

# Exploring the Diagnostic Potential of Video-Based Breathing Control Training: A Sonographic Evaluation of Abdominal Organ Measures

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**Background:** Breathing control training programs have gained attention due to their potential to influence diagnostic procedures. However, the role of video-based tools to demonstrate breathing maneuvers during sonographic quantification of abdominal organs needs to be studied more. This study explores the impact of a video-based breathing training program on sonographic examination of abdominal organs.

**Methodology:** This quasi-experimental study recruited 49 healthy volunteers at the ultrasound lab of College of Health and Rehabilitation Sciences in Princess Nourah bint Abdul Rahman University. The study employed a video-based breathing control training program that includes diaphragmatic breathing exercises. Sonographic assessments of abdominal organs were conducted before and after the intervention period using standardized protocols. Data was analyzed using SPSS V 28.

**Results:** The right renal length (p-value <0.001), thickness (p-value 0.025), and volume measured (p-value <0.001) were significantly improved following the video training. Similarly, splenic length (p-value 0.015), width (p-value <0.001), and volume (p-value 0.001). Additionally, the operator time demonstrated a notable decrease from 13.14 ± 3.4 to 8.1 ± 3.5 minutes after the video training intervention (p-value <0.001).

**Conclusion:** The study provides evidence for the beneficial effects of a video-based breathing control training program on sonographic quantification of abdominal organs. These findings suggest potential clinical utility for integrating video-based breathing interventions into practice, although study limitations require further validation and generalization. Nonetheless, the study highlights the promising role of breathing control training in enhancing the diagnostic accuracy of abdominal sonography.

**Keywords:** breathing, training, kidney, spleen, sonography

## Introduction

The utilization of breathing maneuvers has garnered considerable attention in several diagnostic and therapeutic contexts.<sup>1,2</sup> They have been utilized in influencing various health conditions such as chronic obstructive pulmonary diseases (COPD),<sup>3-5</sup> asthma,<sup>6,7</sup> cardiovascular function,<sup>8</sup> psychological stress,<sup>9</sup> and back pain.<sup>10,11</sup> These techniques aim to optimize respiratory mechanics, enhance gas exchange, and modulate autonomic nervous system activity.<sup>12</sup>

Recent literature indicates that the practice of breathing exercises has the potential to influence intra-abdominal dynamics through modifications in diaphragmatic excursion and the activation of abdominal muscles.<sup>13</sup> Studies have demonstrated differences in the return of blood through the inferior vena cava (IVC) and hepatic veins, as observed on duplex sonography, during various breathing techniques, including free breathing, full inspiration and expiration and holding, Valsalva maneuver,

and resistance-induced suction.<sup>1,14–19</sup> Furthermore, a recent study has unveiled disparities in hepatic rigidity as assessed using magnetic resonance elastography (MRE) during the latter stages of inhalation and exhalation.<sup>20</sup>

Abdominal ultrasound is a diagnostic technique of great value in the assessment of patients who exhibit abdominal symptoms.<sup>21</sup> The noninvasive nature of this imaging technique, the capability to estimate organ size in real-time, and the fact that it does not require the use of radiographic contrast material are the primary attributes that contribute to its advantages.<sup>22</sup>

During abdominal ultrasonography, breathing methods are currently being utilized in order to improve the clarity of visualization. On a continuous basis, shadows are cast on the top poles of the kidneys by the lower rib structure. During the course of normal respiration and the holding of breath, the entire kidney becomes visible as it aligns with the diaphragm and adjusts its position accordingly.<sup>23</sup> A patient may be instructed by the operator to take a deep breath and hold it for a period of time in order to increase the size of the intercostal spaces and improve the visibility of the kidneys of the patient.<sup>24</sup> Nevertheless, the effectiveness of breathing techniques in enhancing the sonography experience is constrained by the patient's understanding and adherence to the prescribed task.

