

Case Study

## Effects of Ba-Duan-Jin Based Deep Breathing on Multimorbidity: A Case Study

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### ABSTRACT

**Introduction:** Interventions for older adults with multiple medical diagnoses may need to have a more general focus that can be applied across a broad range of medical conditions. Ba-Duan-Jin (BDJ), a non-disease specific Tai Chi-Qi Gong based mind-body training coordinated with deep breathing, may be a good choice.

**Case Description:** A 79-year-old white female patient, with diagnoses of cardiopulmonary, gastrointestinal, and perceived sleep dysfunctions, was referred for consultation of geriatric rehabilitation for poor endurance and balance in a senior living retirement complex where rehabilitation services were provided. A BDJ-based deep diaphragmatic breathing (DDB) progressive training was provided 45-50 minutes each time and 3 times a week for 6 months. At the baseline, the end of 3<sup>rd</sup> and 6<sup>th</sup> month of this study, this patient was assessed with the Barthel index for activity of daily living, 1-minute heart rate recovery, Pittsburg sleep quality index, head elevation during sleeping, 4-stage balance, and 2-minute walk test. At the end of 3<sup>rd</sup> and 6<sup>th</sup> month, the patient was able to have improved strength, endurance, balance, cardiorespiratory function, gastral regurgitation, and activities of daily living. The mechanism of the beneficial effects of BDJ-based deep breathing in this case was discussed with body mechanical and anatomical consideration.

**KEY WORDS:** Older adults, Ba-Duan-Jin, Tai Chi, Multiorbidity, Diaphragmatic anatomy.

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### INTRODUCTION

Multimorbidity, referred as a coexistence of multiple chronic medical diagnoses, has been considered a normal part of aging process [1]. Globally, nearly one third of all adults suffer from multimorbidity [2]. The impact of living with multimorbidity is obvious, including declining physical functioning, deteriorating mental status, decreasing quality mobility, and even mortality [3]. One of the main challenges for treating the patients is fragmented care,

resulting from patients having to visit multiple healthcare providers, obtaining various medical prescriptions, and receiving different lifestyle recommendations for their various medical conditions [4].

In addition to individualized management for each medical diagnosis, studies have suggested that interventions for older adults with multimorbidity may need to have a more general focus that will work across a broad range of conditions [4,5], particularly for non-

disease specific practices such as care for physical functions, cognition, sleep quality, and activities of daily living [1,4].

Management for multimorbidity from a geriatric physical therapist perspective includes exercises that may impact both mental and physical health. Ba-Duan-Jin (BDJ), a mind-body Tai Chi-Qi Gong based exercise therapy originating from China could be a suitable one [6-8]. BDJ emphasizes static and dynamic postural control, as well as an integration of body movement with deep breathing [8]. Deep breathing exercise, also called the deep diaphragmatic exercise, is a practice that enables more air to flow into the body. During the deep inspiratory breathing, the peripheral muscle portion of the diaphragm contracts to pull the central tendon of the diaphragm downward to create more space in the thoracic cavity in order for the lungs to expand in the cavity. While during the deep expiratory breathing, the diaphragm relaxes and moves back upward mainly due to increased abdominal pressure caused by the contraction of abdominal muscles and assisted by the pelvic floor muscles [9-11]. Researchers have shown that deep diaphragmatic breathing is able to trigger body relaxation response and benefit both physical and mental health by calming the nervous system, reducing stress and anxiety, improving attention, and even decreasing pain levels [9-11].

In this case study, which was approved by the ethics committee for human research in the place where the 1<sup>st</sup> author worked, and the informed consent was signed by the patient, we described an older lady with multimorbidity who received BDJ-based exercise training that benefited her not only in improvement of physical function, but also in reduction of symptoms related to her multiple chronic diagnoses. Further, a detailed discussion focus on the deep diaphragmatic breathing (DDB) was conducted to understand why the BDJ-based DDB training could benefit the patient.

## CASE DESCRIPTION

A 79 years old white female was consulted for geriatric rehabilitation for poor endurance and

balance in a senior living retirement complex where rehabilitation services were provided.

Six weeks prior to referral, this patient was hospitalized with diagnosis of left urinary tract infection (UTI) based on her lower abdominal pain, lab work, and radiological assessment. During the 7-day hospital stay, her UTI resolved but she developed “generalized weakness”. requiring a discharge from the acute hospital to a skilled nursing facility for nursing and rehabilitation care because she was unable to ambulate independently at the time of discharge. After 4-weeks of physical therapy intervention in the facility, she was able to stand up and walk with a rollator for 105 feet about 5 minutes intermittently and maximally. Then, she was discharged from the skilled nursing facility to this retirement community for physical therapy consultation.

