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Examination of Functional Capacity, Pulmonary Functions, Pain, Depression, Sleep and Quality of Life in Young Adults after COVID-19: A Descriptive Observational Study

COVID-19 Sonrası Genç Erişkinlerde Fonksiyonel Kapasite, Solunum Fonksiyonları, Ağrı, Depresyon, Uyku ve Yaşam Kalitesinin İncelenmesi: Tanımlayıcı Gözlemsel Bir Çalışma

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Abstract

Aim: This study primarily aimed to determine whether COVID-19 leads to long-term impairments in functional capacity among young adults. Secondary objectives included examining associated changes in pulmonary function, pain, depression, sleep quality, and quality of life. We hypothesized that young adults who recovered from COVID-19 would demonstrate reduced functional capacity compared to healthy controls.

Material and Method: Fifty-two participants were included: 26 with a history of post-COVID-19 pneumonia and 26 healthy controls. Assessments consisted of the 6-minute walk test, spirometry (FEV_1, FVC, FEV_1/FVC, MVV), visual analog scale, algometer, and hand-held dynamometer, together with validated questionnaires (Beck Depression Inventory, Pittsburgh Sleep Quality Index, Short Form-36, International Physical Activity Questionnaire, Fatigue Severity Scale, and Corbin Posture Scale).

Results: No statistically significant differences were found between the groups in functional capacity (p=0.350), pulmonary function (p=0.660; p=0.226; p=0.589; p=0.511), pain intensity (p=0.467), pressure pain threshold (p=0.305; p=1.000; p=0.103), depression (p=0.119), sleep quality (p=0.267), quality of life subdomains (p=0.056–0.873), muscle strength (p=0.097–0.228), fatigue (p=0.873), or posture (p=0.933). In both groups, most participants were minimally active (38.5% vs. 46.2%; p=0.481).

Conclusion: Young adults with a history of mild post-COVID-19 pneumonia did not differ from healthy controls in physical, psychological, or social health parameters. These findings suggest that COVID-19 had no long-term effects in this cohort.

Keywords: COVID-19, Functional status, Pain, Post-acute COVID-19 syndrome, Respiratory function tests

Öz

Amaç: Bu çalışma birincil olarak, COVID-19'un genç yetişkinlerde fonksiyonel kapasitede uzun vadeli bozukluklara yol açıp açmadığını belirlemeyi amaçlamaktadır. İkincil amaçlar solunum, ağrı, depresyon, uyku ve yaşam kalitesiyle ilişkili değişiklikleri incelemeyi içermektedir. Biz, COVID-19'dan iyileşen genç yetişkinlerin, sağlıklı kontrol grubuna kıyasla fonksiyonel kapasitelerinde azalma göstereceği hipotezini kurduk.

Gereç ve Yöntem: Elli iki katılımcı dahil edilmiştir: 26 COVID-19 sonrası pnömoni öyküsü olan ve 26 sağlıklı kontrol grubu. Değerlendirmeler, 6 dakika yürüme testi, spirometri (FEV_1, FVC, FEV_1/FVC, MVV), görsel analog skala, algometre ve el dinamometresi ile birlikte geçerliliği kanıtlanmış anketlerden (Beck Depresyon Envanteri, Pittsburgh Uyku Kalitesi Endeksi, Kısa Form-36, Uluslararası Fiziksel Aktivite Anketi, Yorgunluk Şiddet Ölçeği ve Corbin Duruş Ölçeği) oluşmaktadır.

Bulgular: Gruplar arasında fonksiyonel kapasite (p=0.350), solunum (p=0.660; p=0.226; p=0.589; p=0.511), ağrı yoğunluğu (p=0.467), basınç ağrı eşiği (p=0.305; p=1.000; p=0.103), depresyon (p=0.119), uyku kalitesi (p=0.267), yaşam kalitesi alt alanları (p=0.056–0.873), kas gücü (p=0.097–0.228), yorgunluk (p=0.873) veya postür (p=0.933) açısından istatistiksel olarak anlamlı bir fark bulunmamıştır. Her iki grupta da katılımcıların çoğu minimal düzeyde aktifti (%38.5'e karşı %46,2; p=0.481).

Sonuç: Hafif fonksiyonel limitasyonu olan COVID-19 sonrası pnömonisi olan bireyler ile sağlıklı genç yetişkinler karşılaştırıldığında fiziksel, ruhsal ve sosyal sağlık açısından gruplar arasında anlamlı bir fark görülmemiştir. Mevcut çalışma, COVID-19'un bu kohort üzerinde uzun vadeli bir etkisinin olmadığını göstermektedir.