Video-based interventions showed effectiveness in achieving educational and illustrative purposes in the clinical setting.<sup>25–28</sup> This study has suggested the implementation of a video training program as a means to effectively illustrate the intended maneuver with precision. The objective of this study is to investigate the effects of a breathing control training program on the sonographic quantification of abdominal organs.

## Methodology

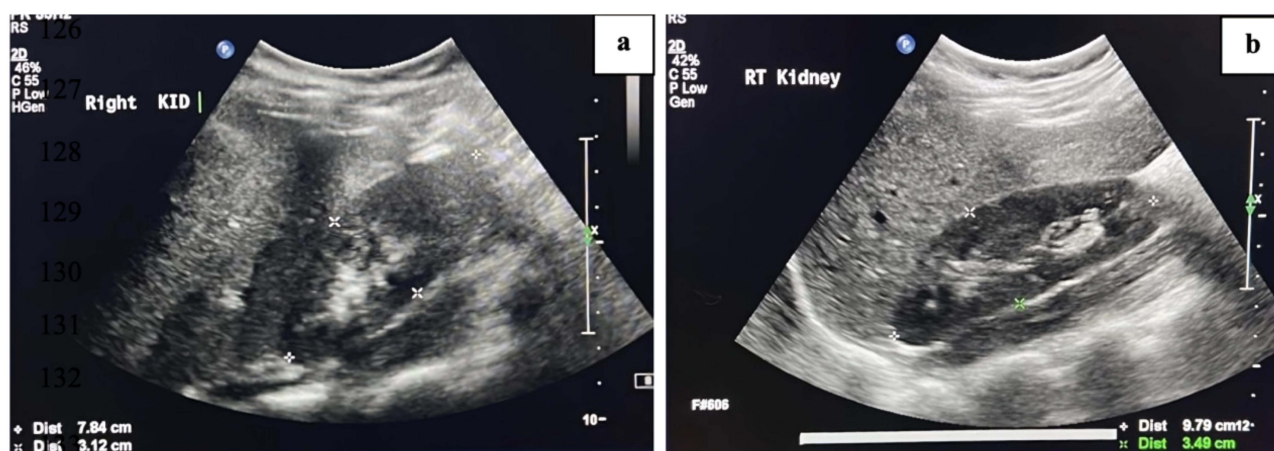
This study employed a quasi-experimental design to examine the impact of a video-based breathing control training program on sonographic quantification of abdominal organs. It included young, healthy volunteers between 18 and 25 years old with BMIs up to 29.9 kg/m<sup>2</sup>. Volunteers with chronic illness (eg, irritable bowel syndrome) and volunteers with BMIs equal to 30 kg/m<sup>2</sup> and above were excluded.

The data collection process took place between January 2023 and November 2023 at the College of Health and Rehabilitation Sciences ultrasound lab at Princess Nourah bint Abdulrahman University (PNU).

The breathing control training program was designed through video of different breathing maneuvers, including diaphragmatic breathing and holding. The diaphragmatic breathing is also known as deep inspiration breathing. Each volunteer had to watch this video with an Arabic voiceover and an English subtitle. The instructions were 1) lie down while keeping your shoulders relaxed; 2) inhale slowly, allowing the lower abdomen and chest to expand; 3) hold your breath for as long as possible; and 4) now exhale slowly through your mouth or nose. The volunteer had to practice this maneuver (deep inspiration) for five days before the exam, five times per day, for five minutes.

Sonographic assessment of abdominal organs, including the right (RT) kidney and spleen, was conducted at baseline (standard abdominal scanning before watching video) and immediately following the intervention period. Both required the volunteer to be instructed to take a deep breath and hold it during scanning. Trained sonographers with two years of experience in abdominal scanning performed the scan. All exams were performed under the supervision of one skilled and certified ultrasound imaging specialist.