Before hospitalization, this patient lived on her own in an apartment in the retirement community with a “sedentary lifestyle” without participating any community-provided exercise programs, but she was able to perform indoor daily activities independently. She had her own rollator and single-tip cane that she used one of them occasionally when she went to the dining hall, which is approximately 400 feet away downstairs. She is a retired elementary school teacher without history of smoking and alcohol use. She had hypertension for 11 years, gastroesophageal reflux disease (GERD) for 7 years, chronic bronchitis for 5 years, and cardiac bypass surgery 4 years ago due to coronary artery disease. Medications used by the patients included Nexium for GERD, Spironolactone for hypertension, Amoxicillin for bronchitis, pneumonia, aspirin for post-heart bypass surgery, and Melatonin for sleep.

**Physical evaluation and examination:** The patient appeared pleasant, was cognitively intact and oriented to name, place, and time without any communication issues. She stated that she sometimes experienced urinary stress incontinence when coughing and/or sneezing, and often could not sleep well, waking 3-4 times at night. When laying down, she did not like the flat supine position because it gave her the sense of choking with occasional

coughing. In her bedroom she had an adjustable bed with the head part quarter-way (almost two-thick-pillows high) elevated to accommodate her need. No other symptoms and signs were reported. Physical exams in the therapy room revealed her at-rest vital signs: blood pressure at 138/92 mmHg, axillary temperature at 97.5° F, pulse rate at 77, and respiratory rate at 18. Also, her fingertip SaO<sub>2</sub> was at 95 at rest. She was able to perform bed mobility tasks such as supine to sit independently. Additionally, she was also able to perform sit-to-stand, stand-to-sit transfers, and functional reach-over to shelf and cabinet by holding her walker or some furniture. She needed to take rest intervals several times between these activities.

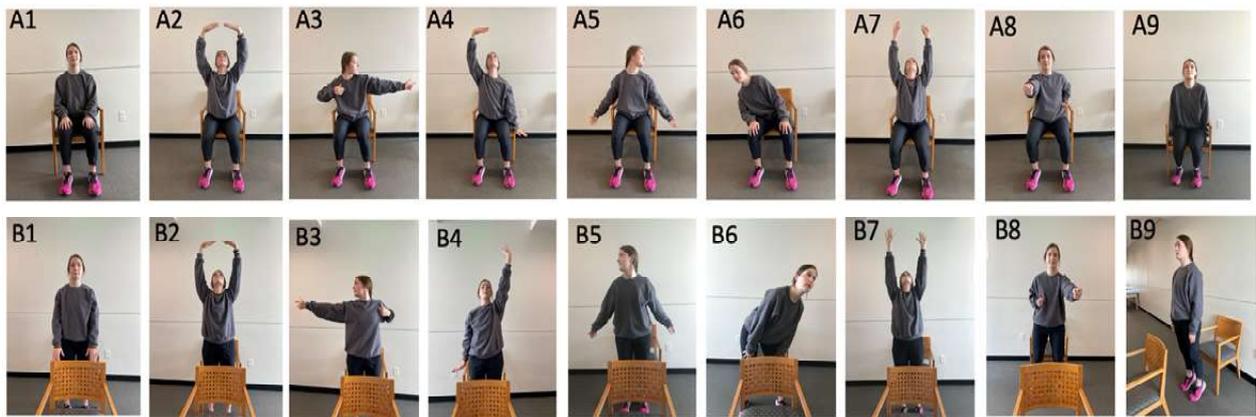
**Interventions:** It was recommended for the patient to learn and practice Ba-Duan-Jin (BDJ) exercise provided by an experienced BDJ practitioner, and followed by indoor ambulation in the community. She was allowed to have a hand on the handrail on the wall of the hallway if needed during walking. There are eight BDJ forms which coordinated slow and self-controlled body movement with deep breathing that can be practiced in either seated or stance positions (Figure 1). The coordination between the arm movement and deep breathing is defined as the time used for the movement of arms from their initial position to the end position is the same as the whole time used for inspiration; likewise, the time used for the movement of arms from their end position back to the initial position should be the same as the whole time used for expiration. The patient practiced while seated for the 1st week and progressed to standing starting in the 2<sup>nd</sup> week when she was still with the instructor (see Figure 1). It has been reported that a body and mind harmony of BDJ movements could be achieved by practicing on daily routine [8,12].

