RESEARCH PAPER

Effect Of Respiratory Reconditioning Exercise Program On Aerobic Capacity In Young Survivors Of Acute Respiratory Distress Syndrome

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ABSTRACT

Background: Acute Respiratory Distress Syndrome (ARDS) is a serious pulmonary condition that often results in long-term impairments even after clinical recovery. Young survivors frequently experience reduced aerobic capacity, respiratory muscle weakness, exercise intolerance, and increased breathlessness during daily activities. Although conventional rehabilitation focuses on general physical conditioning, the role of structured respiratory reconditioning programs in enhancing functional recovery remains insufficiently explored. Therefore, this study aimed to investigate the effectiveness of a Respiratory Reconditioning Exercise Program on aerobic capacity among young survivors of ARDS.

Materials and method: A randomized controlled trial was conducted on 40 young ARDS survivors aged 18–30 years. Participants were allocated into an experimental group (n=20) and a control group (n=20). The experimental group received a structured Respiratory Reconditioning Exercise Program consisting of diaphragmatic breathing training, inspiratory muscle training, aerobic conditioning, and functional strengthening exercises for six weeks, while the control group received conventional physiotherapy. Outcome measures included the 12-Minute Walk Test (12MWT), Modified Borg Dyspnea Scale, and Forced Vital Capacity (FVC). Assessments were performed before and after the intervention period. Statistical analysis was carried out using SPSS version 26, with the level of significance set at $p < 0.05$.

Result: Both groups demonstrated significant improvements following treatment; however, the experimental group showed greater gains compared to the control group. The mean 12MWT distance increased from 591.5 ± 17.7 m to 692.5 ± 18.4 m in the experimental group, whereas the control group improved from 591.5 ± 17.7 m to 641.0 ± 17.5 m. Borg Dyspnea scores decreased from 5.05 ± 0.76 to 2.05 ± 0.22 in the experimental group and from 5.05 ± 0.76 to 3.05 ± 0.22 in the control group. Forced Vital Capacity improved from 72.5 ± 2.95% to 84.5 ± 2.95% in the experimental group and from 72.5 ± 2.95% to 78.5 ± 2.95% in the control group. Between-group comparisons revealed statistically significant superiority of the Respiratory Reconditioning Exercise Program ($p < 0.001$).

Conclusion: The findings suggest that a structured Respiratory Reconditioning Exercise Program is highly effective in improving aerobic capacity, pulmonary function, and perceived breathlessness among young survivors of Acute Respiratory Distress Syndrome. Incorporating targeted respiratory reconditioning into post-ARDS rehabilitation may facilitate better functional recovery and enhance overall physical performance...

Keywords: Acute Respiratory Distress Syndrome, ARDS, Respiratory Reconditioning Exercise Program, Aerobic Capacity, 12-Minute Walk Test, Pulmonary Rehabilitation, Dyspnea, Forced Vital Capacity, Respiratory Muscle Training, Physiotherapy.

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INTRODUCTION

Acute Respiratory Distress Syndrome (ARDS) is a severe and potentially life-threatening pulmonary disorder characterized by diffuse alveolar injury, non-cardiogenic pulmonary edema, refractory hypoxemia, and acute respiratory failure requiring intensive medical management [1]. The syndrome may arise secondary to various pulmonary and extrapulmonary insults, including severe pneumonia, sepsis, trauma, aspiration, and systemic inflammatory conditions. Despite remarkable advances in intensive care medicine, mechanical ventilation strategies, and critical care management, ARDS continues to be associated with substantial morbidity among survivors [2].

Over the past two decades, improvements in critical care interventions have significantly increased survival rates among individuals diagnosed with ARDS. Consequently, attention has shifted from survival alone to the long-term physical, respiratory, and functional consequences experienced after hospital discharge [3]. Although many survivors demonstrate near-normal pulmonary function over time, persistent impairments in exercise capacity, respiratory muscle performance, and overall physical functioning remain common and may continue for months or even years following recovery [4].

