Effect of a Breathing Exercise on Respiratory Function and 6-Minute Walking Distance in Patients Under Hemodialysis: A Randomized Controlled Trial

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Abstract

Background: Pulmonary disorders and poor functional capacity are common complications in patients under hemodialysis. Although breathing exercise is frequently prescribed to improve respiratory function, its efficacy in this patient community is not well established.

Purpose: Our study was designed to determine the effectiveness of a breathing exercise on respiratory function and 6-minute walk (6MW) distance in patients under hemodialysis.

Methods: A randomized controlled trial approach was used. The sample consisted of 52 patients under hemodialysis from a university teaching hospital in Iran. The experimental group (n = 26) received the breathing exercise program and was encouraged to perform incentive spirometry for 2 months. The control group (n = 26) received only routine hospital care. The respiratory function test and 6MW test were performed at baseline and at 2 months after the intervention (posttest).

Results: The two groups were homogeneous in terms of respiratory function parameters, 6MW distance, and demographic characteristics at baseline. Forced expiratory volume in 1 second and forced vital capacity were significantly better in the experimental group compared with the control group at 2 months after intervention. No significant difference was found in 6MW distance between the groups at the 2-month posttest.

Conclusions/Implications for Practice: The 2-month breathing exercise effectively improved pulmonary function parameters (forced vital capacity, forced expiratory volume in 1 second) in patients under hemodialysis but did not affect 6MW distance. Hemodialysis nurses should strengthen their clinical health education and apply breathing exercise programs to reduce the pulmonary complications experienced by patients under hemodialysis.

Key Words: hemodialysis, respiratory function tests, breathing exercise, incentive spirometry, six-minute walk test.

Introduction

Chronic kidney disease (CKD), an increasing concern worldwide, is characterized by irreversible destruction of nephrons (De Nicola & Zoccali, 2016; Lin et al., 2013). CKD is a complicated and progressive disorder that affects most important organ systems, including the cardiovascular, musculoskeletal, metabolic, and respiratory systems (Webster et al., 2017). Pulmonary complications are important and prevalent disorders in patients with CKD, with prominent complications including pleural effusion, pulmonary edema, pulmonary hypertension, and acute respiratory distress syndrome (Hsieh et al., 2016; Palamidas et al., 2014). Hemodialysis is the most common method used to treat kidney failure in patients with CKD (de Almeida et al., 2019). Although hemodialysis reduces some CKD complications, impaired pulmonary function is a prevalent complication that leads to severe problems in patients under hemodialysis (Cho et al., 2018; Unal et al., 2010). Pulmonary disorders in these patients may be the result of fluid overload, high blood pressure, permeability of the capillaries, or circulating uremic toxins (Yılmaz et al., 2016). Respiratory disorders are common complications among Iranian patients under hemodialysis, and a high prevalence of pulmonary hypertension has been shown in this population (Mousavi et al., 2008). Breathing exercises are frequently a
and forced expiratory volume in 1 second (FEV1) values at 6MW distance in patients under hemodialysis. Therefore, this study was designed to determine the effectiveness of a breathing exercise on respiratory function and physical performance and provides valuable information about physical performance and response to therapy in cases of chronic cardiopulmonary disease such as chronic pulmonary hypertension (Ghofraniha et al., 2015). Therefore, this study was designed to determine the effectiveness of a breathing exercise on respiratory function and 6MW distance in patients under hemodialysis.

**Methods**

**Design**

This study used a randomized, nonblinded controlled trial approach with two groups (experimental and control).

**Setting and Participant**

This study was conducted at Shahid Hasheminejad Kidney Center, which is the national referral center for urology and nephrology in Iran. The participants were patients undergoing hemodialysis in the dialysis ward. Data were collected from November 2018 to March 2019. Study inclusion criteria included (a) ≥18 years old; (b) forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) values at least 15% below the normal ranges, based on age and height; (c) having normal thoracic and vertebral column and legs; (d) being able to perform the breathing exercise and the 6MW test; (e) currently receiving hemodialysis three times a week; and (f) under hemodialysis for at least 6 months. Otherwise eligible patients were excluded from this study if they had an acute respiratory disease or respiratory infections during the study period or if they were unable or unwilling to participate.