During the initial four weeks of BDJ learning time, the patient practiced in the activity room of the community. In the 1<sup>st</sup> 2 weeks, she followed the practitioner 3 sessions a week to learn BDJ in a seated position and then next 2 weeks she did in standing position with a chair in front of her in case needed (Figure 1). She started to practice on her own in the 5<sup>th</sup> week

with provided BDJ handouts, video clip, and written precautions from the practitioner. Each BDJ session lasted 45–50 minutes and consisted of a 5-minute warm-up, 35–40 minutes of performance, and a 5-minute cool-down. The warm-up included simple movements of trunk rotation and arm swinging, while the cool-down imagery review of the performed BDJ in seated position. During the exercise training time, coordination between breathing pattern and body movements was required during practice - performing slow deep diaphragmatic inspiration when the arms were moving away from the body or the trunk was extending; then holding on the breathing for 1-3 seconds at the end of the inspiration; while performing slow deep expiration when the arms are moving toward the body or the trunk was flexing; followed by holding on the breathing for 1-3 seconds at the end of the expiration.

It should be noted that the diaphragm is concentrically contracting during inspiration, eccentrically contracting during expiration, and isometrically contracting at the end of either the inspiration or the expiration. At the end of expiration, the patient was encouraged to palpate her belly button sinking in (as if she was fitting in a tight jean), coccyx (pelvic floor) moving superiorly and anteriorly. In addition, ½ to 3 pounds of cuff and ankle weights were gradually applied from one hand/ankle to both hands/ankles starting in 4<sup>th</sup> month of BDJ practice. Also the patient was asked to take a rest interval when she felt she needed during the BDJ practice time.

**Outcome assessments:** The patient was assessed at the baseline and the end of 3<sup>rd</sup> and 6<sup>th</sup> months of the coordinated BDJ with self-controlled deep breathing (Table 1). At the end of 3<sup>rd</sup> and 6<sup>th</sup> month, a short survey with 3 questions, including: “How have you been feeling in last 3 months? How do you feel your energy now? and have you done any extra activities you usually were not able to do in last 3 months?” Also there were 7 assessments conducted in 2 consecutive days for each assessment session in order to avoid or minimize the fatigue effect. On the 1<sup>st</sup> day, the 4 assessments included the following: the Barthel index is an instrument that can be utilized



**Fig. 1:** Demonstration of 8-form Ba-Duan-Jin exercise with deep breathing at sitting (A1-9) and standing (B1-9) positions. For safety consideration, a chair was provided in case needed when standing. There are 8 forms of BDJ movements. **A1/B1** are the initial position of deep inspiration or the end position of deep expiration. **A2-9** or **B2-9** are the end position of deep inspiration or the initial position of deep expiration of each BDJ form. **A2/B2** – two hands pushing up; **A3/B3** – bow shooting on left and then right sides; **A4/B4** – one hand pushing-up and other hand pushing down with left- and right-hand positions alternated; **A5/B5** – look back (on left and then right) with arms open-up; in seating; **A6/B6** – body side-bend and sway left to right and then right to left; **A7/B7** – two arms pray-up; **A8/B8** – left and right fist out alternated; and **A9** – both fists on the edge of the chair to push the body slowly up, **B9** – both heels slowly off the ground to tiptoe stance.

on the elderly to measure the activities of daily living [13]; the Pittsburgh Sleep Quality Index is a self-rated questionnaire that can be used in older adults to assesses sleep quality and disturbances over a 1-month time interval [14]; the heart rate recovery is a non-invasive assessment of cardiac autonomic function with the rate drop between 12 and 23 beats within a minute as good [15’16]; and pillows used in supine position. On next day, three more physical functional assessments were randomly conducted, including the 4-stage balance test is a progressive assessment testing balance form side-by-side, semi-tandem, tandem, to single leg stance [17]; the 5-times sit-to-stand test is a reliable functional lower extremity strength assessment that is often used in the elderly [18]; and the 2-minute walk test is to assess a person’s endurance or aerobic capability [19].

All physical tests were randomly conducted. During the baseline assessment time.

