

Effect of Virtual reality-based rehabilitation versus traditional pulmonary rehabilitation on functional fitness and health-related quality of life in individual with Chronic Obstructive Pulmonary Disease: a comparative analysis

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ABSTRACT

Background

Chronic Obstructive pulmonary disease (COPD) is defined with progressive airflow restriction and decrease exercise capacity, altered functional ability, and less efficient health-related quality of life. Conventional pulmonary rehabilitation (PR) is a recognized non-pharmacological therapeutic yet; patient involvement and adherence pose considerable problems. Virtual reality (VR) rehabilitation has developed as a novel method that may improve motivation and functional results through immersive, task specific training.

Objective

To find out the efficacy of VR-based therapy versus traditional pulmonary rehabilitation for functional fitness, mobility, exercise tolerance and health-related quality of life in patients with COPD.

Methods

A pre-post experimental study design was conducted and involved 85 patients with COPD aged 45-70 years. Participants were distributed into experimental group as Group A which is VR based and conventional Group as group B which is conventional pulmonary rehabilitation. Outcome measures includes St George's Respiratory Questionnaire (SGRQ), muscle strength assessment, Fullerton functional fitness test components, and the six minutes' walk test (6MWT). Within group and between-group comparisons were performed using appropriate parametric or non-parametric statistical tests, with significance set at $p < 0.05$.

Results

In both groups shows significant improvement in quality of life, functional strength mobility and exercise tolerance following intervention ($p < 0.05$). However, post intervention comparison revealed that VR group achieved significantly greater improvements in SGRQ scores, functional fitness measures, mobility, and 6MWT distance compared to the conventional PR group ($p < 0.01$).

Conclusion

Virtual reality-based therapy surpassed traditional pulmonary rehabilitation in enhancing functional fitness and health-related quality of life of individuals with COPD. VR-based therapies may work as a beneficial complement or substitute to conventional pulmonary rehabilitation programs to improve patient engagement and functional outcomes.

Index Terms: Virtual reality, Pulmonary rehabilitation, COPD, Functional fitness, Quality of life, 6MWT.

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I. INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory condition marked by enduring airflow restriction, chronic shortness of breath, diminished exercise capacity and compromised health related quality of life. COPD as a fundamental source of disease and mortality globally, to a large extent burdening participants and healthcare systems [1]. Furthermore pulmonary dysfunction, individual with COPD in many cases exhibit systemic manifestations which indulge peripheral muscle weakness, altered functional fitness, limited mobility and activity limitation, all these factors significant contribute to disability and poor health related quality of life. Pulmonary rehabilitation (PR) is a non-pharmacological management of COPD. It is most endorsed by the clinical guidelines internationally [1, 3]. The traditional pulmonary rehabilitation programs, which includes aerobic endurance training, resistance exercises, breathing exercises and patient education, shown much enhancements in the exercise capacity, the COPD symptom management, and health related quality of life [3, 4]. However these benefits, sustained compliance with traditional pulmonary rehabilitation is much difficult because of variabilities like the repetitiveness of exercise regimes, lack of patient's motivation, weariness and restricted to supervised rehabilitation services [4, 5]. In recent studies virtual reality (VR)-based rehabilitation has revealed that an innovative, technology-driven approach to physiotherapy and rehabilitation. Virtual reality therapies gives immersive and interactive training environments that integrate real time visual feedback with task-oriented functional exercise. Evidence in neurological and musculoskeletal rehabilitation indicate that VR based rehabilitation encourage patient engagement, motivation and training intensity, lead to superior functional outcomes compared to conventional therapy approaches [6,7]. For COPD patient, VR-based therapy be superior traditional rehabilitation methods as it integrates physical activity with multisensory input and cognitive challenges. In the previous research have demonstrated improvements in balance, functional performance, and exercise tolerance following VR-