Anahtar Kelimeler: Ağrı, COVID-19, Fonksiyonel durum, Post-akut COVID-19 sendromu, Solunum fonksiyon testleri

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INTRODUCTION

Coronavirus Disease 2019 (COVID-19), caused by the SARS-CoV-2 virus, has led to a global pandemic with negative consequences for individual and public health.[1] Although initial attention was directed towards the acute phase of the disease and older adults with comorbidities,[2] increasing evidence has revealed that even young adults who recover from COVID-19 may experience persistent symptoms and functional impairments -collectively termed "post-COVID-19 condition" or "long COVID".[3] Recent studies have emphasized that post-COVID-19 symptoms are not limited to respiratory issues, but also include musculoskeletal pain, fatigue, cognitive disturbances, sleep disorders, and emotional problems such as depression and anxiety.[4–6] These symptoms can have profound effects on daily functioning and overall quality of life, even in previously healthy individuals.[7] In particular, functional capacity and pulmonary functions (core indicators of physical health) may remain compromised weeks or months after recovery.[1,8] Likewise, psychological outcomes such as increased depressive symptoms and decreased sleep quality have been reported across various age groups, including young adults.[9] However, despite rising concerns about the long-term sequelae of COVID-19, the literature remains unclear on the specific impact of the COVID-19 on healthy young adults without chronic illnesses. Most studies to date have focused on elderly populations, patients with severe COVID-19, or individuals with pre-existing medical conditions.[10] This limited scope remains unanswered questions about how even mild COVID-19 infections affect healthy young adults' functional performance, pain perception, mental well-being, and quality of life. Given that young adults constitute a significant portion of the labor and academic population, understanding the subclinical or maintaining effects of COVID-19 in this group is crucial. In young adults, COVID-19 has been associated with a decline in functional performance even months after the acute infection phase. For instance, a reduction in 6-minute walking distance (6MWD) and pulmonary functions observed in young post-COVID individuals.[3,11] Similarly, a study reported lower extremity muscle weakness and impaired physical endurance in young adults following recovery.[12] These findings are reinforced with another study which highlighted functional limitations can persist regardless of initial symptom severity, indicating subclinical sequelae among this age group.[13] Such results underscore the necessity of evaluating not only elderly or comorbid populations but also younger cohorts who may silently bear the burden of post-COVID conditions. In the pandemic due to fears about the high risk of contagion, strict home confinement was enforced. This led to people feeling more depressed or anxious, and reduced overall quality of life.[2] The prevalence of depression/anxiety induced by the COVID-19 has increased by up to 33%.[6]

Moreover, a systematic review and meta-analysis noticed post-COVID-19 patients may experience persistent respiratory symptoms, fatigue, and diminished functional capacity up to 6 months after infection.[14] The diminished functional capacity in severe COVID-19 patients is mediated by impaired pulmonar functions,[15] and indicates exercise intolerance.[3] The post-COVID-19 fatigue has been linked to increased levels of cytokines and a history of autoimmune diseases.[5] Further studies were recommended to establish the effects of post-COVID-19 remaning beyond 6 months.[14]

Unlike all these knowledge stated above, there is some evidence regarding no long term impact of COVID-19 in young adults on functional capacity,[15,16] pulmonary function,[1,17,18] pain,[19,20] depression,[21] sleep quality,[22] and health-related quality of life. As there is no consensus about long term impacts of COVID-19, it is need to be fully understood the existence of subclinical or persistent deficits among young adults with a history of mild infection. While numerous studies have explored older or comorbid populations, only a few have examined younger cohorts. By integrating physical, psychological, and social parameters, this study provides a multidimensional evaluation of post-COVID-19 outcomes in a limitedly investigated group. Hence, the present study primarily aims to evaluate long-term effects of COVID-19 on functional capacity in healthy young adults. Secondary aims of the study to investigate the impacts of COVID-19 on pulmonary function, pain, depression, sleep quality, and health-related quality of life. We hypothesized that young adults with a previous history of mild COVID-19 would demonstrate decreased functional capacity compared to non-infected peers.

MATERIAL AND METHOD

Ethics Statement

All participants provided written informed consent to participate in the study according to the Declaration of Helsinki. Ethics committee approval was provided with a 2/2021.K-087 protocol number from Istinye University on 10/11/2021. This study was registered in clinicaltrials.gov (NCT05282043).

Study Design and Setting

This cross-sectional, observational study was conducted with 52 participants consisting of post-COVID-19 pneumonia (n=26) and healthy adults (n=26). Detailed participant information is presented in **Figure 1**. The present study was conducted in Istanbul Arel University in Istanbul, Türkiye. All measurements were performed by an assessor who was blinded to participants' group allocation.