**Sampling**

This study followed a similar study (Haeffener et al., 2008) in targeting 99% power and 95% confidence interval and aiming to find a minimum 4% difference in FVC and FEV1 among the two groups. Thus, a minimum of 17 patients was required in each group. Fifty-two patients (26 per group) participated in the study, accounting for a possible sample loss up to 50%.

One hundred eighty patients visited the target hospital for hemodialysis three times per week. Of these, 87 visited the hospital on even-numbered days of the week, and 93 visited the hospital on odd-numbered days of the week. Cluster randomization was initially advocated to minimize treatment contamination between the two groups. Days of the week were randomly assigned to the experimental (even-numbered days) and control (odd-numbered days) arms by flipping a coin. Subsequently, 87 patients in the even-day pool and 93 patients in the odd-day pool were assessed for eligibility. Thirty-four and 32 patients, respectively, in the two pools failed to meet the inclusion criteria and were excluded from the randomization list. Finally, 26 eligible patients in each cluster (n = 53 in the experimental arm and n = 61 in the control arm) were assigned randomly to the study by a random number generator application. All 52 patients (26 per group) completed the study program, and all completed the posttest questionnaire at 2 months after program completion (Figure 1).

**Intervention**

The experimental group received the breathing exercise program in addition to routine hospital care. The breathing exercise program included use of the IS device. The experimental group participants were instructed in how to use the IS and were asked to (a) “hold the IS in an upright position”; (b) “put the mouthpiece spirometer in your mouth”; (c) “after quiet expiration, inhale deeply and slowly”; (d) “hold your breath for as long as possible and then exhale normally”; and (e) “repeat each of these steps 10 times every hour after you wake up for a period of 2 months.” The researcher provided each patient with one IS device and an associated pictorial educational booklet. All of the IS devices used in this study were similar and of the same brand. Compliance with the breathing exercise was assessed through telephone calls every week. All of the participants in the experimental group adhered to the breathing exercise program, and no complaints were reported by these participants regarding using the IS device. The remaining 26 patients (control group) received only routine hospital care, which included connecting the patient to the hemodialysis machine, performing weight control, and providing education on fluid imbalance, hypertension, nutritional diet, and the prevention of hemodialysis complications such as muscle cramps and peripheral edema.

**Outcome Measures**

Respiratory function parameters and 6MW distance, assessed using the FVC and FEV1 test and the 6MW test, were the primary end point measures used in this study. The respiratory function tests, including the FVC, FEV1, and 6MW tests, were performed in both groups at baseline as well as 2
months after study enrollment. One standard spirometer model (model: Flowhandy ZAN Type 3.1) was used during the study. The reliability of this spirometer was assessed using the test–retest method. To assess reliability, the respiratory function test was measured in 15 subjects twice within 5 minutes under the same conditions. The obtained correlation coefficient was 95%.

The 6MW test was performed in accordance with the comprehensive guidelines developed by the American Thoracic Society (ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002). All of the participants performed the 6MW test along a 30-meter-long, flat and comfortable surface in the hospital (marked with meter tacks). They were instructed to (a) wear comfortable shoes and clothes, (b) rest for 10 minutes before doing the test (during which time heart rate and blood pressure were measured and potential contraindications were assessed by the researcher), and (c) walk for 6 minutes. All necessary information was given to the participants, including walking speed, stop time, and advice regarding potential adverse feelings such as fatigue, cramps, chest pain, and dyspnea. The supervisor used standard phrases of encouragement (e.g., you are doing fine) recommended by the American Thoracic Society.

**Data Analysis**

The SPSS Version 16.0 (SPSS, Inc., Chicago, IL, USA) was used to examine the data. Descriptive statistics such as mean, standard deviation, and percentage were used to describe the baseline characteristics of the patients. Statistical analyses to identify the differences among the groups included unpaired t tests and chi-square test.

