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The impact of diaphragmatic breathing exercises combined with facial cold stimulation on dyspnea perception, respiratory rate, and peak expiratory flow in COPD patients

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Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) represents a significant global health burden, contributing substantially to long-term morbidity and mortality rates worldwide.

Purpose: To evaluate the effectiveness of diaphragmatic breathing exercises combined with facial cold stimulation on dyspnea perception, respiratory rate, and peak expiratory flow in COPD patients.

Method: A quasi-experimental study was conducted using a pre-test and post-test control group design, involving 46 participants divided into intervention and control groups. Data collection tools included questionnaires, respiratory rate observations, and a peak flow meter. For data analysis, inferential statistics were applied: the Independent t-test and Paired t-test were used for normally distributed ratio data, while the Wilcoxon Signed Ranks Test and Mann-Whitney U Test were employed for ordinal data.

Results: The combination of diaphragm breathing exercises and cold facial stimulation significantly reduces dyspnea perception in COPD patients. This intervention was also found to be effective in lowering the respiratory rate of COPD patients. Additionally, the results revealed a significant improvement in Peak Expiratory Flow Rate (PEFR) in the intervention group compared to the control group.

Conclusion: Peak Expiratory Flow Rate (PEFR) significantly improved in the intervention group compared to the control group, indicating the combined intervention's efficacy in enhancing respiratory function in COPD patients.

Keyword: Cold Stimulation Over the Face; Diaphragm Breathing Exercise; Dyspnea Perception; Peak Expiratory Flow Rate; Respiratory Rate.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a major global health challenge contributing to chronic morbidity and mortality worldwide (Gao, Wang, & Jiang, 2024). Increased dyspnea, respiratory rate, and low peak expiratory flow rate (PEFR) are the main problems in COPD (Romer & Polkey, 2018). COPD is a respiratory disorder characterized by progressive airflow limitation due to airway obstruction. This obstruction occurs in the peripheral airways, air volume can be trapped in the lungs, a condition known as hyperinflation (Borge, Hagen, Mengshoel, Omenaas, Moum, & Wahl, 2014). The main indicator of airflow limitation is a

decrease in the forced expiratory volume in one second (FEV1) ratio. Decreased FEV1 is a hallmark in patients with COPD. PEFR measurement using a peak flow meter correlates with and is equivalent to FEV1 (Chatterjee & Mukherjee, 2020).

COPD was the third leading cause of death in 2020, with approximately 3 million deaths due to COPD in 2017, accounting for approximately 6% of all deaths worldwide that year. In Indonesia, COPD ranks fifth as a cause of death, with approximately 4.8 million people affected (Black & Hawks, 2022). The prevalence of COPD was 3.7%, while in Aceh the prevalence was 2.9%. Data from H. Sahudin

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Hospital revealed a rising trend in COPD cases, with 764 patients recorded in 2019, increasing to 1,237 in 2020, and slightly decreasing to 1,076 in 2021. Between January and September 2022 alone, 1,273 cases were reported, establishing COPD as the second most prevalent lung disease after tuberculosis. (Hopkins, Dominelli, Davis, Guenette, Luks, Molgat-Seon, & Stickland, 2021).

A peak expiratory flow assessment carried out at the Lingkar Timur Health Center in Bengkulu City in February 2021 involving 21 individuals revealed that 90.47% exhibited severe airway obstruction, with peak expiratory flow values ranging from 50 to 300 L/min. The remaining 9.53% showed moderate obstruction, with values between 300 and 600 L/min (Anzueto & Miravittles, 2017). A preliminary study conducted by researchers on May 20, 2023 involving 10 COPD patients found that all patients reported complaints of shortness of breath. So far, patients have only relied on pharmacological therapy prescribed by doctors. Diaphragmatic breathing exercises can increase abdominal movement during natural breathing, thereby increasing functional capacity (Knudson, Slatin, Lebowitz, & Burrows, 2016). Diaphragmatic breathing exercises strengthen the diaphragm muscle, which is the main respiratory muscle and serves as the lower boundary of the thorax. Contraction of the diaphragm pulls the muscle downward, increasing the thoracic space, and actively expanding the lungs (Booth, Galbraith, Ryan, Parker, & Johnson, 2016).

A study conducted in China on the use of electric fans to alleviate dyspnea in terminal cancer patients found that exposure to cold air from a fan effectively reduced dyspnea symptoms, suggesting its potential as a non-pharmacological intervention (Jesse & Alligood, 2014). However, current research remains inconclusive regarding the effectiveness of combining diaphragmatic breathing exercises with

cold facial stimulation in reducing the perception of dyspnea and enhancing Peak Expiratory Flow Rate (PEFR) in patients with COPD.