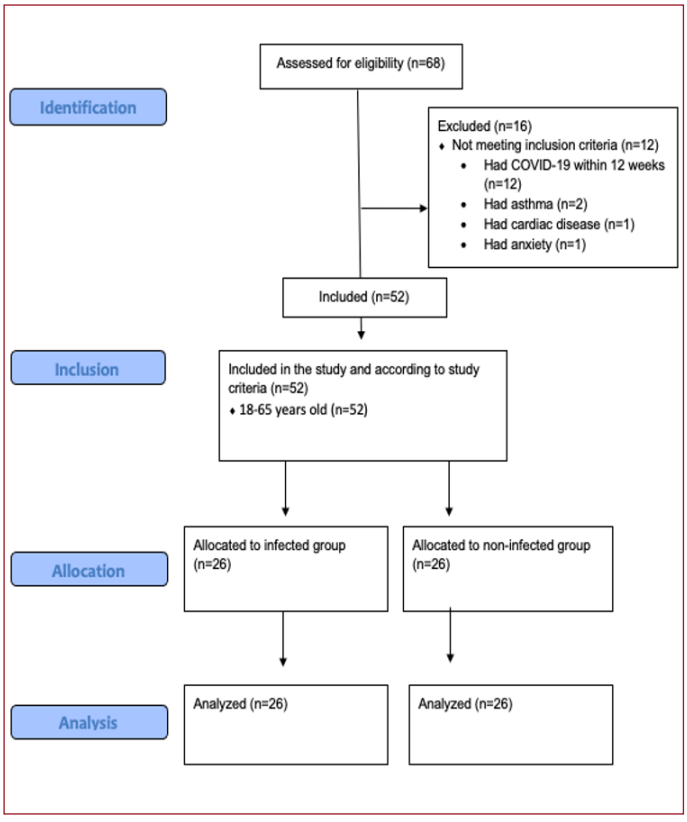

Figure 1. Flow diagram of the study

Participants

Participants aged between 18 and 65 years who had recovered from COVID-19 infection at least 12 weeks prior were included in the post-COVID group (n = 26). This ensured a sufficient period to evaluate potential long-term effects. Participants who had any cardiac or pulmonary disease, any psychological disorder, or any orthopedic or neurological impairment restricting physical activity prior to the onset of COVID-19 infection were excluded. Age-gender-matched healthy individuals who were not infected with COVID-19 were recruited for the control group (n=26).

Variables

This study demonstrates the effects of COVID-19 on 6-minute walk distance, spirometry, pain intensity and pain threshold, depression, sleep quality, quality of life, and other parameters in healthy young adults. Outcome measurements included the 6-Minute Walk Test (6MWT), spirometry which comprised forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio, and maximal voluntary ventilation (MVV), as well as the Visual Analogue Scale (VAS), pressure pain threshold, and muscle strength. The Beck Depression Inventory (BDI) for depression, the Pittsburgh Sleep Quality Index (PSQI) for sleep quality, the Short Form-36 (SF-36) for quality of life, the International Physical Activity Questionnaire (IPAQ) for physical activity levels, the Fatigue Severity Scale (FSS) for fatigue, and the Corbin Posture Scale for posture assessment were also used.

Data Sources/Measurement

1. Functional capacity: The 6MWT was used to determine participants' functional capacity. The test requires a 30-metre walkway and cones to mark the turn-around points. Participants walk for six minutes at their own pace. The number of laps and walking distance in metres are recorded. The test procedure is based on the American Thoracic Society (ATS) criteria.[23]

2. Pulmonary functions: Pulmonary function tests were performed using a digital spirometer (Pony FX, COSMED Inc., Italy). FEV_1, FVC, FEV_1/FVC were measured for airway obstruction, and MVV for maximal ventilation capacity. The evaluations were conducted according to the standards of the European Respiratory Society (ERS) and the American Thoracic Society (ATS).[24]

3. Pain: Participants were asked to rate pain intensity on a 10-centimeter VAS. Higher scores indicate greater pain. Pressure pain threshold was measured using a digital algometer (Commander Algometer, J-Tech, USA) from 3 muscle points (upper trapezius, tibialis anterior, and interossei of hand). The algometer displays units in Newton. Lower readings indicate a more likely pain.

4. Depression: BDI was used to evaluate the level of depression.[25] Scores between 0-9 refer to minimal depression, 10-16 mild depression, 17-29 moderate depression, and 30-63 severe depression.

5. Sleep quality: The PSQI is a 19-item self-rated scale used to evaluate sleep quality and disturbances. It generates seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Scores range from 0 to 21. A score of ≤5 refers to good sleep quality while >5 refers to poor.[26]

6. Quality of life: The SF-36 was used to indicate the health status of participants. It contains eight subdomains: physical functioning, role functioning/physical, role functioning/emotional, energy/fatigue, emotional well-being, social functioning, pain, and general health. Scores for each subdomain range from 0 to 100, with 0 indicating poor health and 100 indicating good health.[27]

7. Other parameters

7.a. Muscle strength: Maximal isometric strength of the biceps muscle (upper extremity), quadriceps muscle (lower extremity) and finger flexor group muscles (hand grip strength) was recorded. The measurements were made using a hand-held dynamometer (MicroFET2, Hogan Health Industries Inc., USA) and a digital dynamometer (Baseline, Baseline Inc. USA). All measurements are in kilograms (kg).

7.b. Physical activity level: The physical activity level of participants was measured using the IPAQ-short form, which asks about the time spent and frequency of several activities

performed over the past week. Each activity has a specific MET value, which is used to calculate total energy expenditure.[28]

7.c. Fatigue: The Fatigue Severity Scale was utilized to measure the fatigue of participants and has 9 items.[29] If the score is ≥4, it reveals severe fatigue.

7.d. Posture: The Corbin Posture Scale assesses postural impairment. Key features include forward head, rounded shoulders, excessive lumbar lordosis, abdominal ptosis, hyperextended knees and flat arches (rated between 0-3). A total score of 0-4 indicates excellent, 5-7 very good, 8-10 good, 11-13 fair and ≥14 poor.[30]

Study Size

Sample size estimation was performed using G*Power 3.1 software. A two-tailed t-test was planned with a significance level (α) of 0.05 and a statistical power (1−β) of 0.80. For the sample size calculation, a conservative large effect size of Cohen's d=0.80 was assumed.[31] Accordingly, a total of 52 participants were included in the study, with 26 individuals in each group.