assisted training in participants with COPD [8,9]. Rutkowski et al. has indicated that the exercise programs utilizing virtual reality (VR) considerably enhance the physical fitness and functional capacity of individuals with COPD [8]. Recent systematic evaluations have shown the efficacy of VR-assisted rehabilitation in enhancing adherence and enjoyment in fitness training for chronic respiratory illness [9,10]. Although pulmonary rehabilitation is firmly established is the treatment of COPD, there is a significant lack of studies directly comparing VR-based therapy to traditional pulmonary rehabilitation using standardized, multidimensional outcome measures. Recent studies have primarily investigated virtual reality as an adjunct to conventional therapy or focused on certain outcome such as balance or exercise tolerance, overlooking a comprehensive assessment of

functional fitness and health-related quality of life [9,10]. Consequently, there remains an insufficient amount of high-quality experimental evidence directly comparing these two rehabilitation techniques. In the present study we have designed to assess the effectiveness of virtual reality-based rehabilitation compared to standard pulmonary rehabilitation with chronic obstructive pulmonary disease. The study sought to evaluate changes in health-related quality of life, functional fitness, mobility, and exercise tolerance following the intervention and to determine if VR-based rehabilitation produced superior functional and quality of life result compared to traditional pulmonary rehabilitation.

II. METHODS

An experimental pre-post study design was employed. Eight-five patient diagnosed with COPD, aged 45-70 years were recruited. Participants were categories into Group A (VR-based rehabilitation) and Group B (conventional pulmonary rehabilitation). This study included both males and females. Group A participated in VR based therapy that included immersive, task-oriented exercises focused on functional movements, balance, and endurance, Group B received standard pulmonary rehabilitation, comprising aerobic workouts, resistance training, respiratory exercise and educational sessions. Outcome Measures • St. George's Respiratory Questionnaire (SGRQ) • Manual Muscle Testing (Upper and Lower Limb) • Fullerton Functional Fitness Test components • Six-Minute Walk Test (6MWT)

III. STATISTICAL ANALYSIS

The analysis was done within group comparisons by using paired t-tests or Wilcoxon signed-ranked tests, while between group comparisons were performed using independent t-test or Mann-Whitney U tests. Significance was set up at $p \leq 0.05$.

IV. RESULTS

This study included 85 people with COPD which given the intervention regimen, participants were randomly allocated to either Group A or Group B i.e. experimental group or control group respectively. The participants were aged in between 45-70 years, both male and female COPD patients in each group. At the baseline there was no statistically significant difference in between both the group in terms of age, gender distribution or outcome measures, including that the groups were equal prior to the intervention ($p \geq 0.05$).

A. Within group comparison (Pre- vs Post-Intervention)

A (Experimental Cohort) The analysis revealed a significant enhancement in all the outcome measures following the intervention in Group A. • Health-Related Quality of Life (SGRQ): A significant reduction in SGRQ scores was observed post-intervention, indicating improvement in quality of life ($p \leq 0.001$). • Muscle Strength (MMT UL LL): Both upper limb and lower limb muscle strength showed statistically significant

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improvement after the intervention ($p < 0.01$). • Functional Fitness (Fullerton Functional Fitness Test): Group A demonstrated significant improvements in: 30-second Chair Stand Test o Arm Curl Test o Back Scratch Test o Chair Sit and Reach Test o 8-Foot Up and Go Test (reduced time) o 6-Minute Walk Test distance All the functional fitness outcomes showed the significant improvement from pre to post intervention ($p < 0.001$). Group B (Control Group) Group B also showed improved in certain outcome measures following the intervention; however, the level of improvement was comparatively less. • SGRQ: A modest but statistically significant reduction in SGRQ scores was observed post- intervention ($p < 0.05$). • MMT and Functional Fitness: Improvements were observed in muscle strength and selected functional fitness parameters; however, changes were less pronounced compared to Group A.

significant greater in Group A compared to Group B. we established the significance threshold at 0.05 .

VI. DISCUSSION

This study evaluated the impact of virtual-reality rehabilitation against traditional pulmonary rehabilitation on functional fitness and health related quality of life in individual with

B. Between-Group Analysis (Post-Intervention Comparison)

Number equations consecutively. To make your post-intervention comparison between both groups A and B revealed that group A shows significantly greater improvements across most outcome measures. SGRQ was markedly lower in Group A compared to Group B ($p < 0.001$). For upper and lower limb muscle strength showed significant improvement in Group A ($p < 0.01$). Functional fitness outcomes indulge chair stand, arm curl, flexibility measures, mobility (8-foot up and go) and aerobic capacity (6-minute walk test) were significantly improved in Group A compared to Group B at post-test ($p < 0.001$).