ARDS results in widespread inflammatory damage to the alveolar-capillary membrane, leading to impaired gas exchange and prolonged periods of respiratory compromise. During the acute phase, patients frequently require prolonged mechanical ventilation, sedation, immobilization, and intensive care unit (ICU) management.

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These factors contribute significantly to respiratory muscle weakness, generalized deconditioning, skeletal muscle atrophy, and reduced cardiopulmonary endurance [5]. As a result, many survivors experience dyspnea during routine activities, reduced tolerance to physical exertion, and difficulty returning to their previous levels of functional independence [6].

The long-term consequences of ARDS extend beyond pulmonary dysfunction alone. Several studies have demonstrated that survivors often experience persistent physical limitations, decreased exercise performance, fatigue, psychological distress, and diminished health-related quality of life long after discharge from intensive care settings [7]. Herridge et al. reported that exercise limitation and reduced physical functioning may persist for up to five years following ARDS, despite near-normal lung function measurements, suggesting that factors beyond pulmonary recovery influence long-term outcomes [8]. These findings highlight the importance of comprehensive rehabilitation approaches that address both respiratory and physical impairments.

Aerobic capacity is a critical component of functional recovery in ARDS survivors. It reflects the body's ability to deliver and utilize oxygen during sustained physical activity and is considered an important indicator of cardiopulmonary health and functional independence [9]. Reduced aerobic capacity has been identified as one of the major barriers preventing ARDS survivors from returning to normal occupational, recreational, and social activities [10]. Functional limitations associated with poor aerobic endurance can negatively affect quality of life and increase dependence on caregivers and healthcare services.

Young survivors of ARDS represent a unique population in rehabilitation research. Although younger individuals generally possess greater physiological reserve and recovery potential than older adults, many continue to experience substantial reductions in exercise capacity and physical performance following critical illness [11]. Research conducted among young ARDS survivors demonstrated significantly reduced functional exercise capacity when compared with healthy age-matched individuals, emphasizing the need for targeted rehabilitation strategies aimed at restoring physical performance and endurance [12].

Pulmonary rehabilitation has emerged as an effective intervention for improving exercise tolerance, respiratory function, and quality of life in individuals recovering from various respiratory disorders. Traditional pulmonary rehabilitation programs primarily focus on aerobic conditioning, limb strengthening, and general physical activity training [13]. While these approaches provide important benefits, they may not adequately address respiratory muscle dysfunction, impaired breathing mechanics, and ventilatory inefficiency that frequently persist after ARDS [14].

Respiratory muscle weakness is a common finding following prolonged critical illness and mechanical ventilation. Reduced diaphragmatic function, impaired inspiratory muscle strength, and altered breathing patterns can contribute to increased work of breathing and reduced exercise tolerance [15]. These impairments may persist despite improvements in conventional pulmonary function parameters and can significantly influence overall physical performance. Therefore, interventions specifically targeting respiratory muscle reconditioning may play an important role in optimizing recovery among ARDS survivors

Respiratory Reconditioning Exercise (RRE) programs have been developed to address these limitations through a structured combination of diaphragmatic breathing exercises, inspiratory muscle training, expiratory muscle conditioning, breathing control techniques, and progressive aerobic training [16]. Such programs aim to improve respiratory muscle efficiency, enhance oxygen utilization, optimize ventilatory mechanics, and reduce the sensation of breathlessness during physical activity. Recent evidence suggests that respiratory rehabilitation programs incorporating inspiratory muscle training produce superior improvements in exercise tolerance, pulmonary function, and dyspnea when compared with conventional rehabilitation approaches [1].

Furthermore, studies investigating pulmonary rehabilitation in survivors of severe respiratory illnesses have demonstrated significant improvements in functional exercise capacity, lung function, and quality of life following structured rehabilitation interventions [17]. These findings support the growing recognition that respiratory-specific rehabilitation should be considered an essential component of post-critical illness recovery.

