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Deep Breathing Exercise and Active Range of Motion Influence Physiological Response of Congestive Heart Failure Patients

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ABSTRACT

Background: Dyspnea and physiological changes are clinical manifestations of Congestive Heart Failure (CHF) due to respiratory failure. Deep breathing exercise combined with active range of motion increases respiratory muscles and blood circulation. As a result, it reduces breathing effort and decreases blood pressure.
Purpose: This research aimed to analyze the influence of deep breathing exercise and active range of motion (ROM) on the physiological response of CHF patients.
Methods: This study used a quasi-experiment with pretest-posttest control group design recruiting 32 respondents by stratified random sampling technique. The intervention was done three times a day for three days. Deep breathing exercise for thirty times and continued with active range of motion for five times each movement. Digital sphygmomanometer and digital watch were used as measuring instruments. Data were analyzed using independent and paired t-tests.
Result: The results showed that there were significant differences in the systole (p=0.000), diastole (p=0.000) and respiratory rates (p=0.003) after the intervention compared to the control group. There was also a significant difference in systolic blood pressure between the intervention and the control group (p=0.003). However, no significant difference in diastole and respiratory rates was found.
Conclusion: Deep breathing exercise combined with active range of motion decreases the systole in CHF patients. Further research is expected to lengthen the time of intervention to allow better significance.

Keywords: Active range of motion; CHF; deep breathing exercise; physiological response

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BACKGROUND

Heart and blood vessel diseases are one of the major health problems in both developed and developing countries. This disease is the first leading cause of death in the world, and the prevalence is estimated to continually increase up to 23.3 million in 2030 (Ministry of Health Republic of Indonesia [MoHRI], 2014; Yancy et al., 2013). Similar phenomena also occur in Indonesia. The result of Basic Health Research (*Riskesdas*) by the Ministry of Health, Republic of Indonesia in 2013 reported that the prevalence of heart failure in Indonesia reached 0.3% (MoHRI, 2013). The highest prevalence in Java island occurs in Yogyakarta Province, with the percentage of 0.25 % (MoHRI, 2014). The increasing prevalence will cause problems for diseases, disabilities, and socio-economic problems for family, communities, and the state (MoHRI, 2014; Ziaeian & Fonarow, 2016). Therefore, comprehensive management for heart failure, especially symptom management, needs to be addressed.

Dyspnea is a hallmark symptom of Congestive Heart Failure (CHF). Dyspnea impairs functional capacity and quality of life. Dyspnea caused by ventricular dysfunction causes decreased cardiac output and increased pulmonary venous pressure resulting in pulmonary congestion. This ultimately leads to extravasation of fluid into the interstitial space and lung alveoli, which reduces pulmonary compliance and impairs the ease of breathing. Patients who have the NYHA functional class of III-IV will be having high levels of dyspnea complaints (Kupper, Bonhof, Westerhuis, Widdershoven & Denollet, 2016). Patients with NYHA IV will be panting every day, even during mild activity or at rest. This is because dyspnea affects the decrease in tissue oxygenation and energy production, so that patient’s daily activity will also decrease, which can lower the quality of patients’ life (Sepdianto & Maria, 2013). The pharmacological management provided for these patients includes cardiac glycoside, diuretic therapy, and vasodilator therapy (Shah, Gandhi, Srivastava, Shah, & Mansukhani, 2017). However, studies in the form of systematic review and meta-analysis revealed that heart failure rehabilitation is recommended for low and moderate risk of heart failure (NYHA II and III) (Sagar et al., 2015).

Cardiac rehabilitation can be useful in clinically stable patients with heart failure (Yancy et al., 2013). The American Heart Association recommends physical exercise to be performed in patients with stable CHF. Physical exercise is done 20-30 minutes with a frequency of 3-5 times each week. Before beginning physical exercise, patients with CHF require a comprehensive assessment of risk stratification and are recommended to rest due to fatigue. This exercise is one of the hospitalized exercises (inpatient) that can be performed to the patients with NYHA II and III. Gradual activity management in such patients is a mild and regular physical activity so that peripheral blood circulation and tissue perfusion conditions can be improved (Adsett, Hons & Robbie, 2010; Alvarez, Hannawi & Guha, 2016). Moreover, giving position and breathing exercises can be done to reduce effort and improve respiratory muscle function. Tolerable exercise can be managed to improve tissue perfusion and facilitate circulation. Exercise training or regular physical activity is recommended as safe and effective for patients with heart failure (Yancy et al., 2013).

