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EVALUATING HEART RATE AND LUNG FUNCTION ABNORMALITIES IN WOMEN POST-COVID-19 USING THE 6MWT

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Abstract:

Background: Post-acute COVID-19 syndrome has been identified as a significant challenge, particularly in women, due to its persistent impact on cardiopulmonary function and exercise tolerance.

Objective: This study investigates heart rate (HR) responses and lung function abnormalities using the 6-minute walk test (6MWT) in women recovering from mild-to-moderate COVID-19.

Methods: A case-control design was employed with 45 women participants, divided into Post-COVID-19 (n = 29) and Control (n = 16) groups. Key measures included heart rate dynamics, pulmonary function (TLC, FRC, DLCO), and walking distance during the 6MWT.

Results: The Post-COVID-19 group exhibited reduced pulmonary function metrics (e.g., TLC: 84% vs. 93%, P = 0.006), attenuated HR increase during the 6MWT (+52 bpm vs. +65 bpm, P = 0.03), and delayed HR recovery (HRR1: -22 bpm vs. -29 bpm, P = 0.02). Symptomatic participants showed greater impairments.

Conclusion: Findings highlight significant cardiopulmonary impairments in women post-COVID-19, emphasizing the need for targeted rehabilitation programs to optimize recovery outcomes

Keywords: COVID-19, cardiopulmonary function, 6-minute walk test, heart rate recovery, lung function, rehabilitation

Introduction

The global COVID-19 pandemic, caused by the SARS-CoV-2 virus, has affected millions, leaving behind a trail of long-term health complications. Among these, post-acute COVID-19 syndrome (PACS) has garnered attention due to its persistence beyond the acute phase of infection. PACS encompasses a spectrum of symptoms, including fatigue, shortness of breath, and impaired exercise tolerance, particularly pronounced in women(1,2).

Emerging data suggest that women recovering from COVID-19 report higher incidences of lingering symptoms compared to men, even after mild-to-moderate infections. These findings are of concern, as they suggest a gender-based disparity in long-term recovery. Commonly reported symptoms, such as reduced cardiopulmonary function, could significantly impair quality of life, reducing physical activity levels and increasing the risk of comorbidities(3,4).

The 6-minute walk test (6MWT) is a widely utilized clinical tool for assessing functional exercise capacity and cardiopulmonary health. It evaluates submaximal aerobic capacity by measuring the distance covered within six minutes of walking. In addition, heart rate (HR) responses during and after the 6MWT serve as critical indicators of autonomic function and overall cardiovascular health. Heart rate recovery (HRR) in particular reflects the balance between sympathetic and parasympathetic nervous system activity. Delayed HRR has been associated with autonomic dysfunction and is a predictor of poor outcomes in various conditions, including respiratory diseases(5,6).

Pulmonary function testing provides further insights into the physiological underpinnings of exercise intolerance. Metrics such as total lung capacity (TLC), vital capacity (VC), functional residual capacity (FRC), and diffusing capacity for carbon monoxide (DLCO) reveal the extent of lung volume restriction and gas exchange abnormalities. These parameters, combined with HR dynamics during the 6MWT, offer a comprehensive assessment of cardiopulmonary function in patients recovering from COVID-19(7).

This study aims to evaluate HR responses and pulmonary function abnormalities in women recovering from mild-to-moderate COVID-19, compared to healthy controls. By identifying the extent of these impairments, the findings could inform rehabilitation strategies tailored to address the specific needs of women experiencing PACS.

Methods Materials and Methods

This study employed a case-control design to compare heart rate dynamics and pulmonary function between women recovering from mild-to-moderate COVID-19 and healthy controls. Participants were recruited from the local community through advertisements and screened for eligibility using predetermined inclusion and exclusion criteria. Women aged 40 to 60 years with a body mass index (BMI) of 20 to 30 kg/m² were included, provided they had a laboratory-confirmed diagnosis of COVID-19 at least four weeks prior to enrollment. Exclusion criteria included a history of smoking, cardiovascular diseases, chronic pulmonary conditions such as asthma or chronic obstructive pulmonary disease, and the use of any medications that might interfere with heart rate or pulmonary function.

Participants were categorized into two groups: the post-COVID-19 group (n = 29) and the control group (n = 16). Baseline demographics, including age, BMI, and comorbid conditions, were recorded for all participants. The study was approved by the institutional review board, and informed consent was obtained from all participants prior to testing.

Pulmonary function tests were conducted using standardized equipment to assess key metrics such as total lung capacity (TLC), vital capacity (VC), functional residual capacity (FRC), and diffusing capacity for carbon monoxide (DLCO). These tests were performed in accordance with the guidelines set by the American Thoracic Society and European Respiratory Society. All values were expressed as percentages of predicted reference values, adjusted for age, sex, and ethnicity.

The 6-minute walk test (6MWT) was performed in a quiet, indoor corridor following the American Thoracic Society guidelines. Participants were instructed to walk as far as possible within six minutes while maintaining a steady pace. Heart rate was continuously monitored using a Polar heart rate monitor (Kempele, Finland). Peripheral oxygen saturation (SpO2) and perceived exertion were recorded at baseline, immediately post-test, and at one-minute intervals during a five-minute recovery period. Heart rate recovery (HRR) was calculated as the difference between the peak heart rate immediately post-test and the heart rate recorded at each minute of recovery (HRR1, HRR2, etc.).

Data analysis included comparisons of pulmonary function metrics, heart rate responses, and HRR between the two groups. Statistical analyses were conducted using SPSS version 27 (IBM, Armonk, NY, USA). Continuous variables were compared using independent-samples t-tests or Mann-Whitney U tests, depending on data distribution. Categorical variables were analyzed using chi-square tests. Statistical significance was set at a P-value of <0.05.