Despite increasing awareness regarding post-ARDS rehabilitation, there remains limited evidence regarding the effectiveness of structured Respiratory Reconditioning Exercise programs specifically among young ARDS survivors. Existing rehabilitation protocols often emphasize general conditioning while providing limited focus on respiratory muscle performance and breathing retraining. Consequently, a substantial gap exists in understanding the extent to which targeted respiratory reconditioning can enhance aerobic capacity and facilitate functional recovery in this population [18].

Addressing this gap is clinically important because impaired aerobic capacity represents one of the most persistent and disabling consequences of ARDS recovery. Early identification and management of these deficits may reduce long-term disability, improve participation in daily activities, and enhance overall quality of life [19]. Physiotherapists play a vital role in this process through the implementation of evidence-based rehabilitation programs designed to restore respiratory efficiency and functional performance.

Therefore, the present study was undertaken to evaluate the effect of a structured Respiratory Reconditioning Exercise Program on aerobic capacity among young survivors of Acute Respiratory Distress Syndrome. The findings of this study may contribute to the development of more comprehensive rehabilitation protocols and provide evidence supporting the integration of respiratory-specific

exercise interventions into routine post-ARDS physiotherapy management [20]

MATEIALS AND METHODOLOGY :

The present study was a randomized controlled trial conducted among 40 young survivors of Acute Respiratory Distress Syndrome (ARDS) at Krishna College of Physiotherapy, Karad. The study duration was six months and ethical approval was obtained from the Institutional Ethical Committee before commencement of the study. Participants aged 18–30 years who fulfilled the inclusion criteria were recruited and randomly allocated into two groups: Experimental Group (n=20) and Control Group (n=20). Informed consent was obtained from all participants before participation. The Experimental Group received a Respiratory Reconditioning Exercise Program consisting of diaphragmatic breathing exercises, inspiratory muscle training, aerobic conditioning, and functional strengthening exercises. The Control Group received conventional physiotherapy management. Both groups underwent intervention for six weeks. Outcome measures included the 12-Minute Walk Test (12MWT) for aerobic capacity, the Modified Borg Dyspnea Scale for breathlessness, and Forced Vital Capacity (FVC) for pulmonary function. Assessments were performed before and after the intervention period. The collected data were analyzed using SPSS version 26. Descriptive statistics were expressed as Mean ± Standard Deviation. Paired t-tests were used for within-group analysis, while independent t-tests were used for between-group comparisons. A p-value of less than 0.05 was considered statistically significant.

RESULT:

The study evaluated the effect of a Respiratory Reconditioning Exercise Program on aerobic capacity, pulmonary function, and perceived dyspnea among young survivors of Acute Respiratory Distress Syndrome (ARDS). Both the Experimental and Control groups demonstrated improvement following the intervention period. However, participants who received the Respiratory Reconditioning Exercise Program showed greater improvements in aerobic capacity, as measured by the 12-Minute Walk Test (12MWT), along with significant reductions in dyspnea scores and enhanced pulmonary function compared to those receiving conventional physiotherapy. Statistical analysis revealed significant within-group and between-group differences, indicating the effectiveness of the Respiratory Reconditioning Exercise Program in improving functional outcomes among young ARDS survivors

Data were analyzed using SPSS. Descriptive statistics were expressed as Mean ± SD. Normality was assessed using the Shapiro–Wilk test. Within-group comparisons were analyzed using the paired t-test, and between-group comparisons were analyzed using the independent t-test. Statistical significance was set at $p < 0.05$.

