2). Specifically, during DB (T4), significant increases were observed in SDNN [*F*(2,48) = 12.84, *p* < 0.001], RMSSD [*F*(2,48) = 4.21, *p* = 0.021], LF [*F*(2,48) = 15.62, *p* < 0.001], LF/HF ratio [*F*(2,48) = 18.96, *p* < 0.001], TP [*F*(2,48) = 14.23, *p* < 0.001], and LFnu [*F*(2,48) = 45.68, *p* < 0.001], while HFnu showed a significant decrease [*F*(2,48) = 45.68, *p* < 0.001]. Notably, absolute HF power showed no significant changes throughout the protocol [*F*(2,48) = 0.88, *p* = 0.42]. In the immediate post DB period (T5), LF power, LFnu, and LF/HF ratio remained elevated (all *p* < 0.05), and HFnu remained lower than baseline (*p* < 0.05). The findings are illustrated in Fig. 2.

3.4. BP response

Mean BP values remained stable throughout the protocol in both groups (SDB: SBP 127.86 $\pm$ 16.34 to 129.38 $\pm$ 17.05 mmHg, DBP 68.40 $\pm$ 10.20 to 67.88 $\pm$ 10.92 mmHg; NDB: SBP 133.75 $\pm$ 13.34 to 132.44 $\pm$ 16.58 mmHg, DBP 71.56 $\pm$ 6.13 to 71.36 $\pm$ 8.37 mmHg). For both SBP and DBP, no significant effect for group, time or interaction were found (all *p* > 0.05).

4. Discussion

This study examined the immediate effects of structured versus natural DB on HRV and BP in healthy older adults. Analysis of 26 participants (SDB: *n* = 14; NDB: *n* = 12) revealed that while the SDB group maintained more consistent breathing rates (6.09 $\pm$ 0.22 breaths/min),