RESEARCH METHOD

A quasi-experimental study employing a pre-test and post-test control group design was conducted in the pulmonary isolation unit at the Pulmonary Clinic of RSUD H. Sahudin Kutacane from May to June 2025. The study involved 46 patients with Chronic Obstructive Pulmonary Disease (COPD), who were selected through purposive sampling and divided equally into intervention and control groups, with 23 participants in each. Both groups underwent pre-test measurements, after which the intervention group received diaphragm breathing exercises combined with cold stimulation over the face. This intervention was administered individually in each patient's room for 15-20 minutes, twice daily (morning and evening). The control group received standard pharmacological treatment without additional interventions. Post-tests were conducted to assess the impact of the intervention.

The study was guided by Roy's Adaptation Model, which conceptualizes the adaptation process through components of input (stimulus), process, effectors, and output. In this context, the diaphragm breathing exercise combined with cold facial stimulation functioned as the stimulus to facilitate adaptation and reduce the perception of dyspnea.

For data analysis, inferential statistical methods were employed. The Independent t-test and Paired t-test were used for normally distributed ratio data, while the Wilcoxon Signed Ranks Test and Mann-Whitney U Test were applied to ordinal data. Ethical approval for this study was granted by the Ethics Committee of Strada University Indonesia, with approval number 0223480/EC/KEPK/II/03/2025.

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RESEARCH RESULTS

Table 1. Characteristics of the Participants (N=46)

Variable	Control Group (n=23)	Intervention Group (n=23)
Age (Mean±SD)(Range)(Year)	(46.5±15.5)(31-65)	(46.0±15.0)(31-65)
31-40	3/13.1	7/30.4
41-50	7/30.4	3/13.1
51-60	6/26.1	7/30.4
≥60	7/30.4	6/26.1
Gender (n/%)		
Male	17/73.9	17/73.9
Female	6/26.1	6/26.1
Education (n/%)		
Elementary School	0/0.0	2/8.7
Junior High School	3/13.0	5/21.7
Senior High School	10/43.5	7/30.4
College/University	10/43.5	9/39.2
Employment (n/%)		
State-Owned Enterprise Employee	1/4.3	0/0.0
Civil servant	2/8.7	0/0.0
Teacher	1/4.3	4/17.4
Seller	4/17.4	4/17.4
Self-employed	4/17.4	5/21.7
Gardener	2/8.7	5/21.7
Retired	3/13.1	2/8.7
Unemployed	6/26.1	3/13.1
Smoking History (n/%)		
No	8/34.8	9/39.1
Yes	15/65.2	14/60.9
History of Illness (n/%)		
3 Years	6/26.1	6/26.1
4 Years	7/30.4	7/30.4
5 Years	6/26.1	6/26.1
6 Years	3/13.1	3/13.1
7 Years	1/4.3	1/4.3

Table 1 presents the demographic characteristics of respondents in both the control and intervention groups. In the control group, the average age was 46.5 years with a standard deviation of 15.5 years. Respondents ranged in age from 31 to 65 years, with the majority aged 60 years and above (30.4%, n=7). Most respondents were male (73.9%, n=17), and the highest level of education attained by most was senior high school or university (43.5%, n=10). A notable portion of respondents were unemployed (26.1%, n=6), and the majority had

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a history of smoking (65.2%, n=15). Regarding the duration of illness, 30.4% (n=7) reported being ill for four years.

In the intervention group, the average age was 46 years with a standard deviation of 15.0 years, ranging from 31 to 65 years. The largest age group was 31–40 years (30.4%, n=7). Similar to the control group, the majority of respondents were male (73.9%, n=17). Most participants had completed university education (39.2%, n=9), and the most common occupation was gardener (21.7%, n=5). A total of 60.9% (n=14) had a history of smoking, and 30.4% (n=7) had experienced illness for four years.

Table 2. Paired Samples Statistics of CAT, RR, and PEFr

Paired Samples Statistics	Intervention Group (n=23)			Control Group (n=23)		
	Mean	SD	Std. Error Mean	Mean	SD	Std. Error Mean
CAT_PRE_INT	29.870	3.757	0.783	25.565	2.253	0.470
CAT_POST_INT	32.783	3.999	0.834	23.435	2.312	0.482
RR_PRE_INT	27.913	1.164	0.243	27.783	1.242	0.259
RR_POST_INT	26.261	1.789	0.373	28.261	1.514	0.316
PEFR_PRE_INT	236.391	8.206	1.711	234.000	8.246	1.719
PEFR_POST_INT	262.087	19.351	4.035	211.217	33.052	6.892

Table 2 presents the results of the paired sample statistical analysis for both the intervention and control groups of COPD Assessment Test (CAT), Respiratory Rate, and Peak Expiratory Flow Rate (PEFR). In the intervention group of CAT, the pre-test mean score was 29.87 with a standard deviation (SD) of 3.76 and a standard error (SE) of 0.78. The post-test mean score increased to 32.78, with an SD of 4.00 and an SE of 0.83. In the control group of CAT, the pre-test mean score was 25.57, with an SD of 2.25 and an SE of 0.47. The post-test mean score decreased to 23.43, with an SD of 2.31 and an SE of 0.48.