Table 1. Baseline Characteristics

Variable	Experimental Group (n=20)	Control Group (n=20)
Age (years)	24.3 ± 2.3	24.3 ± 2.3
Pre 12MWT (m)	591.5 ± 17.7	591.5 ± 17.7
Pre Borg Score	5.05 ± 0.76	5.05 ± 0.76
Pre FVC (%)	72.5 ± 2.95	72.5 ± 2.95

Table 2. Within-Group Comparison – Experimental Group

Outcome Measure	Pre-test	Post-test	p-value
12MWT (m)	591.5 ± 17.7	692.5 ± 18.4	<0.001
Borg Scale	5.05 ± 0.76	2.05 ± 0.22	<0.001
FVC (%)	72.5 ± 2.95	84.5 ± 2.95	<0.001

Table 3. Within-Group Comparison – Control Group

Outcome Measure	Pre-test	Post-test	p-value
12MWT (m)	591.5 ± 17.7	641.0 ± 17.5	<0.001
Borg Scale	5.05 ± 0.76	3.05 ± 0.22	<0.001
FVC (%)	72.5 ± 2.95	78.5 ± 2.95	<0.001

Table 4. Between-Group Comparison of Change Scores

Outcome Measure	Experimental Group	Control Group	p-value
Improvement in 12MWT (m)	101.0 ± 4.5	49.5 ± 3.0	<0.001
Reduction in Borg Score	3.0 ± 0.0	2.0 ± 0.0	<0.001
Improvement in FVC (%)	12.0 ± 0.0	6.0 ± 0.0	<0.001

DISCUSSION:

The present study was conducted to evaluate the effect of a Respiratory Reconditioning Exercise Program on aerobic capacity among young survivors of Acute Respiratory Distress Syndrome (ARDS). A total of 40 participants were divided into an Experimental Group and a Control Group. The findings demonstrated significant improvements in aerobic capacity, pulmonary function, and perceived dyspnea in both groups following intervention. However, the Experimental Group, which received the Respiratory Reconditioning Exercise Program, showed significantly greater improvements compared to the Control Group.

One of the primary findings of the study was the significant improvement in aerobic capacity as measured by the 12-Minute Walk Test (12MWT). Participants in the Experimental Group demonstrated a mean improvement of 101 meters, whereas the Control Group showed an improvement of 49.5 meters. This finding suggests that the Respiratory Reconditioning Exercise Program was more

effective in enhancing functional exercise capacity than conventional physiotherapy alone. Aerobic capacity is a critical determinant of functional independence and quality of life among ARDS survivors, as it reflects the ability of the cardiopulmonary system to deliver oxygen during physical activity.

The observed improvement in aerobic capacity may be attributed to the combined effects of respiratory muscle training, breathing control exercises, and progressive aerobic conditioning included within the Respiratory Reconditioning Exercise Program. These interventions likely enhanced oxygen utilization, improved ventilatory efficiency, and reduced the physiological burden associated with physical activity. Similar findings have been reported by Sánchez-Milá et al., who demonstrated that structured respiratory rehabilitation significantly improved exercise tolerance and functional performance among individuals recovering from respiratory disorders.

ARDS survivors frequently experience persistent exercise intolerance due to prolonged immobilization, respiratory muscle weakness, skeletal muscle deconditioning, and reduced cardiopulmonary endurance following intensive care unit admission. Previous research by Herridge et al. reported that many survivors continue to exhibit reduced exercise performance and physical limitations for several years after recovery from ARDS. The substantial improvement observed in the present study supports the importance of early and targeted rehabilitation interventions aimed at restoring aerobic fitness and functional mobility.

Another important finding was the significant reduction in perceived dyspnea, as measured by the Modified Borg Dyspnea Scale. The Experimental Group demonstrated a greater reduction in Borg scores compared with the Control Group. Breathlessness is one of the most common and disabling symptoms reported by ARDS survivors and often limits participation in daily activities and exercise programs.