V. FIGURES AND TABLES

The Paired t-test analysis indicated that both the groups exhibited statistically significant enhancements in HRQOL, muscle strength, functional mobility, and exercise tolerance

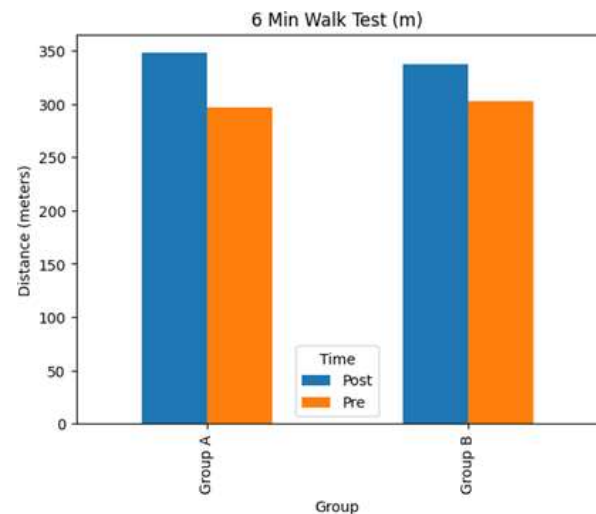
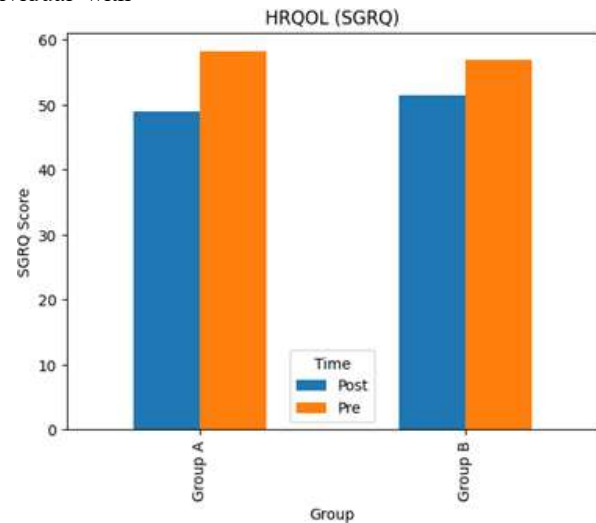


Fig. 1. HRQOL

Fig. 2. 30 chair stand

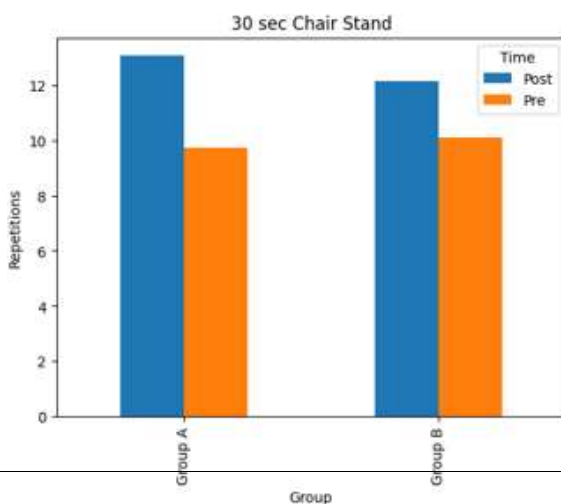


TABLE I

BASILINE CHARACTERISTICS OF PARTICIPANTS IN GROUP A AND GROUP B

Variable	Group A (n≈42)	Group B (n≈43)
Age (years)	45–70	45–70
Gender (M/F)	Comparable	Comparable
HRQOL (SGRQ)	58.14 ± 10.27	56.85 ± 9.82

following the intervention. The independent t-test analysis of post-intervention scores indicated that the enhancement was