Participants in the volunteer program were instructed to refrain from consuming any meals for six to eight hours. The RT kidney and spleen were scanned according to AIUM practice guidelines for conducting an ultrasound examination of the abdomen and/or retro-peritoneum.<sup>29</sup> When the volunteer was supine, the probe was placed in the right lower intercostal space in the midaxillary line to scan the RT kidney and obtain length and thickness. Then, the probe was rotated for a transverse section to obtain width. The volunteer was in a supine or RT lateral position for the spleen. The spleen was scanned in the longitudinal plane to obtain splenic length. Then, the probe was rotated 90° to view the spleen in the transverse plane to obtain thickness and width. All measurements were taken during deep inspiration and holding. These measurements are RT renal length, width, thickness, volume, and splenic length, width, thickness, and volume. Scanning time was measured as well before and after the intervention. The kidney was considered normal when measured 9–13 cm long, 4–6 cm wide, and 3–5 cm thick. The splenic length was considered normal when measured



**Figure 1** RT renal measurements (length and thickness) with deep inspiration for the same volunteer before (a) and after (b) breathing control training. The kidney measured 7.64 cm in length and 3.12 cm in thickness before the training program, 9.79 cm in length, and 3.49 cm in thickness after the program.

<13 cm in length, 6–7 cm in width, and 5 to 6 cm in thickness. **Figure 1** demonstrates renal measurements (length and thickness) with deep inspiration for the same volunteer before and after the training program.

Data analysis involved comparing pre- and post-intervention sonographic measurements using a paired samples *t*-test. A significant difference was assumed if the *p*-value was less than 0.05. The data was analyzed using SPSS V 28 software.

## Results

The study included 49 volunteers with a mean age of  $21.3 \pm 0.9$  years and an average body mass index (BMI) of  $21.4 \pm 3.3$  (**Table 1**).

Before the implementation of the video training intervention, the measurements of the renal length, width, thickness, and volume were as follows:  $9.60 \pm 0.99$  cm,  $5.32 \pm 0.93$  cm,  $3.90 \pm 0.62$  cm, and  $104.95 \pm 29.67$  ml. The measurements after the video training were found to have increased to  $10.01 \pm 0.92$  cm,  $5.21 \pm 0.83$  cm,  $4.11 \pm 0.76$  cm, and  $167.65 \pm 42.63$  ml, respectively. These increases indicate considerable improvements in renal measures, except renal width (**Table 2**).

**Table 1** Demographic Characteristics of Volunteers

| Variable                       | Mean $\pm$ SD  | Minimum | Maximum |
|--------------------------------|----------------|---------|---------|
| Age (years)                    | $21.3 \pm 0.9$ | 19      | 24      |
| BMI ( $\text{kg}/\text{m}^2$ ) | $21.4 \pm 3.3$ | 17.2    | 28.3    |

**Table 2** Pre- and Post-Intervention Sonographic Measurements of the RT Kidney

| Measure              | Pre-training       | Post-training      | Difference (post-pre) | P-value |
|----------------------|--------------------|--------------------|-----------------------|---------|
| Renal length (cm)    | $9.60 \pm 0.99$    | $10.01 \pm 0.92$   | +0.40                 | <0.001* |
| Renal width (cm)     | $5.32 \pm 0.93$    | $5.21 \pm 0.83$    | -0.11                 | 0.377   |
| Renal thickness (cm) | $3.90 \pm 0.62$    | $4.11 \pm 0.76$    | +0.21                 | 0.025*  |
| Renal volume (ml)    | $104.95 \pm 29.67$ | $167.65 \pm 42.63$ | +62.70                | <0.001* |

**Note:** \*Indicates significant P-value (<0.05), estimated using paired *t*-test.

**Table 3** Pre- and Post-Intervention Sonographic Measurements of the Spleen

| Measure                | Pre-Training  | Post-Training | Difference (Post-Pre) | P-Value |
|------------------------|---------------|---------------|-----------------------|---------|
| Splenic length (cm)    | 8.95± 0.93    | 9.27± 1.10    | +0.32                 | 0.015*  |
| Splenic width (cm)     | 7.74±0.72     | 8.06± 0.64    | +0.32                 | <0.001* |
| Splenic thickness (cm) | 4.05± 0.84    | 4.23± 0.63    | +0.18                 | 0.135   |
| Splenic volume (ml)    | 147.72± 42.21 | 166.69± 42.39 | +18.96                | <0.001* |

Note: \*Indicates significant p-value (<0.05), estimated using paired t-test.