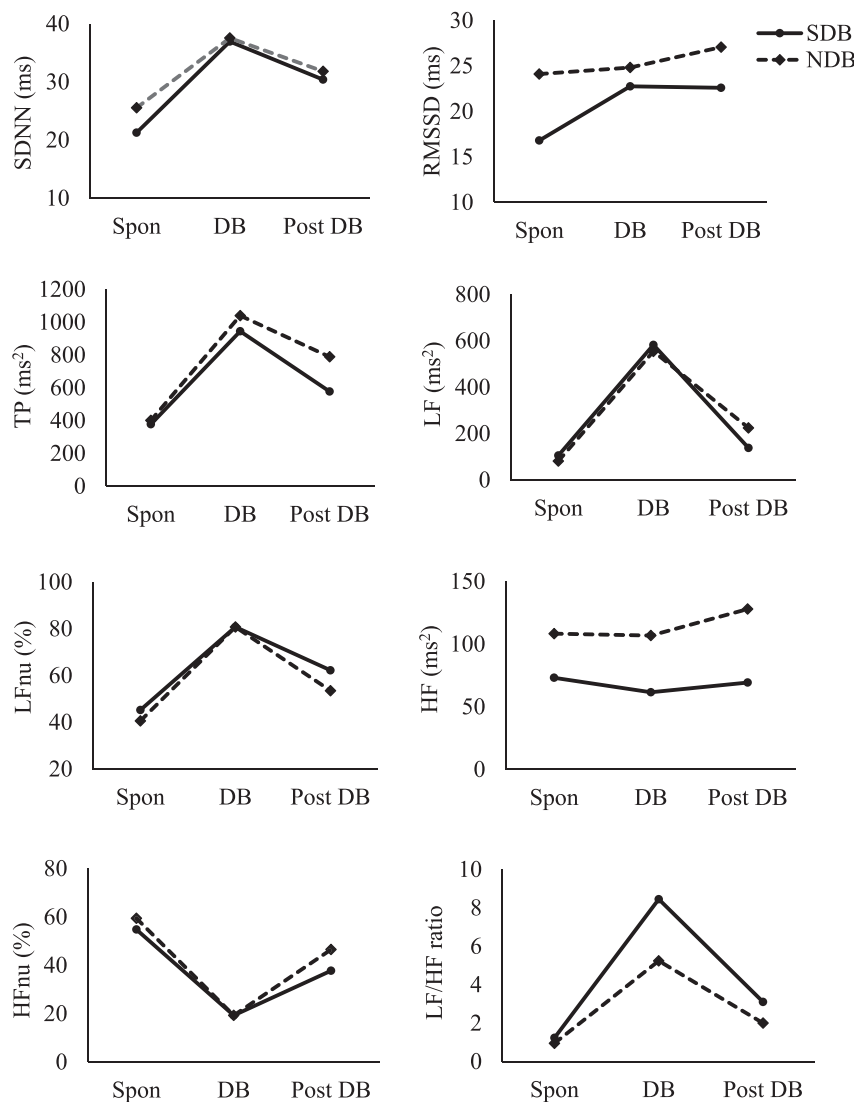


Fig. 2. Effects of deep breathing on heart rate variability parameters across time points.

Line charts represent mean $\pm$ standard deviation for: SDNN, RMSSD, TP, LF power, HF power, LFnú, HFnu, and LF/HF ratio. Measurements were taken at T2 (baseline, spontaneous breathing), T4 (during DB intervention), and T5 (post DB). SDB = Structured deep breathing; NDB = Natural deep breathing. Abbreviations: SDNN: standard deviation of normal RR intervals; RMSSD: root mean square of successive differences; TP: total power; LF: low frequency; HF: high frequency; LFnú: normalized low frequency; HFnu: normalized high frequency; LF/HF: ratio of low frequency to high frequency power.

both groups were able to perform DB exercises, despite greater variability in the NDB group (5.67 ± 2.7 breaths/min). Both interventions induced similar autonomic responses, with significant increases in time-domain (SDNN, RMSSD) and frequency-domain (TP, LF, LFnú, LF/HF). HRV parameters during DB, and some effects persisting in the immediate post DB. While HFnu decreased significantly during DB, absolute HF power remained unchanged, and no significant changes were observed in BP. These findings suggest that both structured and natural DB approaches can effectively modulate cardiac autonomic function in healthy older adults, regardless of whether specific guidance is provided.

Our findings regarding breathing rate achievement are particularly noteworthy in the context of aging populations. While the SDB group showed more consistent breathing patterns (range: 5.8–6.2 bpm), the successful performance of DB by both groups challenges the common assumption that older adults require strict guidance for breathing exercises. This observation aligns with Wang et al. (2019), who reported that older adults can effectively perform controlled breathing with minimal instruction. However, the greater variability in the NDB group (range: 2–10.2 bpm) suggests that some guidance might help optimize

breathing patterns. Similar variations in unguided breathing have been reported by Brown and Gerbarg (2009), although their study focused on younger populations.

The observed changes in HRV parameters reveal complex patterns of autonomic modulation that merit detailed examination. The significant increase in time-domain parameters (SDNN and RMSSD) during DB indicates enhanced overall HRV and vagal tone. This finding aligns with Shaffer and Ginsberg (2017), who identified RMSSD as a particularly reliable index of vagal-mediated autonomic modulation. The concurrent increase in both parameters suggests a robust acute autonomic response to DB, regardless of the method used. The frequency-domain findings present an intriguing physiological pattern that expands our understanding of breathing-related autonomic modulation in older adults. The increase in LF power and LF/HF ratio, coupled with decreased HFnu but unchanged absolute HF power, can be interpreted through several mechanistic frameworks. According to Sevoz-Couche and Laborde (2022), breathing at approximately 0.1 Hz (6 breaths/min) creates a resonance effect where vagal activity shifts into the LF band, potentially explaining our observed LF power increase. This resonance phenomenon, first detailed by Lehrer and Gevirtz (2014), occurs when breathing