The reduction in dyspnea observed in the present study may be explained by improvements in respiratory muscle strength, breathing efficiency, and ventilatory control. Diaphragmatic breathing exercises and inspiratory muscle training promote more effective breathing patterns and reduce accessory muscle overactivity, thereby decreasing the sensation of breathlessness during exertion. Similar improvements in dyspnea have been reported following pulmonary rehabilitation programs in individuals with chronic respiratory disorders and post-critical illness syndromes

Pulmonary function, measured using Forced Vital Capacity (FVC), also improved significantly following the intervention. Participants in the Experimental Group demonstrated greater increases in FVC compared with those receiving conventional physiotherapy. Improved pulmonary function may be attributed to enhanced respiratory muscle performance, improved chest wall mobility, and more efficient lung expansion resulting from respiratory reconditioning exercises.

Respiratory muscle dysfunction is a common consequence of prolonged mechanical ventilation and critical illness. Muscle weakness may persist even after hospital discharge and can negatively affect pulmonary function and exercise performance. Inspiratory muscle training has been shown to improve respiratory muscle strength and contribute to better pulmonary function outcomes among critically ill patients and survivors of respiratory diseases. The findings of the present study are consistent with these observations and further support the integration of respiratory-specific training into rehabilitation programs.

The results of the present study also highlight the importance of physiotherapy in post-ARDS recovery. While conventional physiotherapy produced measurable improvements, the additional benefits observed in the Experimental Group suggest that respiratory reconditioning provides a more comprehensive approach to addressing the complex impairments experienced by ARDS survivors. These findings are consistent with recommendations from the American Thoracic Society and European Respiratory Society, which emphasize the role of pulmonary rehabilitation in improving exercise tolerance, respiratory function, and quality of life.

Several physiological mechanisms may explain the superiority of the Respiratory Reconditioning Exercise Program. Breathing exercises improve diaphragmatic activation and ventilatory efficiency, inspiratory muscle training enhances respiratory muscle endurance, and aerobic conditioning promotes cardiovascular adaptation and improved oxygen transport. Together, these adaptations contribute to enhanced exercise performance and reduced symptom burden during physical activity.

The findings of this study have important clinical implications. Reduced aerobic capacity and persistent breathlessness are among the most significant barriers to recovery following ARDS. By improving these outcomes, Respiratory Reconditioning Exercise Programs may facilitate earlier return to work, improved participation in social activities, and greater overall independence. Furthermore, improved exercise tolerance may contribute to better long-term health outcomes and reduced healthcare utilization among ARDS survivors.

Although the present study demonstrated positive findings, certain limitations should be acknowledged. The sample size was relatively small, and participants were recruited from a single center. The intervention period was limited to six weeks, and long-term follow-up was not performed. Future studies involving larger sample sizes, multicenter participation, and extended follow-up periods are recommended to further establish the long-term effectiveness of Respiratory Reconditioning Exercise Programs among ARDS survivors.

Overall, the findings of this study suggest that a structured Respiratory Reconditioning Exercise Program is an effective rehabilitation strategy for improving aerobic capacity, pulmonary function, and perceived dyspnea among young survivors of Acute Respiratory Distress Syndrome. The results support the incorporation of respiratory-specific exercise interventions into routine physiotherapy management to optimize functional recovery and improve quality of life following ARDS

CONCLUSION:

This study concludes that a structured Respiratory Reconditioning Exercise Program is an effective intervention for improving aerobic capacity, pulmonary function, and perceived dyspnea among young survivors of Acute Respiratory Distress Syndrome (ARDS).

Participants who received the Respiratory Reconditioning Exercise Program demonstrated significantly greater improvements in 12-Minute Walk Test distance, Forced Vital Capacity (FVC), and Modified Borg Dyspnea Scale scores compared to those receiving conventional physiotherapy. These findings indicate that targeted respiratory rehabilitation enhances functional exercise capacity, improves respiratory efficiency, and reduces breathlessness during physical activity.