**Ethical Approval**

The ethical research committee of Tehran University of Medical Sciences reviewed and approved this study (approval number: 91-02-28-18230), and the study was registered in the Iranian Registry of Clinical Trials under Registration Code IRCT2012080522226N10. All of the participants provided informed consent and were assured that their participation was voluntary and that their data would be anonymized and kept confidential. Furthermore, the participants were informed that they could withdraw from the study at any time without any negative impact to their regular treatment.

**Results**

Experimental and control group demographic characteristics are compared in Table 1. This study found no significant differences in baseline characteristics between the groups. Most of the participants in both groups were middle-aged women. No significant intergroup differences were found in terms of gender ($p = .57$), age ($p = .08$), weight ($p = .68$), or time since diagnosis ($p = .59$).

Respiratory function tests and 6MW distance were compared between the two groups at baseline, with results
shown in Table 2. No significant intergroup difference was found at baseline in terms of FEV1 ($p = .54$), FVC ($p = .33$), and 6MW distance ($p = .68$). At the 2-month posttest, the experimental group earned significantly better values in terms of FEV1 ($p = .02$) and FVC ($p = .04$) than the control group. However, no significant intergroup difference was found in terms of 6MW distance at the 2-month posttest ($p = .43$; Table 2).

**Discussion**

This study investigated the efficacy of a breathing exercise on respiratory function and 6MW distance in patients under hemodialysis. Although the use of IS as a breathing exercise has increased in recent years and IS is now frequently prescribed to improve respiratory function, there is limited evidence supporting its benefits. Moreover, no clear evidence establishing the effectiveness of IS in improving respiratory function and functional capacity in patients under hemodialysis has been published (Eltorai et al., 2018).

In this study of patients under hemodialysis, the data analysis showed a positive effect of using IS on respiratory function test results (FVC, FEV1). These findings are congruent with the finding of a previous study that practicing a breathing exercise with IS (IS training for 2 months, three sessions per week) improved diaphragmatic excursion in patients under hemodialysis (Mansour et al., 2018). In addition, a systematic review showed that inspiratory muscle training with a load ranging from 30% to 60% of the maximal inspiratory pressure and lasting from 2 to 6 months has the potential to improve respiratory muscle strength, functional capacity, and lung function in patients with CKD (de Medeiros et al., 2017). Despite the above, some studies have recommended against adding IS to the common standard of treatment (Tyson et al., 2015). Martin et al. cited patients’ nonadherence to IS protocols as an important factor behind patients failing to achieve the positive effect of IS. They mentioned that patient perspectives on the potential benefits of IS, multimedia patient education, and previous use of the device may improve the rate of correct IS usage and increase compliance during IS implementation (Martin et al., 2018). Analysis of a systematic review study (Narayanan et al., 2016) revealed an inconsistency in the evidence related to IS compliance. Therefore, comprehensive research in these areas is needed to help obtain valid inferences regarding the effectiveness of using IS.

**Table 1**

*Baseline Characteristics of the Research Sample*

| Parameter          | Experimental Group ($n = 26$) | Control Group ($n = 26$) |
|--------------------|-----------------------------|--------------------------|
|                    | $n$ (%)                     | $M$  | $SD$ | $n$ (%)| $M$  | $SD$ | $\chi^2/t$ | $p$ |
| Gender             |                             |                 |       |       |       |       |           |     |
| Male               | 12 (46.2)                   | 45.76 | 2.11 | 10 (38.5) | 48.12 | 3.01 | 1.76 | .08 |
| Female             | 14 (53.8)                   | 46.24 | 2.11 | 16 (61.5) | 48.76 | 2.96 | 4.03 | .68 |
| Age (years)        |                             | 45.76 | 2.11 | 48.12 | 3.01 | 0.63 | .59 |
| Weight (kg)        |                             | 67.65 | 3.17 | 70.14 | 2.96 | 3.08 | .03* |
| Height (cm)        |                             | 165.00 | 1.89 | 168.00 | 4.78 | 0.67 | .59 |