Statistical Methods

Statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as means±standard deviations and ranges (minimum–maximum), while categorical variables were presented as frequencies (n) and percentages (%). The normality of the data distribution was assessed using the Kolmogorov–Smirnov test. For normally distributed variables, inter-group comparisons were conducted using the independent samples t-test or the Chi-square test. For variables that are not normally distributed, the Mann–Whitney U test or Fisher's exact test was applied. A p-value of <0.05 was considered statistically significant.

RESULTS

Descriptive Data

The mean age, body weight, height, gender, smoke use, comorbidities, the Post-COVID-19 Functional Status scale (PCFS) score, and post-COVID-19 duration for the infected and the non-infected group were demonstrated in **Table 1**. There were no statistically significant differences between the groups in terms of age (p=0.655) and body weight (p=0.564), while a significant difference was observed in height (p=0.040). The comparison of the groups according to gender (p=0.522), smoke use (p=0.572), and comorbidities (p=0.226) was not different. The Post-COVID-19 Functional Status scale score of the infected group was determined as 1.54±0.93 and it indicates that the participants had slight functional limitations. In the infected group (n=26), the mean duration from diagnosis of COVID-19 was 90.23±53.45 weeks.

Table 1. Demographic and clinical features of participants

Characteristics	Infected with COVID-19 (n=26)	Non-infected with COVID-19 (n=26)	p value
Age	23.08±3.61	23.76±4.38	0.655[a]
Weight	66.46±22.08	66.94±18.68	0.564[a]
Height	166.57±7.73	171.61±9.41	*0.040[a]
Gender			
Female	21 (80.8%)	18 (69.2%)	0.522[b]
Male	5 (19.2%)	8 (30.8%)	
Smoke use			
Yes	12 (46.2%)	9 (34.6%)	0.572[b]
No	14 (53.8%)	17 (65.4%)	
Comorbidities			
None	22 (84.6%)	23 (88.5%)	0.226[b]
Hashimoto thyroiditis	-	2 (7,7%)	
Hypertension	2 (7.7%)	1 (3.8%)	
Rheumatoid arthritis	2 (7.7%)	-	
PCFS grade	1.54±0.93	-	
Duration from diagnosis of COVID-19 (weeks)	90.23±53.45	-	

Abbreviations: mean±SD, mean±Standard Deviation; n(%), frequency (percentage). [a]Mann-Whitney U Test, [b]Chi-square test, *p<0,05 is significant. Data are expressed as mean±SD or n(%).

As Post-COVID-19 duration ranged widely, the stratification analysis was conducted to compare subjects 3 months–1 year and 1–4 years post-COVID-19. This analysis revealed that functional capacity (p=0.090), pulmonary function (p=0.090-0.495) except for FVC % predicted (p=0.047), pain (p=0.054-0.849), depression (p=0.644), sleep quality (p=0.567), quality of life (p=0.216-0.978), muscle strength (p=0.216-0.605), physical activity level (p=0.644), fatigue (p=0.765), and posture (p=0.567) were similar between the groups. Although the FVC % predicted value was statistically significant (p=0.047), it was not considered clinically important. All pulmonary function parameters were within clinically normal ranges in the table (Table S1 and Table S2). Since the height was different among groups a stratification analysis was conducted. When the 6MWD was stratified according to height of the subjects, no significant differences were seen among groups (Table S3). Table S1, S2 and S3 were presented in Supplementary Material_Tables.

In the infected group, 18 (69.2%) of the participants had received two doses of the vaccine, eight (30.8%) had received three doses, and one (3.8%) had received one dose. In the non-infected group, 11 participants (42.3%) had received two doses, 12 participants (46.2%) had received three doses, and two participants (7.7%) had received four doses. There was no statistically significant difference between the groups when the number of vaccines was compared (p=0.139).

Figure 2 presents the clinical characteristics of participants associated with post-COVID-19 pneumonia. The infected

group reported a wide range of symptoms, with 28.8% reporting five or more. The most common symptoms were fever, sore throat, joint pain, anosmia, ageusia, headache, myalgia, cough and chest pain. Less common symptoms included diarrhea, malaise, loss of appetite, nausea and dyspnea. None of the participants in the COVID-19 infected group has required hospitalization, or referral to an intensive care unit, or medical treatment.