**RESULTS**

At the end of 3<sup>rd</sup> month, she reported that she felt much better with “falling sleep much easier although still waking-up sometimes at night”, “seemingly more energy back”, and “participating more craft work in the community”. At the end of 6<sup>th</sup> month, her comments on herself included “I can walk in the hallway by just occasionally holding the handrail”, “I can lay on my back with just one pillow under my head”, and “I even went to watch a concert last Saturday”. As of these 7 assessments, after 3 months of the training, the patient had improvement in all assessed areas in which the Pittsburg index of sleep quality, 4-stage balance, 2- minute walk, and Barthel index in mobility, toilet use, and

**Table 1:** Outcome Assessed.

	At baseline	At the end of 3 <sup>rd</sup> month	At the end of 6 <sup>th</sup> month
Barthel Index	70	85 (transfer, mobility, and toilet use improved)	100 (voiding and stairs improved)
1-minute Heart Rate Recovery (March-in-place - (60%HRMzx*))	7	13	21
Pittsburgh Sleep Quality Index (PSQI)	18/21	8/21	6/21
Supine with head elevated on	2 thick pillows	2 thin pillows	1 thin pillow
5-times sit-to-stand	24	20	13
4-Stage Balance	Side-by-side – 10 s	Tandem - 4s	Single leg - 7s
2-min walk test	99 feet with rollator and 2 rest stops (10-15 secs)	201 feet with handhold on the handrail on the wall with 1 rest stop (5 secs)	417 feet with handhold on the handrail on the wall without rest stop.

transfer. With 3 additional months of training, improvements continued with the 1-minute heart rate recovery, head elevation in supine position, Barthel index in pelvic function and stair use, functional lower extremity strength (sit-to-stand test), 4-stage balance, and 2-minute walk test demonstrating improved strength, activities of daily living, balance and endurance. Also, at the end of 3<sup>rd</sup> and 6<sup>th</sup> month, the patient's blood pressure was 132/89 and 128/84 respectively.

## DISCUSSION

The patient in this case benefited from a BDJ-based deep breathing exercise program with improvements in functional (e.g., Barthel index), physical (e.g., 4-stage balance test, 5-times sit-to-stand test, 2-minute walk test), physiological (e.g., heart rate recovery), and even medical symptoms (including insomnia, gastric regurgitation, and urinary voidness). The physical and functional results from this study are in agreement with previous studies [8,20-22]. Also, the present study demonstrated progressive improvements in all assessments. However, it seems that the sleep quality, balance, endurance, mobility and transfer were improved more and earlier that occurred in 1<sup>st</sup> 3 months. Then during 2<sup>nd</sup> 3- months, more obvious improvements were identified in the 1-minute heart rate recovery, preferred supine position, pelvic function, balance, endurance, and lower extremity strength. These indicate that a time length factor may play a role in expected outcomes during BDJ practice.

BDJ is the most commonly used Qigong-related exercise [8]. Qigong related exercises seem to be better than the conventional rehabilitation exercise in postural control, pulmonary functions, and activities of daily living ability for patients in early stage of stroke recovery [23]. Due to its slow and controllable movements with self-awareness, BDJ-based deep breathing could be considered as a self-controlled gentle perturbation exercise. These controlled perturbation variables may include body parts (e.g., arms) involved, movement directions, range, speed, and additional resistance to have during the exercise in coordination with the deep breathing. Compared between the 1<sup>st</sup> and 2<sup>nd</sup>

3-month training, consistent and progressive improvements were noticed throughout the whole 6 months. However, the lower extremity strength seemed not to be significantly improved in 1<sup>st</sup> 3-month, which is similar to a prior 12-week BDJ study [20], but in the present study, the obvious improvement of 5-time sit-to-stand test during 2<sup>nd</sup> 3-month time is evident, which may be resulted from cuff and ankle weights added as resistive load to challenge the patient.

Coordination is the key to the training in this case study. Compared with regular deep breathing exercise that arm or body movements are not required, the BDJ-based deep breathing exercise that is coordinated with the arm/body movements as shown in the present case is different and also similar to the regular deep breathing exercise (Table 2)[9-11,24]. As defined in the Intervention section, the coordinated arm movement and deep breathing is to add emphasis to deep breathing by coordinating arms movement are presented; or to add and emphasize the arm movement when the deep breathing is performed. Previous studies had reported that the areas in M1 (motor cortex) for activation of diaphragm contraction and upper limb muscles are proximal to each other. Compared to a non-deep breathing, a deep breathing is able to express a force for better performance of motor coordination of the upper extremity [25,26]. Speaking of the interactive coordination among brain, respiration, and extremity movements, Varga and Heck [25] stated that neural oscillation in human can be modulated by movement of extremities, and gesture with arm movement may function analogously to respiration in terms of the underlying neuronal mechanism. In other words, brain, diaphragm, and extremity movements need to work communicatively and collaboratively to complete a motor task. Thus, it is feasible that the BDJ-based deep breathing may assist the brain and the diaphragm to communicate and coordinate for a motor-related functional task. If the time used for the arms to move away from the body or move back toward the body is not equal or similar to the time used for the inspiration time or expiration time respectively during the BDJ-DDB practice, it might indicate a miscommunication or discoordination between the brain,