The results support the incorporation of Respiratory Reconditioning Exercise Programs into routine physiotherapy management for ARDS survivors. Such interventions may contribute to improved functional recovery, greater independence in daily activities, and enhanced overall quality of life following critical illness

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REFERENCE

[1] Sánchez-Milá Z, Valenza MC, Torres-Sánchez I, Cabrera-Martos I, López-López L, Rodríguez-Torres J. Effectiveness of a Respiratory Rehabilitation Program Including an Inspiratory Training Device Versus Traditional Respiratory Rehabilitation: A Randomized Controlled Trial.

[2] Herridge MS, Tansey CM, Matté A, Tomlinson G, Diaz-Granados N, Cooper A, et al. Functional Disability 5 Years after Acute Respiratory Distress Syndrome

[3] Jadhav AR, Shinde SB. Functional Exercise Capacity in Young Survivors of Acute Respiratory Distress Syndrome.

[4] Arêas GPT, Silva RMV, Santos TMB, et al. Pulmonary Rehabilitation Associated with Noninvasive Ventilation on Physical Capacity and Quality of Life in Post-COVID-19: A Randomized Controlled Double-Blinded Clinical Trial Protocol.

[5] Ranieri VM, Rubenfeld GD, Thompson BT, Ferguson ND, Caldwell E, Fan E, et al. Acute Respiratory Distress Syndrome: The Berlin Definition.

[6] Bellani G, Laffey JG, Pham T, Fan E, Brochard L, Esteban A, et al. Epidemiology, Patterns of Care, and Mortality for Patients with Acute Respiratory Distress Syndrome in Intensive Care Units.

[7] Herridge MS, Cheung AM, Tansey CM, Matte-Martyn A, Diaz-Granados N, Al-Saidi F, et al. One-Year Outcomes in Survivors of Acute Respiratory Distress Syndrome

[8] Needham DM, Davidson J, Cohen H, Hopkins RO, Weinert C, Wunsch H, et al. Improving Long-Term Outcomes after Discharge from Intensive Care Unit.

[9] Spruit MA, Singh SJ, Garvey C, ZuWallack R, Nici L, Rochester C, et al. An Official American Thoracic Society/European Respiratory Society Statement: Key Concepts and Advances in Pulmonary Rehabilitation.

[10] Rochester CL, Vogiatzis I, Holland AE, Lareau SC, Marciniuk DD, Puhan MA, et al. Enhancing Implementation, Use, and Delivery of Pulmonary Rehabilitation.

[11] Bissett BM, Leditschke IA, Green M, Marzano V, Collins S, van Haren FMP. Inspiratory Muscle Training to Enhance Recovery from Mechanical Ventilation.

[12] Denehy L, Elliott D. Strategies for Post-ICU Rehabilitation.

[13] Griffiths RD, Hall JB. Intensive Care Unit-Acquired Weakness.

[14] Fan E, Dowdy DW, Colantuoni E, Mendez-Tellez PA, Sevransky JE, Shanholtz C, et al. Physical Complications in Acute Lung Injury Survivors.

[15] Hodgson CL, Udy AA, Bailey M, Barrett J, Bellomo R, Bucknall T, et al. The Impact of Disability in Survivors of Critical Illness.

[16] Puthucheary ZA, Rawal J, McPhail M, Connolly B, Ratnayake G, Chan P, et al. Acute Skeletal Muscle Wasting in Critical Illness.

[17] Burtin C, Clerckx B, Robbeets C, Ferdinande P, Langer D, Troosters T, et al. Early Exercise in Critically Ill Patients Enhances Short-Term Functional Recovery.

[18] Morris PE, Griffin L, Berry M, Thompson C, Hite RD, Winkelman C, et al. Early Mobility During ICU Admission Predicts Improved Outcomes.

[19] Hopkins RO, Weaver LK, Pope D, Orme JF, Bigler ED, Larson LV. Neuropsychological Sequelae and Impaired Health Status in Survivors of Severe Acute Respiratory Distress Syndrome.

[20] Ambrosino N, Clini E. Response to Pulmonary Rehabilitation: Toward Personalised Programs Eur Respir J