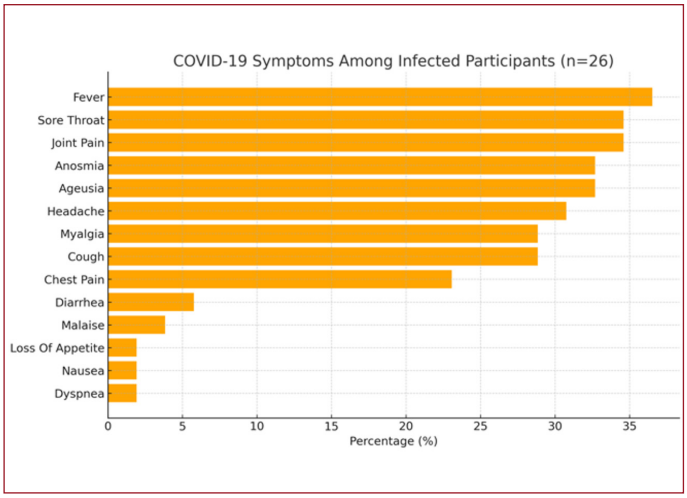

Figure 2. Characteristics of the participants regarding COVID-19 infection

Outcome Data

As shown in **Table 2**, the 6-Minute Walk Test (6MWT) distance was not different in the non-infected group compared to the infected group (p=0.350). Pulmonary function parameters including FEV_1(L) (p=0.660), FVC (L) (p=0.226), FEV_1/FVC (%) (p=0.589), and MVV (L) (p=0.511) did not differed between groups. Similarly, the predicted percentages of FEV_1 (p=0.620), FVC (p=0.400), FEV_1/FVC (p=0.856), and MVV (p=0.327) parameters were not demonstrated statistical significance. Pain intensity was not different among groups (p=0.467). Additionally, pressure pain threshold values measured at three anatomical sites including the upper part of the m. trapezius (p=0.305), m. tibialis anterior (p=1.000), and mm. interossei dorsales of the hand (p=0.103) were similar in the non-infected group when compared to the infected group.

In **Table 3**, the inter-group comparisons of depression, sleep quality, quality of life, muscle strength, physical activity level, fatigue, and posture were demonstrated. No statistically significant differences were seen between groups in depression (p=0.119), sleep quality (p=0.267), and subdomains of quality of life (p=0.873 for physical functioning; p=0.056 for role physical; p=0.308 for role emotional; p=0.632 for vitality; p=0.251 for mental health; p=0.290 for social functioning; p=0.560 for bodily pain; p=0.671 for general health), upper extremity (p=0.097), lower extremity (p=0.228) and grip strength (p=0.117). Considering the groups' physical activity level, most participants were sufficiently active in both the infected and the non-infected groups (38.5% and 46.2% respectively). There is no significant difference among groups' physical activity levels (p=0.481). Participants in both groups had severe fatigue (p=0.873), and excellent posture (p=0.933).

Table 2. Inter-group comparisons of functional capacity, pulmonary functions, and pain

Characteristics	Infected with COVID-19 (n=26)			Non-infected with COVID-19 (n=26)			d	p value
	Mean±SD	95% CI	Median	Mean±SD	95% CI	Median		
6MWT (m)	578.47±48.07	559.05-597.89	582.04	585.61±54.21	563.71-607.51	590.21	0.139	0.350[a]
Pulmonary functions								
FEV_1 (L)	3.22±0.76	2.91-3.53	3.22	3.37±1.21	2.88-3.86	3.29	0.148	0.660[a]
FVC (L)	4.16±0.77	3.85-4.48	3.94	4.52±1.27	4.01-5.04	4.12	0.343	0.226[b]
FEV_1/FVC (%)	77.16±13.99	90.56-99.11	80.00	73.72±15.58	89.32-99.20	80.00	-0.232	0.589[a]
MVV (L)	112.39±31.73	99.58-125.21	115.70	119±39.80	102.93-135.08	115.85	0.184	0.511[b]
FEV_1 % predicted	95.42±10.31	91.57-99.91	95.42	97.84±14.80	91.53-103.50	97.84	0.190	0.620[b]
FVC % predicted	104.94±16.06	98.77-111.76	104.94	107.31±14.75	101.03-112.96	107.31	0.154	0.400[a]
FEV_1/FVC % predicted	94.94±10.58	90.56-99.11	94.97	94.15±12.22	89.32-99.20	96.57	-0.069	0.856[b]
MVV % predicted	95.68±14.06	90.73-102.14	95.68	101.31±12.90	95.32-105.79	101.31	0.417	0.327[a]
VAS (cm)	3.80±3.02	2.57-5.02	4.00	4.35±2.39	3.38-5.32	4.07	0.202	0.467[b]
Pressure pain threshold (N)								
M. trapezius (upper part)	25.48±13.39	20.07-30.89	23.86	22.24±8.01	19.00-25.48	22.20	-0.294	0.305[a]
M. tibialis anterior	38.05±21.30	29.45-46.66	30.75	35.29±14.05	29.62-40.97	36.13	-0.153	1.000[a]
Mm.interossei dorsales (hand)	14.71±5.95	12.30-17.12	14.25	12.74±4.55	10.90-14.59	12.50	-0.372	0.103[a]

Abbreviations: FEV_1, Forced Expiratory Volume in 1 Second; FEV_1/FVC, Forced Expiratory Volume in 1 Second/ Forced Vital Capacity; FVC, Forced Vital Capacity; mean±SD, mean±Standard Deviation; MVV, Maximal Voluntary Ventilation; VAS, Visual Analogue Scale; 6MWT, 6 Minute Walk Test; 95% CI, 95% confidence interval. [a]Mann-Whitney U Test, [b]Independent groups t-test, *p<0,05 is significant. Data are expressed as mean±SD.