In the intervention group of RR, the pre-test mean score was 27.91 with a standard deviation (SD) of 1.16 and a standard error (SE) of 0.24. The post-test mean score decreased to 26.26, with an SD of 1.79 and an SE of 0.37. In the control group of RR, the pre-test mean score was 27.78, with an SD of 1.24 and an SE of 0.26. The post-test mean score increased slightly to 28.26, with an SD of 1.51 and an SE of 0.32.

In the intervention group of PEFR, the mean pre-test score was 236.39, with a standard deviation (SD) of 8.21 and a standard error (SE) of 1.71. Following the intervention, the mean post-test score decreased to 262.09, with an SD of 19.35 and an SE of 4.03. In the control group of PEFR, the mean pre-test score was 234.00, with an SD of 8.25 and an SE of 1.72. The post-test mean score slightly increased to 211.22, with an SD of 33.05 and an SE of 6.89.

Table 3. Paired Samples t-test of CAT, RR and PEFr

Paired Samples Test	Intervention Group						Control Group					
	Paired Differences			t	df	Sig. (2-tailed)	Paired Differences			t	df	Sig. (2-tailed)
	Mean	SD	SE Mean				Mean	SD	SE Mean			
CAT_PRE_INT	-2.913	2.952	0.6157	-4.731	22	0.000	-2.130	1.632	0.340	6.260	22	0.000
CAT_POST_INT												
RR_PRE_KON	-1.652	1.496	0.312	5.298	22	0.000	-0.478	1.377	0.287	-1.665	22	0.110
RR_POST_KON												
PEFR_PRE_INT	-25.696	19.827	4.134	-6.215	22	0.000	22.783	35.800	7.465	3.052	22	0.006
PEFR_POST_INT												

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Table 3 presents the results of the paired samples t-test analysis for both the intervention and control groups of COPD Assessment Test (CAT), Respiratory Rate, and Peak Expiratory Flow Rate (PEFR). In the intervention group of CAT, the mean difference between pre- and post-tests was -2.91, with an SD of 2.95, an SE of 0.62, and a t-value of -4.731. The degrees of freedom (df) was 22, and the p-value (sig. 2-tailed) was 0.000, indicating a statistically significant improvement. In the control group of CAT, the mean difference was -2.13, with an SD of 1.63, an SE of 0.34, and a t-value of 6.260. The df was also 22, and the p-value (sig. 2-tailed) was 0.000, suggesting a statistically significant change within the group.

In the intervention group of RR, the mean difference was -1.65, with an SD of 1.50, an SE of 0.31, and a t-value of 5.298. The degrees of freedom (df) was 22, and the significance value (p-value) was 0.000, indicating a statistically significant difference. In the control group of RR, the mean difference was -0.48, with an SD of 1.38, an SE of 0.29, and a t-value of -1.665. The df was 22, and the p-value was 0.110, indicating no statistically significant change in this group.

In the intervention group of PERF, the mean difference between pre- and post-test scores was -25.69, with an SD of 19.83, an SE of 4.13, and a t-value of 6.215. The degrees of freedom (df) was 22, and the p-value (2-tailed) was 0.000, indicating a statistically significant difference. In the control group of PEFR, the mean difference was -22.78, with an SD of 35.80, an SE of 7.46, and a t-value of 3.052. The df was 22, and the p-value (2-tailed) was 0.006, indicating that the change was not statistically significant.

Table 4. Independent Sample T-Test of CAT, RR and PEFR

Group Statistics		N	Mean	Std. Deviation	Std. Error Mean
CAT	Intervention	23	2.913	2.953	0.616
	Control	23	-2.130	1.632	0.340
RR	Intervention	23	-1.652	1.496	0.312
	Control	23	0.478	1.377	0.287
PEFR	Intervention	23	25.696	19.827	4.134
	Control	23	-22.783	35.800	7.465

Independent Samples Test		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
CAT	Equal variances assumed	7.169	44	0.000	5.043	0.703
	Equal variances not assumed	7.169	34.296	0.000	5.043	0.703
RR	Equal variances assumed	-5.025	44	0.000	-2.130	0.424
	Equal variances not assumed	-5.025	43.705	0.000	-2.130	0.424
PERF	Equal variances assumed	5.681	44	0.000	48.478	8.533
	Equal variances not assumed	5.681	34.336	0.000	48.478	8.533