**Table 2**

*Comparison of Outcomes Between the Experimental and Control Groups at Baseline and at 2 Months After the Intervention (Posttest)*

| Time                | Experimental Group ($n = 26$) | Control Group ($n = 26$) |
|---------------------|------------------------------|--------------------------|
|                     | $M$  | $SD$ | $M$  | $SD$ | $t$  | $p$   |
| Baseline            |      |      |      |      |      |     |
| FEV1 (L)            | 2.12 | 0.54 | 2.04 | 0.39 | 0.60 | .54  |
| FVC (L)             | 2.81 | 0.58 | 2.66 | 0.53 | 0.97 | .33  |
| 6MW distance (meters) | 349.00 | 57.55 | 359.88 | 65.04 | −0.63 | .68  |
| 2 months after intervention |      |      |      |      |      |     |
| FEV1 (L)            | 2.31 | 0.48 | 2.03 | 0.40 | 2.28 | .03* |
| FVC (L)             | 2.98 | 0.61 | 2.66 | 0.53 | 2.04 | .05* |
| 6MW distance (meters) | 359.65 | 54.75 | 360.65 | 67.26 | −0.05 | .43  |

*Note. FEV1 = forced expiratory volume in 1 second; FVC = forced vital capacity; MW = minute walk; L = liters.

*p < .05.*
Respiratory disorders are a leading cause of poor exercise capacities in patients under hemodialysis, with these patients experiencing significantly poorer exercise capacities, as evaluated using the 6MW test, than healthy adults (Bučar Pajek et al., 2016; Watanabe et al., 2016). This study was designed to investigate the effect of a breathing exercise on 6MW distance in patients under hemodialysis. Although the mean walking distance of the experimental group had improved by about 10 meters at the 2-month posttest, no significant difference was found between the two groups at the 2-month posttest. The results of this study echo the findings of Aliasgharpour and Hadiyan (2011), which showed that, although the 6MW distance of patients under hemodialysis in the intervention group increased after doing the exercise, the increase did not result in a statistically significant posttest difference between the intervention and control groups. Contrary to our results, Silva et al. (2011) found that inspiratory muscle training for 2 months significantly increased 6MW distance scores in patients under hemodialysis but did not affect pulmonary function.

In addition to respiratory complications, other factors such as uremic myopathy, anemia, and malnutrition are known to affect the results of the 6MW distance test in patients under hemodialysis. The breathing exercise program did not affect these factors, which may be a reason why the participants in this study exhibited effectively improved pulmonary function parameters but no significant change in 6MW distance.

A review of related articles found inconsistent evidence regarding a positive effect for breathing exercises on functional capacity and endurance as measured using the 6MW test in patients. Further prospective studies should be conducted to evaluate the use of IS in this context and to compare results with respiratory physical therapeutic techniques and other respiratory devices.

Research Limitations
During this study, patient follow-up was conducted by telephone call only (no home visits). To remedy this limitation, this intervention should be repeated using home visits, observational follow-up, or hourly, audible reminders for IS implementation.

Conclusions/Implication for Practice
The findings of the study showed that the use of IS improves pulmonary function parameters (FVC, FEV1) and does not significantly change 6MW distance. An IS is a convenient and inexpensive breathing exercise device that may easily be used by patients under hemodialysis to improve their respiratory functions.

Hemodialysis nurses spend far more time with patients than other healthcare workers and are responsible for teaching patients about preventing and managing hemodialysis complications. Therefore, teaching breathing exercises to patients under hemodialysis as a safe way to reduce pulmonary complications may play an important role in improving pulmonary outcomes in these patients.

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Author Contributions
Study conception and design: SM, MA, TA. Data collection: SM, TA. Data analysis and interpretation: AK, NM. Drafting of the article: SM, TA, NM, AK. Critical revision of the article: SM, TA, NM.

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