Breathing exercise is an exercise to improve breathing and functional performance (Cahalin & Arena, 2015). One of the breathing exercises that can be done is a deep breathing exercise, a nursing activity, that serves to increase the function of respiratory muscles resulting in ventilation and oxygenation improvement (Bulechek, Butcher, Dochterman, & Wagner, 2013; Herdman, Kamitsuru, & North American Nursing Diagnosis Association, 2014; Kupper et al., 2016). Sepdianto and Maria (2013), in their study, reported that breathing exercise in patients with heart failure for 15 minutes as many as three times a day within 14 days reduces dyspnea. A systematic review of 27 studies also showed that physical exercise could increase oxygen saturation and quality of life of patients with heart failure (Jewiss, Ostman, & Smart, 2016). Therefore, it is important to conduct a study to examine the influence of breathing exercise and active range of motion in CHF patients.

The use of deep breathing exercises and active range of motion as a nursing intervention in CHF patients has not been widely studied in Indonesia. There are no studies that combine the two interventions. This encourages researchers to study the effect of deep breathing exercise and active range of motion on dyspnea in CHF patients.

PURPOSE

This research aimed to examine the effect of deep breathing exercises combined with an active range of motion on physiological response in CHF patients.

METHODS

Research design and samples

The study used a pretest-posttest quasi-experimental research design with a control group, and was conducted in two hospitals in Yogyakarta, Indonesia. A stratified random sampling method was utilized to recruit the samples of NYHA II and III CHF patients who met the inclusion criteria, which were stable hemodynamic status, no weakness in both extremities, more than 17 years old, and receiving the same pharmacological treatment. Whereas, the exclusion criteria included the patients with neuro-musculoskeletal, severe systemic, mental and communication disorders, and respiratory diseases. As many as thirty-two respondents who met the inclusion and exclusion criteria were recruited. They were then divided into the equally same number between the intervention and control groups.

Research instrument and data collection

The instruments used in this study were digital sphygmomanometer and digital watch to measure blood pressure and respiratory rate. Pre-test and post-test on both groups were conducted in the first and third days, respectively. All respondents in both groups were measured their blood pressure and respiratory rates. The pre-test measurements were performed 15 minutes before the intervention began, while the post-tests were done 15 minutes after the intervention ended. Interventions were initiated after 48 hours of hospital admission. The intervention was started by deep breathing exercises for 30 times, followed by an active range of motion gradually on the hands, legs, hips, and knees with each movement performed for five times. This intervention was done three times a day for three days. On the other hand, the control group obtained standard intervention, which was a semi-fowler position.

Data analysis

A paired t-test was used to analyze the mean difference before and after the intervention, while an independent t-test was used to compare the mean differences between the intervention and the control groups.

Ethical consideration

Prior to the study, all respondents expressing agreement to participate in the study were informed of the objectives, benefits, and procedures of the research. They were also requested to sign informed consent. In terms of the privacy and confidentiality of respondents, providing training fairly, benefits, and avoiding dangerous actions were ensured during the study. This research had been reviewed and obtained ethical permission from the ethics and research committee in the Faculty of Medicine, Diponegoro University, Semarang, Indonesia, with the number of ethical approval of 202/EC/FK-RSDK/IV/2017.

RESULTS

Characteristics of respondents

The results of the study showed that more than half of the respondents in the intervention and the control group were women and aged more than 60 years. A majority of the respondents in both groups had common co-morbidities, which were hypertension. The proportion of respondents who had NYHA II was the same as NYHA III in both groups (50%), while most respondents in both groups obtained diuretic drugs (Table 1).

Table 1. Characteristics of respondents (n=32)

Characteristic	Intervention	Control	Total	*p*
	f (%)	f (%)	*f* (%)	
Age				
18 – 45 years old	2 (12.5)	2 (12.5)	4 (12.5)	
46 – 60 years old	3 (18.8)	6 (37.5)	9 (28.1)	0.132*
> 60 years old	11 (68.7)	8 (50.0)	19 (59.4)	
Gender				
Man	7 (43.8)	7 (43.8)	14 (43.8)	0.341**
Woman	9 (56.2)	9 (56.2)	18 (56.2)	
Co-morbidities				
Hypertension	10 (62.4)	7 (43.7)	17 (53.1)	
Diabetes mellitus	3 (18.7)	4 (25.0)	7 (21.9)	
Kidney failure	1 (6.3)	3 (18.7)	4 (12.6)	0.333*
Anemia	1 (6.3)	1 (6.3)	2 (6.2)	
Gastritis	1 (6.3)	1 (6.3)	2 (6.2)	
NYHA class				
NYHA II	8 (50.0)	8 (50.0)	8 (50)	1.000**
NYHA III	8 (50.0)	8 (50.0)	8 (50)	
Pharmacological therapy				
Diuretic	6 (37.5)	8 (50.0)	14 (43.7)	
Vasodilator	3 (18.8)	5 (31.3)	8 (25.0)	0.242*
Diuretic and vasodilator	7 (43.8)	3 (18.8)	10 (31.3)	