Table 3. Inter-group comparisons of depression, sleep quality, quality of life, muscle strength, physical activity level, fatigue, and posture

Characteristics	Infected with COVID-19 (n=26)			Non-infected with COVID-19 (n=26)			d	p value
	Mean±SD or n(%)	95% CI Upper-Lower	Median	Mean±SD or n(%)	95% CI Upper-Lower	Median		
BDI	15.03±10.54	10.78-19.29	12.50	10.53±7.78	7.39-13.68	10.00	-0.486	0.119[a]
PSQI	6.76±2.56	5.72-7.79	6.58	6.39±1.98	5.59-7.19	6.58	-0.162	0.267[a]
SF-36								
Physical functioning	83.43±11.73	78.69-88.17	79.93	81.62±19.43	73.77-89.47	79.96	-0.113	0.873[a]
Role physical	54.99±29.03	43.26-66.72	60.48	70.94±29.72	58.93-82.94	67.74	0.543	0.056[b]
Role emotional	42.51±34.44	28.60-56.42	50.54	52.11±32.76	38.87-65.34	50.54	0.286	0.308[b]
Vitality	48.13±14.59	42.23-54.01	51.13	52.70±14.86	46.69-58.70	51.13	0.310	0.632[a]
Mental health	47.88±16.87	41.06-54.69	49.29	53.22±16.27	46.64-59.78	49.29	0.322	0.251[b]
Social functioning	59.10±18.27	51.72-66.48	64.92	68.15±15.21	62.00-74.29	64.92	0.538	0.290[a]
Bodily pain	66.51±19.00	58.83-74.18	66.94	66.73±20.89	58.28-75.16	66.94	0.011	0.560[a]
General health	58.07±14.80	52.08-64.05	55.48	56.32±14.70	50.38-62.26	55.48	-0.119	0.671[b]
Muscle strength (kg)								
Upper extremity	11.11±4.77	9.18-13.04	9.96	13.04±4.69	11.15-14.94	11.82	0.408	0.097[a]
Lower extremity	12.17±3.59	10.72-13.62	11.96	11.74±3.38	10.38-13.11	11.96	-0.123	0.228[a]
Grip strength	25.28±7.10	22.41-28.15	24.83	28.19±7.81	25.03-31.34	26.73	0.390	0.117[a]
IPAQ								0.481[a]
Inactive	8 (30.80%)	-	-	9 (34.60%)	-	-	-	-
Sufficiently active	10 (38.50%)	-	-	12 (46.20%)	-	-	-	-
Active/very active	8 (30.80%)	-	-	5 (19.20%)	-	-	-	-
FSS	34.15±12.40	29.14-39.16	31.70	33.38±13.13	28.07-38.69	31.70	-0.060	0.873[a]
Corbin posture scale	4.09±1.49	3.48-4.69	4.00	4.12±1.42	3.54-4.69	4.00	0.021	0.933[b]

Abbreviations: BDI, Beck Depression Inventory; FSS, Fatigue Severity Scale; IPAQ, International Physical Activity Questionnaire; mean±Standard Deviation; n(%), frequency (percentage); PSQI, The Pittsburgh Sleep Quality Index; SF-36, Short Form-36; 95% CI, 95% confidence interval. [a]Mann-Whitney U Test, [b]Independent groups t-test, *p<0,05 is significant. Data are expressed as mean±SD or n (%).

Key Results

The current study found no statistically significant differences between the post-COVID-19 pneumonia and non-infected groups across all parameters. Therefore, the observed findings suggest that the COVID-19 infection did not influence various aspects of physical and psychological health in this population for long term. While some previous studies have shown that many people have experienced adverse physical, mental, and social effects of COVID-19 disease due to post-COVID-19, several studies have revealed no significant differences occured in young adults after the COVID-19 infection compared to healthy age- and gender-matched peers. As the impact of the COVID-19 infection on young adults is still controversial, this study focused on examining the long term impacts of the COVID-19 on physical and psychological parameters in young adults. The findings of the present study revealed that the COVID-19 has no significant long term effects on functional capacity, pulmonary functions, pain, depression, sleep and quality of life in young adults.

DISCUSSION

In the present study functional capacity, pulmonary functions, pain, depression, sleep and quality of life in young adults after COVID-19 were examined and no significant effect of COVID-19 on these parameters was found in this population.

Preceding studies have reported reduced functional capacity after infection.[13,14] Reduced 6MWT performance was found comparing people with different functional status,[8] and a decline in functional capacity after COVID-19 infection compared to healthy individuals was revealed.[11] Decline in exercise capacity with 6MWD after COVID-19 ranges from 180 to 561 metres.[4] It is noteworthy that the mean age of the subjects varied between 31 and 64 in the former studies unlike recruiting younger cohort in the present study. This might lead to absence of significant differences in functional capacity between groups. Considering the small effect size, it is possible that this study did not detect any reductions in functional capacity in the 6MWT. These results align with studies on young adults demonstrating full recovery of 6MWD within months after mild infection.[15,16] but contrast with older or hospitalized populations where prolonged functional limitations were reported.[13] Clinically, this suggests that young adults with mild symptoms are likely to return to normal exercise tolerance.