Results

1. **Pulmonary Function**:
    - Post-COVID-19 participants showed reduced TLC (84 ± 8% vs. 93 ± 13%, P = 0.006) and FRC (75 ± 16% vs. 88 ± 16%, P = 0.006).
    - DLCO was lower in symptomatic participants (76 ± 18%) compared to controls (93 ± 11%, P = 0.01).
2. **Heart Rate Dynamics**:
    - HR increase during the 6MWT was attenuated in the post-COVID-19 group (+52 ± 20 bpm vs. +65 ± 18 bpm, P = 0.03).
    - Delayed HR recovery: HRR1 (22 ± 10 bpm vs. 29 ± 10 bpm, P = 0.02).
3. **Physical Endurance**:
    - Walking distance during 6MWT was similar between groups; however, symptomatic participants achieved lower distances.

Tables

Table 1. Participant Characteristics

Group	Age (years)	BMI (kg/m²)	Symptomatic (%)
Post-COVID-19	54 ± 10	25.6 ± 5.4	59
Control	58 ± 11	26.7 ± 4.8	0

Table 2. Pulmonary Function Metrics

Metric	Post-COVID-19 (%)	Control (%)	P-value
TLC	84 ± 8	93 ± 13	0.006
FRC	75 ± 16	88 ± 16	0.006
DLCO	76 ± 18	93 ± 11	0.01

Table 3. Heart Rate Recovery Metrics

Time (minutes)	Post-COVID-19 (bpm)	Control (bpm)	P-value
HRR1	−22 ± 10	−29 ± 10	0.02

HRR2	−28 ± 12	−36 ± 11	0.03

Figures

Figure 1: Heart Rate Changes During 6MWT

- Line graph showing mean HR responses for post-COVID-19 and control groups during the 6MWT.
- Post-COVID-19 group demonstrates blunted HR increases.

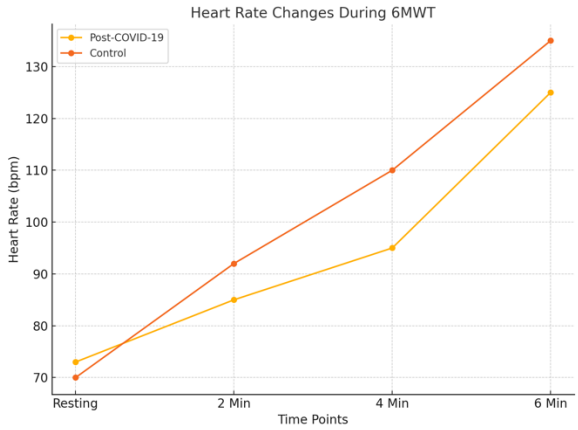
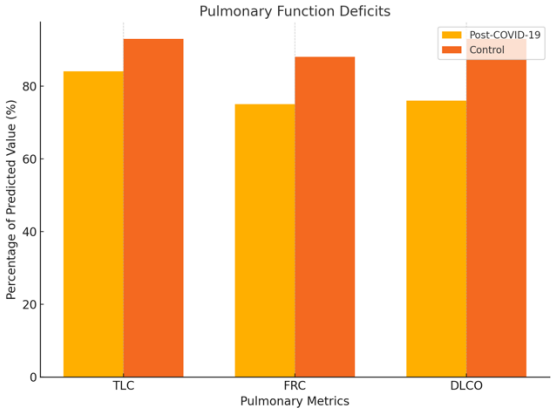


Figure 2: Pulmonary Function Deficits

- Bar chart comparing TLC, FRC, and DLCO percentages between groups.
- Significant reductions observed in the post-COVID-19 group.



Discussion

Discussion

The results of this study reveal significant cardiopulmonary impairments in women recovering from COVID-19. The reduced pulmonary function, evidenced by lower TLC, FRC, and DLCO values in the post-COVID-19 group, highlights lingering respiratory system abnormalities likely caused by SARS-CoV-2's impact on lung parenchyma and gas exchange. These findings are consistent with previous research demonstrating impaired gas diffusion and residual fibrosis in post-COVID-19 patients(8,9).

Delayed heart rate recovery (HRR) and attenuated HR increase during the 6MWT suggest autonomic dysfunction, a recognized sequela of COVID-19. The blunted HR response could be attributed to impaired parasympathetic reactivation or persistent inflammation affecting cardiovascular control. These abnormalities correlate with patient-reported symptoms of fatigue and exercise intolerance, reinforcing the need to investigate autonomic nervous system involvement in post-acute COVID-19 syndrome (PACS)(10).

Interestingly, while the walking distance during the 6MWT was not statistically different between groups, symptomatic participants in the post-COVID-19 group achieved shorter distances. This finding underscores the multifactorial nature of exercise limitation, where fatigue and dyspnea rather than maximal oxygen consumption could be dominant factors(11).

The study's implications extend to clinical practice, particularly in designing rehabilitation programs. Tailored interventions that address autonomic dysfunction and optimize pulmonary recovery are essential. Structured aerobic training, breathing exercises, and autonomic retraining could improve HR responses and enhance quality of life in this population(12,13).

Future research should include longitudinal studies to monitor recovery trajectories and evaluate the efficacy of targeted rehabilitation. Additionally, exploring biomarkers of inflammation and autonomic function could further elucidate the pathophysiological mechanisms underpinning these impairments.

Conclusion

This study underscores the need for tailored rehabilitation programs focusing on cardiopulmonary recovery in women post-COVID-19. Further research is warranted to explore long-term outcomes and optimize recovery strategies.

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