*Mann-Whitney Test **Chi-Square

Effects of deep breathing exercise and active range of motion on blood pressure in CHF patients

The analyses of the effects of deep breathing exercise and active range of motion on physiological responses, including systole and diastole in the intervention group and control group, were shown in Table 2 and Table 3. There was a higher decrease in the mean of systole and diastole after the intervention compared to the control group. There were also significant differences in the systole (*p*=0.000) and diastole (*p*=0.000) in the intervention group (Table 2).

Table 2. Differences in blood pressure of CHF patients (n=32)

Blood pressure	Control Group			Intervention Group		
	Mean±SD	t	*p*	Mean±SD	t	*p*
Systole						
Pre-test	128.31±25.34	1.877	0.080*	128.25±16.97	6.483	0.000*
Post-test	123.00±33.31			110.19±16.46		
Diastole						
Pre-test	74.88±20.14	1.338	0.201*	73.50±10.49	4.748	0.000*
Post-test	70.44±16.57			65.03±10.27		

*paired t-test

As seen in Table 3, there was a significant difference in the mean difference of systolic blood pressure between the intervention and the control group (*p*=0.003). However, the mean difference of diastole was not significantly different between the groups (*p*=0.296). It meant that deep breathing exercises combined with active range of motion decreased the systole, yet the diastole compared with the hospital standard care.

Table 3. Effects of deep breathing exercise and active range of motion on blood pressure of CHF patients (n=32)

Blood pressure	Intervention Group	Control Group		
	Mean±SD	Mean±SD	*t*	*p*
Systole				
Pre-test – Post-test	18.06±11.14	5.31±11.32	3.210	0.003*
Diastole				
Pre-test – Post-test	8.44±7.11	4.44±13.26	1.063	0.296*

*independent t-test

Effects of deep breathing exercise and active range of motion on respiratory rate in CHF patients

The analyses of the effect of deep breathing exercise and active range of motion on the respiratory rate of CHF patients in the intervention group and control group can be seen in Table 4 and Table 5. Table 4 shows that respiratory rates in the intervention group decreased significantly (*p*=0.003) compared to the control group (*p*=0.417).

Table 4. Differences in respiratory rates of CHF patients (n=32)

Respiratory Rate	Control Group			Intervention Group		
	Mean±SD	*t*	*p*	Mean±SD	*t*	*p*
Pre-test	27.00±2.31	0.835	0.417	25.44±3.14	3.503	0.003*
Post-test	26.00±3.72			22.44±1.36		

*paired t-test

The decrease in respiratory rates in the intervention group (3.00±3.43) was higher than the control group (1.00±4.79). However, there was no significant difference in the respiratory rates between the intervention and the control group (*p*=0.184). This meant that deep breathing exercises and active range of motion were less effective at reducing respiratory rates than the hospital-based interventions (Table 5).

Table 5. Effect of deep breathing exercise and active range of motion on the respiratory rate in CHF patients (n=32)

Respiratory rates	Intervention Group	Control Group		
	Mean±SD	Mean±SD	*t*	*p*
Pre-test – Post-test	3.00±3.43	1.00±4.79	1.359	0.184*

*independent t-test

DISCUSSION

Effects of deep breathing exercise and active range of motion interventions on physiological response: Blood pressure in CHF patients

The results of this study showed that deep breathing exercises and active range of motion significantly decreased the systole, but the diastole compared to the standard care from the hospital. The results of previous studies also showed similar results that breathing exercises were able to reduce systolic blood pressure by 3 mmHg (*p*=0.021) and diastolic pressure by 6.2 mmHg (*p*=0.000) in patients with heart failure within 14 days (Sepdianto & Maria, 2013). Another research also revealed that three-week breath exercises were capable of decreasing systolic 5.9±0.8 (*p*<0.001) and diastolic 1.4±0.8 (*p*<0.005) (Lee et al., 2003). A study conducted by Joseph et al. (2005) also showed that controlled breathing decreased systolic and diastolic from 149.77±3.7 to 141.1±4 mm Hg (*p*<0.05) and from 82.7±3 to 77.8±3.7 mm Hg (*p*<0.01). Futhermore, Jewiss et al. (2016) also pointed out that physical exercise could increase oxygen saturation and quality of life of patients with heart failure.