**Table 2:** Comparisons between BDJ-Based DDB and DDB without body movements.

	DDB without body movements	BDJ-based DDB
Self-controlled body perturbation	No	Yes
Coordination between the arm/body movement and deep breathing	No	Yes
Upright posture emphasized	Yes	Yes
Diaphragmatic eccentric, concentric, and isometric activation	(could be) Yes	Yes
Accessory inspiratory muscles activated to increase chest capacity	Yes	Yes, but more (e.g., pectoralis)
Increased intrathoracic space (increased intraabdominal pressure)	Yes	Yes, but more

BDJ: Ba-Duan-Jin exercise; DDB: deep diaphragmatic breathing.

the arm/body movement, and the deep breathing when completing a motor task. For example, a person with a shallow or insufficient breathing might not be able to sustain a task process, like extending an arm out to a cabinet to pick an item, or few rest intervals needed for an on-going task.

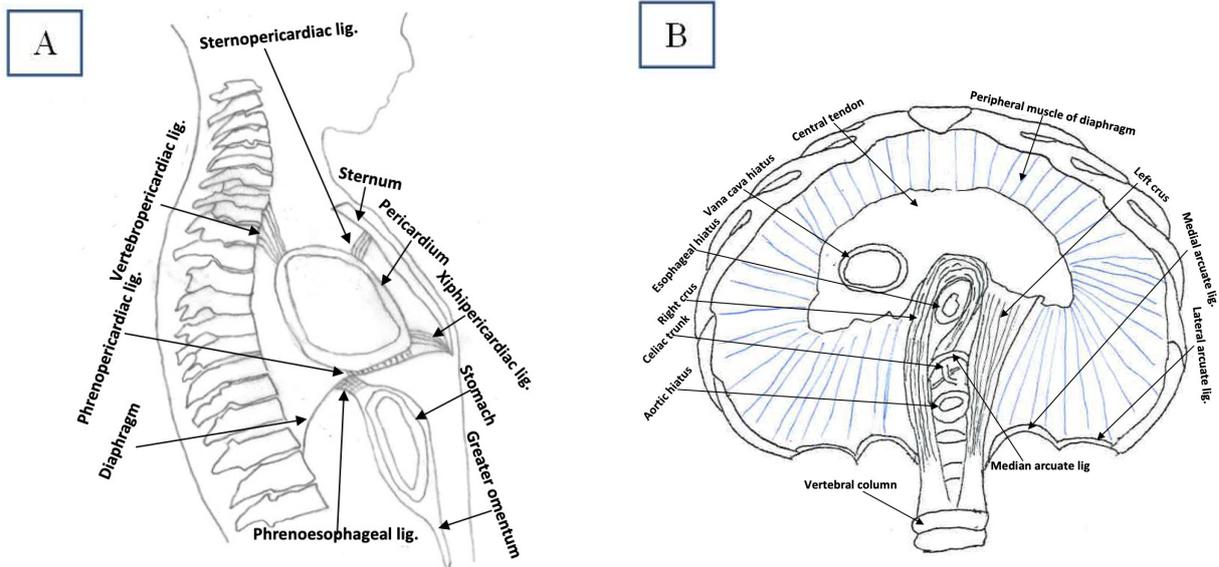
The diaphragm does not only function locally, but also affect the whole-body system [26], which makes sense why the deep diaphragmatic breathing is clinically a common exercise [9-11,24]. In the present study, the BDJ-based deep breathing could be a more advanced and dynamic version than the regular deep diaphragmatic breathing. In addition to the self-aware perturbation and the arm/body movement coordinated with deep breathing, the BDJ based deep breathing also shows some similar and different actions in emphasis of upright posture, diaphragmatic muscle activation, accessory inspiratory muscles, and negative intrathoracic pressure (Table 2). By combining all of these actions along with results from the patient in this case, it is reasonably for us to say that a long-term practice of the BDJ-based DDB, like what was present in this case, might be a better non-medical management than the DDB without body movement involved for those with multimorbidity.