Furthermore, concerning the spleen, the first measurements of its length, width, thickness, and volume were  $8.95 \pm 0.93$  cm,  $7.74 \pm 0.72$  cm,  $4.05 \pm 0.84$  cm, and  $147.72 \pm 42.21$  ml, respectively. Upon completion of the video training, the aforementioned parameters exhibited a notable rise, reaching  $9.27 \pm 1.10$  cm,  $8.06 \pm 0.64$  cm,  $4.23 \pm 0.63$  cm, and  $166.69 \pm 42.39$  ml, respectively. These measurements, with the exception of splenic thickness, demonstrated considerable enhancements in splenic measurements (Table 3).

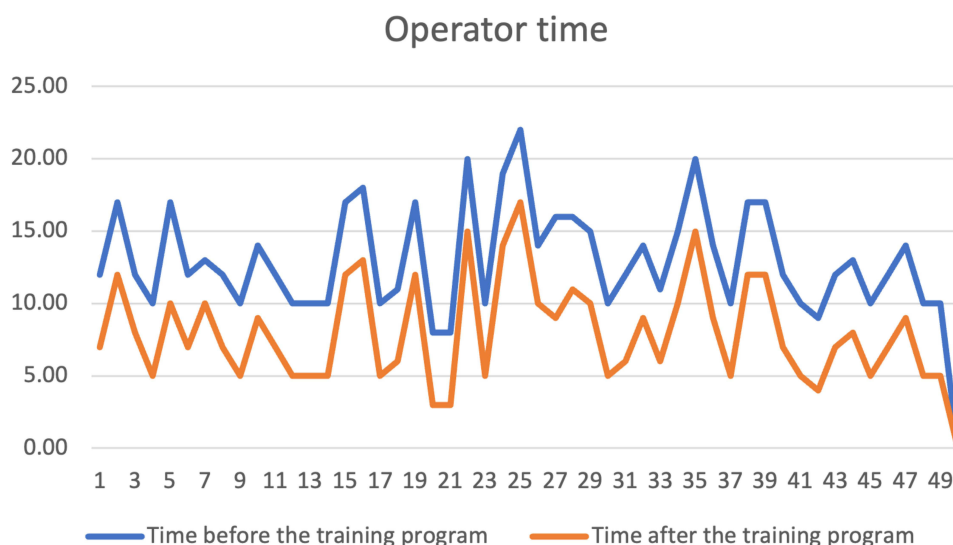
Additionally, the operator time demonstrated a notable decrease from  $13.14 \pm 3.4$  minutes to  $8.1 \pm 3.5$  minutes after the video training intervention (P-value <0.001) with a mean difference of 5.02 minutes (Figure 2).

## Discussion

The diagnostic implications of our study are significant, as they shed light on the potential role of video-based breathing control training in improving the diagnostic accuracy of sonographic assessments of abdominal organs.

The role of breathing training programs for various breathing maneuvers is well-known in clinical practice to aid both the diagnosis and the treatment of various health conditions.<sup>13</sup> Nevertheless, while carrying out a diagnostic test such as a sonographic examination, it may be difficult to ensure that the patient is aware of how to carry out the breathing maneuver.

In this study, we assessed the implementation of a video-based training program as a useful tool to aid sonographic examination. Sonographic abdominal examination showed that both RT kidney and spleen measurements before and after the implementation of the video-based training program were within the normal ranges.<sup>30,31</sup> Otherwise, a statistically significant improvement in the measurements was reported.