frequency matches the intrinsic rhythms of cardiovascular control systems. The similar HRV responses between SDB and NDB groups extend previous findings by [Brown and Gerbarg \(2009\)](#), who primarily studied guided breathing protocols. Our results suggest that the physiological mechanisms underlying breathing-induced HRV changes remain effective even without strict breathing guidance, particularly significant for older populations where autonomic flexibility often decreases ([Thayer et al., 2020](#)). The maintenance of these effects in the immediate post DB (elevated LF, LFnu, and LF/HF) suggests a lasting impact on autonomic regulation, consistent with [Russo et al.'s \(2017\)](#) observations about acute autonomic adaptations to breathing exercises. These HRV changes have important implications for understanding autonomic plasticity in aging. While [Hotta and Uchida \(2017\)](#) reported age-related declines in autonomic responsiveness, our findings demonstrate that older adults retain the capacity for acute autonomic modulation through DB. This preservation of autonomic responsiveness, regardless of DB method, suggests potential for maintaining cardiovascular health through accessible breathing interventions.

The absence of significant BP changes in our study contrasts with some previous findings (e.g., [Wang et al., 2019](#)) that reported acute BP reductions following DB. This discrepancy might be attributed to our focus on healthy older adults rather than hypertensive populations, suggesting that immediate BP responses may depend on initial cardiovascular status. Additionally, the brief intervention duration in our study might be insufficient for observable BP changes, as suggested by [Russo et al. \(2017\)](#), who found BP modifications typically require longer intervention periods.

Perhaps the most significant contribution of our study is demonstrating that natural DB can achieve similar autonomic benefits as structured breathing in community-dwelling older adults. This finding has important practical implications, particularly for developing accessible, cost-effective interventions. By examining acute physiological responses, we establish the minimum effective “dose” of DB needed to produce beneficial outcomes in older adults. This knowledge is crucial for developing safe, effective interventions and understanding the underlying physiological mechanisms. Furthermore, documenting rapid-onset benefits has practical implications for intervention adherence, as early positive feedback can significantly enhance long-term engagement among older adults. Unlike previous studies that relied on specialized equipment (e.g., [Chaddha et al., 2019](#)) or extensive training ([Ubolnuar et al., 2019](#)), our results suggest that simple breathing instructions might suffice for community-based programs. The successful implementation of natural DB could expand access to autonomic regulation strategies, especially in settings where resources for structured programs are limited. Last but not least, while previous studies have focused primarily on clinical populations with conditions such as COPD ([Ubolnuar et al., 2019](#)) or hypertension ([Ping et al., 2018](#)), evidence regarding single-session DB in healthy older adults remains limited. This distinction is crucial because age-related changes in autonomic function and arterial stiffness may uniquely influence breathing intervention outcomes. Given the rapidly growing older adult demographic, understanding these specific physiological responses becomes increasingly important for developing targeted interventions that promote healthy aging.

While our study provides valuable insights, several limitations should be acknowledged. The single-session design, while appropriate for examining immediate effects, cannot inform long-term outcomes. Future research should investigate whether the observed autonomic changes persist with regular practice and whether the greater variability in natural DB affects long-term outcomes. Additionally, studies examining the impact of different intervention durations and frequencies could help optimize breathing protocols for older adults.

5. Conclusion

This study provides the first direct comparison of structured versus natural DB in healthy older adults, demonstrating that both approaches

at 6 breaths/min effectively enhance cardiac autonomic function. Despite more variable breathing patterns in the natural DB group, both methods achieved similar improvements in HRV parameters, challenging assumptions about the necessity of specialized guidance. These findings support DB as an accessible intervention for promoting autonomic health in community-dwelling older adults, with important implications for developing cost-effective, community-based programs.

CRedit authorship contribution statement

Ting-Ting Yeh: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Formal analysis, Data curation, Conceptualization. **Yi-Chieh Ho:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation.

Declaration of competing interest

None declared.

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