Table 4 presents the results for the intervention and control variables of CAT. In the intervention group, the mean score was 2.91, with a standard deviation (SD) of 2.95 and a standard error (SE) of 0.62. In comparison, the control group recorded a mean score of -2.13, with an SD of 1.63 and an SE of 0.34. In the intervention group of RR, the mean value was -1.65, with a standard deviation (SD) of

1.49 and a standard error (SE) of 0.31. In comparison, the control group recorded a mean score of 0.48, with an SD of 1.38, and an SE of 0.29. In the intervention group of PEFR, the mean value was 25.69, with a standard deviation (SD) of 19.83, and the standard error (SE) of 4.13. In comparison, the control group recorded a mean score of -22.78, with an SD of 35.80, and an SE of 7.46.

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DISCUSSION

The study demonstrated a significant improvement in COPD Assessment Test (CAT) scores following the intervention in the intervention group. Supporting evidence from previous research also confirms a notable reduction in CAT scores post-intervention within this group. Although the control group exhibited a decrease in CAT scores, this change was statistically significant, albeit less pronounced than in the intervention group (Price, Arthur, & Macstephen, 2013).

A significant reduction in respiratory rate (RR) was also observed in the intervention group after the intervention. This aligns with prior studies that found similar decreases in RR among intervention groups receiving breathing exercises, including in COVID-19 patients, while the control groups showed no meaningful change (Astuti & Huriah, 2022; Fernandes, Soares, Tinôco, Delgado, Paiva, Lopes, & Lira, 2017). These findings suggest that targeted respiratory interventions can lead to measurable improvements in breathing efficiency, whereas the absence of such interventions in control groups results in negligible change.

In terms of peak expiratory flow rate (PEFR), the intervention group experienced a statistically significant increase after the intervention, which is consistent with findings from earlier research. Conversely, although the control group showed a decrease in mean PEFR values, this decline was also statistically significant. These outcomes emphasize the effectiveness of specific interventions in enhancing pulmonary function.

A marked difference in CAT scores between the intervention and control groups was evident, with the intervention group—supplemented with free-range chicken eggs—showing a more substantial reduction than the control group that followed only a physical exercise regimen (Sepalanita, Faturachman, & Subiakto, 2024). This decline in CAT scores reflects improved quality of life and better symptom management in COPD patients, with the difference being statistically significant ($p < 0.001$).

Significant differences in RR between the groups were also noted, with the intervention group demonstrating a greater reduction. Supporting studies on High-Intensity Interval Training (HIIT) revealed similar patterns, where participants in the

intervention group experienced a significant decrease in RR compared to controls. Low-Intensity Interval Training (LIIT) yielded comparable results, indicating that both HIIT and LIIT are beneficial in managing RR (Cefali, Santini, Lopez, Maselli, Rossettini, Crestani, & Mourad, 2025). Furthermore, music therapy was shown to effectively reduce RR in intervention groups, reinforcing the role of non-pharmacological strategies in improving physiological outcomes (Chang, Lin, Liu, Han, & Chang, 2023). Collectively, these studies highlight the value of diverse and multidisciplinary approaches in respiratory care.

Regarding PEFR, the intervention group consistently exhibited higher gains than the control group. Prior studies support these results, demonstrating significant differences in PEFR improvements favoring intervention groups (Shaikh, Ali, & Moazzam, 2021). For instance, High-Intensity Circuit Training (HICT) significantly enhanced PEFR in intervention groups, while no comparable improvement was observed in controls (Chen, Li, Wang, Wu, & Liu, 2022). Structured physical exercise programs targeting at-risk populations, such as obese children, similarly resulted in significant PEFR increases (Abrams, 2021). Additionally, a comparison between incentive spirometers and inspiratory muscle trainers in Parkinson's disease patients revealed that the spirometer group achieved greater PEFR improvements than controls (Alsharaway, Abo Elyazed, & Helmy, 2021). These findings collectively underscore the importance of incorporating structured physical activities and respiratory aids into clinical practice to support respiratory function and improve patient outcomes.

CONCLUSION

The combination of diaphragmatic breathing exercises and cold facial stimulation was found to significantly alleviate dyspnea perception in patients. This is evidenced by a notable reduction in COPD Assessment Test (CAT) scores in the intervention group compared to the control group, which experienced only a slight improvement. Furthermore, the intervention effectively decreased respiratory rate (RR) among COPD patients, as demonstrated by a significant reduction in RR values post-intervention,

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unlike the control group which exhibited no meaningful change. Additionally, there was a significant enhancement in Peak Expiratory Flow Rate (PEFR) within the intervention group relative to the control group, suggesting improved respiratory capacity, enhanced expiratory function, and potential benefits for lung performance in hospitalized individuals with COPD.

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