Test	Group A (Mean ± SD)	Group B (Mean ± SD)
30-sec Chair Stand (reps)	9.74 ± 3.14	10.10 ± 2.94
8-Foot Up & Go (sec)	11.13 ± 2.15	11.44 ± 2.01
6-Min Walk Test (m)	296.24 ± 49.46	302.19 ± 41.25

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COPD. The result demonstrated both management strategies which shown substantial enhancements in both the groups, yet the led to significant improvements, however, VR-based walking distance was more in the VR group. These findings are very rehabilitation produced considerably more pronounced gains in important since the 6MWT is a tool to states that someone with COPD many functional and quality of life metrics. The SGRQ rating can function, how often they need to go to the hospital and how much has been reduced within the VR group shows a clinically is the mortality rate. [6,7]. The experimental group (VR group) meaningful improvement in health-related quality of life, which showed more significant result may be because they are trained more, indicates that VR rehabilitation may exceed more repetition were given, they did exercise with more fun in VR conventional Fig. 3. Six minute Walk test

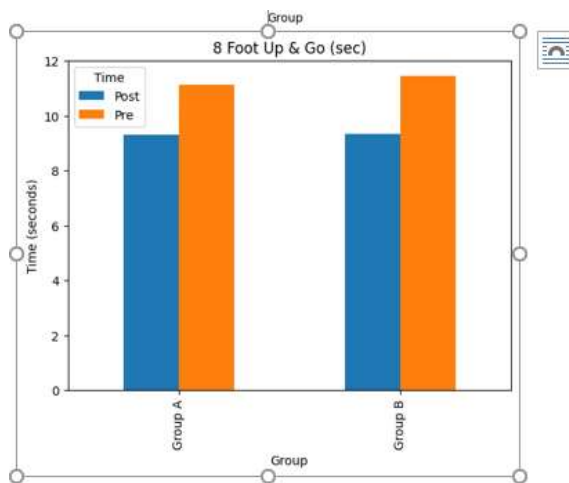


Fig. 4. 8 Foot Up GO

TABLE II
PRE AND POST INTERVENTION COMPARISON OF OUTCOME MEASURES

Outcome Measure	Pre (Mean±SD)	Post (Mean±SD)	p-value
HRQOL (SGRQ)	56.85 ± 9.82	51.47 ± 9.17	0.05
30-sec Chair Stand	10.10 ± 2.94	12.14 ± 2.80	0.05
8-Foot Up Go	11.44 ± 2.01	9.35 ± 2.16	0.05
6-Min Walk Test	302.19 ± 41.25	337.14 ± 52.31	0.05

Pulmonary rehabilitation in effective in handling both physical and psychological aspect of COPD. Patients' motivation and involvement boots probably by the immersive and participatory aspects of VR, which better understanding of health and fewer symptoms. [3,4,8,9]. The result showed that VR group had better improvement in lower limb functional muscle strength than the regular PR group in the 30 second stand chair test. The VR exercise protocol mostly have all the dynamic, task specific movement that are similar to activities of daily

living. That might be the reason for improvement in the functional transfer. The 8 foot-up and go test has been improved the mobility outcomes which showed by decreased time on the test demonstrated, which supports that VR based training can improve balance, co-ordination and functional independence. [7,8]. The six minute walk test was performed to evaluate exercise tolerance

setting which might made them to stick with it more and given more time and dedication. [8,9] Although the PR is validated and effective management for COPD but this study's finding suggest that VR-based rehabilitation may give supplementary benefits, especially VR-based rehabilitation include additional activities which aimed at addressing both the physiological and behavioral aspects of exercise engagement, which are important for enhancing rehabilitation outcomes. [5,9] The findings of this study have shown that VR based rehabilitation is safe, effective way to enhance functional fitness and quality of life in people with COPD then traditional PR. Including VR to PR programs could get patient with COPD more involve in the rehabilitation program and improve their overall health.

CONCLUSION

Virtual reality is more effective than traditional pulmonary rehabilitation for enhancing patient's functional fitness and quality of life of patient with COPD. The rehabilitation based on virtual reality can be addition to the traditional pulmonary rehabilitation programs.

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