Deep breathing exercises in patients with heart failure can improve cardiac autonomic regulation and decrease the sensitivity of chemoreceptors. This exercise will increase left ventricular ejection fraction, decrease pulmonary pressure, and decrease pulmonary edema. This may be due to an increased ventilator mechanism due to the regulation or modulation of cardiopulmonary reflex (Parati et al., 2008). In addition, a range of motion is a physical exercise that can affect blood pressure because the efficiency of the heart or the ability of the heart will increase in accordance with the changes that occur in the form of heart frequency, stroke contents, and bulk heart. Regular physical exercise is done 3-5 times a week with a long exercise of 20-60 minutes once exercise, and it can lower blood pressure. The decrease in blood pressure, among others, occurs because the blood vessels undergo dilation and relaxation (Arovah, 2010; Badriyah, Kadarsih, & Yogyakarta, 2014). The finding showed that there was no significant difference in the diastole between the intervention and the control group. This insignificant difference might due to the small sample size.

Effects of deep breathing exercise and active range of motion interventions on physiological response: Respiratory rate in CHF patients

The result shows that deep breathing exercises and active range of motion decreased respiratory rates, although the decrease was not statistically significant compared to the control group. This was consistent with previous studies. A study showed that breathing exercise could decrease the frequency of breath (p<0.001) (Sepdianto & Maria, 2013). Joseph et al. (2005) also reported that controlled breathing decreases respiratory rates with p <0.05.

Respiratory exercises are performed to improve ventilation and oxygenation. Increased lung compliance during respiratory exercise may cause the amount of air entering the lungs to increase, resulting in lower respiratory frequency. Needs of oxygen are met then the tolerance to the activity will increase. Decreased frequency of breathing after intervention proves that there is an improvement in respiratory function. Breathing exercises can optimize lung development and minimize the use of respiratory muscle. By doing regular breathing exercises, the respiratory function will improve. It was found to be optimal for improving alveolar ventilation in terms of increased arterial oxygen saturation and ease and sustainability in terms of respiratory effort (Russo, Santarelli, & O'Rourke, 2017).

Slow respiration in healthy humans reduces the chemoreflex response to hypercapnia and hypoxia. Deep breathing can improve lung development capability and affect perfusion and diffusion functions so that the oxygen supply to the tissues is adequate. Lower pressure on the intrathorac will cause air to flow from the more atmospheric pressure high entry into the lungs that have lower pressure as a gas exchange process or lung ventilation (Cahalin & Arena, 2105).

Moreover, physical exercise will affect oxygen consumption and carbon dioxide production. A large amount of oxygen will diffuse from the alveoli into the venous blood back to the lungs. Conversely, the same levels of carbon dioxide enter from the blood into the alveoli (Jewiss et al., 2016). Thus, ventilation will increase to maintain appropriate alveolar gas concentrations to allow for increased exchange of oxygen and carbon dioxide. As the exercise progresses, increased metabolic processes in the muscle produce more heat, carbon dioxide, and hydrogen ions. This whole factor increases the oxygen utilization in the muscle, which increases arterial oxygen as well. This results in more carbon dioxide entering the blood, increasing the levels of carbon dioxide and hydrogen ions in the blood. Chemoreceptor stimulates the inspiratory center resulting in increased breathing and depth. Some researchers have suggested that chemoreceptor in the muscle may also be involved that is by increasing ventilation by increasing tidal volume. However, after the resting phase, the need for oxygen in the blood will be fulfilled to lower the frequency of breathing (Nagaya, Hayashi, Fujimoto, Maruoka, & Kobayashi, 2015).

The result of the study showed an insignificant decrease in the respiratory rates between the intervention and the control group. This might occur due to the short duration of the intervention time and the affecting factors which could not be totally controlled. Despite the limitations, this study could show the evidence that deep breathing exercises and active range of motion decreased the systole, diastole, and respiratory rates.

CONCLUSION

The study found that deep breathing exercises and active range of motion reduced the systole, diastole, and respiratory rates. However, the reduction in the systole was the only statistically significant finding compared to the diastole and respiratory rates. Although there was no significant difference in diastole and respiratory rates between the intervention and the control group, the intervention group showed better value than the control group. Further research on the effects of deep breathing exercise and active range of motion is recommended to conduct by extending the intervention time and utilizing a larger sample size.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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