**Figure 2** Pre- and post-intervention measurements of operator time.

The observed improvements in organ dimensions following the training program suggest that video-based breathing interventions are superior to the traditional instruction given to the patient; thus, they further enhance the quality and reliability of sonographic images and aid in the diagnosis of various abdominal conditions. This is consistent with the recent literature assessing the utility of video-based training programs in clinical practice; a meta-analysis by Deshpande et al found that video-based tools are effective interventions to improve patient's knowledge in clinical settings.<sup>28</sup> Another meta-analysis by Monteiro et al showed that video-based programs effectively reduce anxiety and the sense of unfamiliarity that challenges the diagnostic procedures.<sup>26</sup> For example, video-based educational materials resulted in a significant reduction in the levels of anxiety among patients undergoing coronary angiography and were associated with patient satisfaction.<sup>27</sup>

Furthermore, the reduction in the amount of time that the operator spent after the intervention indicates the possibility that the training program may expedite the sonographic evaluation process, which could result in diagnoses that are made more quickly and effectively. This efficiency improvement could be especially useful in hectic clinical environments where time limits are common. It would enable medical professionals to do more tests within a specified amount of time without sacrificing the quality of the examinations. Ultimately, this could lead to faster treatment decisions and improved patient outcomes. Overall, the implementation of this training program has the potential to significantly enhance the efficiency and effectiveness of sonographic evaluations in clinical settings.

In general, the results of our research indicate that including breathing control training in sonographic imaging techniques has the potential to enhance diagnostic accuracy and efficiency, which will ultimately be beneficial to patient care. However, additional study is required to validate these findings in patient groups that are larger and more diverse, as well as to investigate the long-term diagnostic consequences of breathing therapies in clinical practice. Further research is needed to fully understand the impact of breathing control training on sonographic evaluations across different patient populations. This will help to determine the broader implications and benefits of incorporating these techniques into clinical settings.

When analyzing the results of the study, it is important to consider the fact that the study has a number of limitations. Because of these constraints, the results may not be applicable to a wider range of situations because the sample size was relatively small and the research was carried out at a single center. The fact that the study only used one arm for the experience and did not include a control group is another factor that undermines the trustworthiness of the conclusion. When conducting future research endeavors, it is essential to address these limitations to improve the reliability and usefulness of the findings in this respective field.

## Conclusion

In conclusion, the findings of our research demonstrate that video-based breathing control training is an effective method for enhancing sonographic quantification of abdominal organs. This is demonstrated by the fact that there were significant improvements in renal and splenic measurements, as well as a notable reduction in the amount of time that the operator wasted after the intervention. According to the results of our research, the incorporation of video-based breathing treatments into sonographic imaging procedures has the potential to improve diagnostic accuracy and efficiency, which would be beneficial to clinical decision-making and patient care in the field of abdominal health. There is a need for additional studies to validate these findings in larger patient groups, which will ultimately optimize the use of video-based breathing therapies in clinical settings for the purpose of improving diagnostic outcomes and patient care.

## Abbreviations

BMI, Body Mass Index; COPD, Chronic Obstructive Pulmonary Disease; IVC, Inferior Vena Cava; MRE, Magnetic Resonance Elastography; RT, Right; SPSS, Statistical Package for the Social Sciences.

## Ethical Considerations

This study was approved by the Institutional Review Board at Princess Nourah bint Abdul Rahman University (PNU), *IRB no. 22-1009*. This study adheres to the ethical principles outlined in the Declaration of Helsinki. The researchers explained the study's procedures to the volunteers, covering the protocols, potential risks, benefits of participation, and

the measures implemented to protect their personal information. Informed consent was obtained from all volunteers before the procedure. To ensure confidentiality, volunteers' data were carefully coded and securely stored.

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## Disclosure

The authors declare no conflicts of interest in this work.

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