In this case, the patient demonstrated improvements in the heart rate recovery and In this case, the patient demonstrated improvements in the heart rate recovery and 2-minute walk test as

well as reduction of pillows used for supine position. To certain extent, these functional betterments may attribute to the mechanical effects of the cardiopulmonary and gastroesophageal structures in the chest and abdominal cavities. Anatomically in the chest cavity, there are 4 ligaments (Figure 2-A) attached to the pericardium from the superior surface of the diaphragm, sternum, xiphoid process, and thoracic vertebrae [27].

During inhalation, the diaphragm moves inferiorly, the xiphoid and sternum move superiorly and anteriorly, while the thoracic vertebral column extends slightly. The downward movement of the diaphragm would cause more negative intrathoracic pressure. Also the pulling forces from those 4 ligaments on the pericardium would expand the pericardial cavity and make more negative intra-pericardial pressure. Thus, the vacuum action due to both intrathoracic and intra-pericardial negative pressures could be the primary driving factor or the fundamental mechanism to facilitate blood flow to the heart; to increase coronary perfusion, ventricular filling, and stroke volume; and subsequently to enhance circulation to vital organs all over the body [28,29].

In the abdominal cavity, the esophagus passes through the esophageal hiatus to be connected with the stomach. Anatomically, a circular muscular sphincter-like structure around the esophageal hiatus can be easily observed, which is made by the right crus of the diaphragm in most cases (Figure 2-B), and sometimes can be seen by both left and right diaphragmatic crura [30]. Also, the visceral peritoneum wraps around the lower end of the esophagus or the cardiac orifice area of the stomach to make an areolar structure that firmly attaches stomach to the diaphragm [31], which makes the phrenoesophageal ligament (Figure 2-A). Functionally, the sphincter-like muscular structure from the crus and the ligament from the peritoneal reflection may play significant roles in preventing gastric reflux, prolapse, and even esophageal upward displacement [30,31]. So, it is understandable that during inspiration, the diaphragm contracts to close the distal esophagus to avoid gastric reflux (e.g., the gastroesophageal reflux disorder) into the opened trachea.



**Fig. 2: A.** Sagittal view of the chest and abdominal cavities: in the chest cavity, there are 4 ligaments attached onto the pericardium; in the abdominal cavity, the phreno-gastric ligament is around the gastroesophageal junction area.

**B.** Inferior view of the diaphragm: there are three hiatuses at the diaphragm, among which the esophageal hiatus is surrounded by the right crus of the diaphragm as a sphincter-like structure at the lower end of the esophagus.

When deep diaphragmatic breathing is practiced with concentric, eccentric, and isometric contraction, the diaphragmatic muscle including its two crura could get stronger, which can enhance the sprinter-like action of the diaphragmatic crura.

Prior investigations have demonstrated that the deep breathing exercise is an effective intervention to improve the pelvic floor muscle activity and postural stability [32,33]; and on the other hand, the strengthening exercise of the pelvic floor could also improve the diaphragm and pulmonary function [34]. In this case, the improvements in the Barthel index (particularly in voiding and stair use), balance, as well as the sit-to-stand test are in agreement with what had been reported previously [32,33], which occurred more noticeably during the 2<sup>nd</sup> 3-month phase of the BDJ training time. These results demonstrate that the BDJ-based deep breathing might be an effective intervention for patients with pelvic dysfunction, particularly when a resistance (e.g., cuff and ankle weight) is applied to the patients and the training time is long enough (e.g., 6 months).

## CONCLUSION

Clinically it is common to see an older adult with multiple chronic diagnoses that may affect physical, mental and functional capabilities

in daily life. To prevent or minimize these effects, the BDJ-based deep diaphragmatic breathing exercise could be a promising intervention that may improve not only the general physical and functional aspects but also some relevant medical symptoms for people with multimorbidity. In this case, the patient benefited from BDJ intervention showing improvements in strength, endurance, balance, cardiac autonomic function, sleep quality, and activities of daily living. However, it should be pointed out that the results here are not generalizable, but indicative for consideration of clinical application and further research.

## Author Contributions

**HL:** data collection, analysis. and manuscript writing  
**KM:** data collection and manuscript writing (with HL on the discussion part)  
**EA:** manuscript writing (mainly on discussion part)

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## Conflicts of interest: None

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