The static and dynamic lung volumes were mostly unaffected in mild COVID-19 cases.[8,11] The lung volumes (FEV_1, FVC, FEV_1/FVC, MVV) of patients with COVID-19 were preserved compared with those of non-infected patients in the current study. Even in long term, mild-to-moderate COVID-19 does not affect lung functions in young adults.[17] After discharge from intensive care, pulmonary function test results of COVID-19 patients remained within the normal range at 3

and 6 months.[18] Given that none of the participants had severe infection or required hospitalization, and the time since COVID-19 diagnosis was 90.23±53.45 weeks, this finding is consistent with previous reports showing preserved pulmonary function in mild-to-moderate cases.[1,17] The lack of change also supports the notion that long-term respiratory impairment is rare in this age group. Clinically, these data reinforce the importance of focusing respiratory rehabilitation efforts on individuals with severe disease or pre-existing pulmonary conditions.

The pain experienced by patients after COVID-19 varies from 4.5% to 36% for generalized muscle pain (myalgia).[6] and from 6% to 27% for arthralgia.[4] Myalgia and pressure-type headache are early-onset types of pain. Myalgia often persists beyond the acute COVID-19 infection.[32] However, the pain scores of patients with COVID-19 decreased at the one-year follow-up.[19] Pressure pain threshold is another aspect of pain assessment. Granados-Santiago et al. claimed that COVID-19 leads to higher pressure pain sensitivity.[33] However, Matei et al. suggested that vaccinated COVID-19 patients had higher pain thresholds.[20] The current study revealed COVID-19 did not alter pain intensity and pressure pain threshold. The heterogeneous immune response and variable pain adaptation may explain these results. Clinically, the absence of heightened pain sensitivity suggests no persistent nociplastic alterations in this sample.

People with post-COVID-19 syndrome may suffer from depression at about twice the rate of others.[21] Depression was found to be a common mental health problem[5] in 4% to 31% with a higher incidence in women.[4] Nevertheless, depression rates in post-COVID-19 patients were similar to those in the general population and even lower than in many people with obstructive pulmonary disease or heart disease.[7] In the current study, depression scores were similar in both groups. Although the effect size was small-to-moderate, the absence of statistical significance indicates psychological resilience among young adults. This agrees with Naik et al., who observed normalization of depressive symptoms in post-COVID individuals under 35.[21] Clinically, screening for psychological distress remains important but widespread intervention appears unnecessary for mildly affected young populations.

During the pandemic, poor sleep quality scores were found in post-COVID-19 patients related to psychological distress after the lockdown.[9] Adults, and also children and adolescents suffered from insomnia and sleep disturbances up to 33%.[5,22] Sleep disturbance might related to impaired health-related quality of life, productivity, psychological manifestations such as depression and anxiety, and reduced physical activity.[10] No adverse impact of COVID-19 infection on sleep quality was found in our study. These findings may reflect the relatively mild disease course ans small sample size in our cohort. The small effect size suggests that while sleep disturbances are frequently reported after COVID-19, their persistence in young adults is limited. These findings align with Tanriverdi et al.[9] but differ from studies reporting post-lockdown insomnia in severe or long-COVID cases.[22] From a clinical perspective, no medical intervention is required for young adults after COVID-19.

Quality of life decreases for up to 3 months after infection.[4] Self-care, usual activities and depression/anxiety were reported to be the most affected domains of quality of life.[7,18] During the pandemic, almost all quality of life parameters in the SF-36 were reduced in older adults due to social isolation, travel restrictions and fear of infection.[19] Perceived health scores on the EQ-VAS were also found to be low (from 64% to 70), resulting in poor health-related quality of life.[7,18] Physical role functioning declines after COVID-19 infection in 15% to 54% of patients. The current study showed that COVID-19 infected young adults had similar health-related quality of life in all subdomains. Due to functional limitations were slight (PCFS = 1.54±0.93) in our sample, no impairment might observed in the subdomains of quality of life. The clinical implication is that young adults with mild COVID-19 tend to regain pre-disease quality of life within months, consistent with rapid physical and psychological recovery.

Grip strength and leg extension strength could be lower in COVID-19 survivors and this may be mediated by lower limb muscle mass.[12] Semphuet et al. reported that patients with post-COVID-19 syndrome who underwent a 3-month home-based telerehabilitation exercise programme achieved improvements in leg muscle strength.[34] Hand strength was found to be similar between post-COVID-19 and healthy individuals.[11] The current study showed that muscle strength was not altered in upper extremity, lower extremity, and grip strength in the infected group, unlike studies suggesting post-viral infection muscle weakness. This supports prior findings that muscle function remains preserved when functional capacity and pulmonary parameters are unaffected.[11] Clinically, this indicates that preservation of functional capacity and pulmonary function is crucial to maintain muscle performance in young adults following mild infection.

COVID-19 may lead to a decrease in physical activity and people became more inactive during the pandemic period compared with the pre-pandemic period. However, an increase in physical activity levels was observed in the post-pandemic period.[35] When physical activity levels before and after the pandemic were compared, the percentage of people completing 150 minutes of moderate to vigorous physical activity per week decreased.[7] In contrast, most participants in both groups were sufficiently active in the present study. These results were similar Aegerter et al.[36] and De la Rosa et al.[37] who reported no lasting reduction in activity among young adults post-pandemic. This could be attributed to the relatively young and health-conscious sample, who may have resumed regular physical activity more readily, had post-pandemic adaptation and restored routines. Therefore, the effect of COVID-19 on physical activity remains unclear. Clinically, promoting continued engagement in physical activity remains important to sustain physical well-being.

Fatigue was reported as the most common physical health problem after infection (28% to 87%).[2,4,6] Persistently exceeding fatigue at least 6 weeks or 6 months after recovery is identified as postinfectious fatigue syndrome (PIFS).[5] The fatigue syndrome is explained by the direct interaction of the novel coronavirus with the central and peripheral nervous systems and inducing post-inflammatory central nervous system impairments that significantly affect sleep, pain and vitality.[38] Impaired mood, cognitive decline, older age, pre-existing depression/anxiety, comorbidities, initial disase severity, autonomic dysfunction have been implicated in the prolonged COVID-19 fatigue.[39] Moreover, Gourgoura et al. showed that fatigue may trigger depression, and basic mobility limitations such as 6MWD.[40] In contrast to these findings, some studies claimed that there were no differences in fatigue between post-acute COVID-19 and non-infected people.[22,41] Therefore, the results regarding fatigue remain controversial. Our study also showed that there was no difference in fatigue levels between infected and non-infected participants. As depression, poor sleep quality and pain, which are associated with fatigue, did not differ between groups, this may have led to no change in fatigue. Clinically, these findings highlight the role of age and disease severity in predicting post-viral fatigue, suggesting minimal long-term functional consequences in young adults.

The lockdown may have led to poor posture as most people worked or studied from home. Poor ergonomic settings caused musculoskeletal complaints. Pain can occur in different body areas due to restricted neck movement and other factors.[42] The quarantine has had detrimental effects on adults and children, affecting posture and activities.[43] However, a significant difference between infected and non-infected individuals was not found in this study. This may be due to relaxation of quarantine and engage in sufficient physical activity. Clinically, posture-related rehabilitation appears unnecessary in this population, provided that physically active behavior remains.

Across all measured domains, both physical and psychological health parameters were similar between post-COVID-19 and control groups. The results indicate the functional recovery and absence of long-term sequelae in young adults. As the long-term effects of mild cases of the disease are still controversial, this study presents a framework for post-infection manifestations of the disease in young adults, and provides rehabilitation professionals with clinical insights. According to the findings of the current study, it can be clinically concluded that primarily deliver health services for young adults with post-COVID-19 is not required. These individuals will experience remission of physical, psychological, and social symptoms/manifestations over time, and these parameters will be similar to those of non-infected individuals.

Limitations

This study has several limitations. Firstly, since the mean post-infection duration was relatively long (approximately 90 weeks), this may have affected the recovery process, leading to a regression in infection manifestations and contributing to the absence of inter-group differences. Another limitation is the relatively small sample size (n=52), which reduced the post hoc power for outcomes below the conventional threshold of 0.80. Furthermore, pre-COVID-19 data on the participants was unavailable. Therefore, a group of individual who were not infected with COVID-19 was recruited. Consequently, the non-significant findings should be interpreted in light of these factors.

Compared to previous studies, the strength of our study was measuring the MVV parameter, which indicates inspiratory pump function and respiratory muscle endurance. Thus, the current study provides information about maximal ventilatory capacity alongside airway restriction.[44] Our findings suggest that there were no airway restrictions or alterations to respiratory function in young adults post-COVID-19.

Further studies with a larger sample size and including pre-infection baseline data for participants are proposed to reveal the post-acute effects of SARS-CoV-2 more clearly and make the results generalisable. Additionally, as our cohort exhibited only mild functional limitations, subtle inter-group differences were challenging to discern compared to samples with more severe symptoms. Future studies examining different disease severities together are proposed.

CONCLUSION

Consequently, our results indicate no major long-term sequelae in young adults following mild post-COVID-19 infection and we accepted the null hypothesis. These findings complement recent systematic reviews and meta-analyses reporting recovery of functional and pulmonary parameters within months after infection.[1,3,17] Based on this evidence there is no requirement for delivering treatment to young adults with mild post-COVID-19.

Although the results align with existing evidence, the present study provides novel insight by comprehensively examining multiple biopsychosocial outcomes within the same young cohort—an approach rarely applied in previous research. Future studies employing longitudinal or interventional designs may further elucidate subtle physiological or psychosocial changes undetectable in cross-sectional frameworks.

ETHICAL DECLARATIONS

Ethics Committee Approval: Ethical approval was obtained from the İstinye University Clinical Researches Ethics Committee (Date: 10.11.2021, Decision No: 2/2021.K-087).

Informed Consent: All participants provided written informed consent to participate in the study according to the Declaration of Helsinki.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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