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Original Article

Relationship between infection, physical and mental health and exercise habits of some Chinese residents after recovery from COVID-19

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ABSTRACT

This study aimed to determine the infection status, exercise habits, anxiety levels, and sleep quality in Chinese residents who recovered from infection during the period of coronavirus disease 2019 (COVID-19) period. It also aimed to investigate the influencing factors of recovery status and aid in improving intervention measures for COVID-19 recovery. This study is a sub-study nested within a cross-sectional investigation of infection and physical and mental health among partially recovered residents in all 34 provincial areas of China during the COVID-19 pandemic. A total of 1 013 participants (374 males and 639 females) completed the study. Cardiopulmonary endurance was significantly lower after infection than before infection ($p < 0.001$). Women (3.92 ± 4.97) exhibited higher levels of anxiety than men (3.33 ± 4.54, $p = 0.015$). The sleep score was significantly higher after infection (8.27 ± 7.05) than before infection (4.17 ± 4.97, $p < 0.001$). The active and regular exercise groups exhibited significantly shorter durations of fever than the sedentary and irregular groups ($p = 0.033$; $p = 0.021$). Additionally, the active group demonstrated significantly fewer recovery days ([7.32 ± 3.24] days) than the sedentary group ([7.66 ± 3.06] days, $p = 0.035$). We found a correlation between age and the recovery time of symptoms after COVID-19. We noted that a greater number of symptoms corresponded to poorer cardiopulmonary fitness and sleep quality. Individuals who engage in sedentary lifestyles and irregular exercise regimens generally require prolonged recovery periods. Therefore, incorporating moderate exercise, psychological support, sleep hygiene and other health interventions into post-COVID-19 recovery measures is imperative.

1. Introduction

Coronavirus disease 2019 (COVID-19) is a highly infectious disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). It has seriously affected human life and the global economy. COVID-19 is a multisystem disease that primarily affects the respiratory system, but can also cause musculoskeletal, endocrine, and gastrointestinal issues.[1] Symptoms such as fever, exhaustion, loss of taste or smell, and changes in the senses are also associated with coronavirus infection. COVID-19 affects individuals of all ages, although it manifests more severely[2,3] in older patients or those with underlying medical conditions. Symptoms are typically mild in children[4] and individuals under the age of 18. A meta-analysis of respiratory diseases such as Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) showed that anxiety and depression persist even after six months of decline in exercise and quality of life among infected survivors.[5] Halpin et al. stated that COVID-19 has a similar effect on the human body after infection.[6] Sleep has been shown to have a protective effect on immunity. Individuals are more susceptible to illness[7] if sleep is insufficient, and infection with COVID-19 may develop a range of symptoms that can further compromise sleep quality. Hence, post-COVID-19 recovery is deemed critical.

Extensive evidence supports the notion that exercise yields short-, middle- and long-term health benefits. Severe COVID-19 has been associated with an increased likelihood of physical inactivity. Similarly, individuals maintaining high levels of cardiorespiratory fitness have demonstrated a reduction in the risk of COVID-19-related hospitalizations.[8] The onset of the COVID-19 pandemic enforced widespread home confinement measures, which, consequently, had an adverse impact on overall physical activity levels. Additionally, a surge in the consumption of less healthy food, a 28.6% increase in sedentary behavior,[9] and increased levels of anxiety were observed.

The objective of this study was to better elucidate the infection status, recovery status, and physical and mental health of patients who recovered from COVID-19 during the pandemic. The study also aimed to

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List of abbreviations

COVID-19	coronavirus disease 2019
SARS-CoV-2	Severe Acute Respiratory Syndrome 2
SARS	severe acute respiratory syndrome
MERS	Middle East Respiratory Syndrome
GAD-7	General Anxiety Disorder 7-item
PSQI	Pittsburgh Sleep Quality Index
BMI	body mass index
Avg	average
SD	standard deviation
RE	regular exercise
IRE	irregular exercise

investigate the correlation between exercise and recovery, as well as the quantity of symptoms and recovery to assist individuals recovering from infection in developing scientific exercise prescriptions and addressing any potential psychological and sleep problems.

2. Materials and methods

2.1. Sample size calculations

This investigation was a secondary data analysis of a cross-sectional study of a subset of Chinese individuals who recovered from infection from December 19, 2022, to January 17, 2023. Prior to the investigation, G*power was used to estimate the minimum sample size, with test efficacy (1 - β) set at 0.80 and Type I error rate (α) at 0.05. The determined final sample size for the study was a minimum of 568 participants.

2.2. Study design

An online survey format for questionnaire administration, disseminated via WeChat and other social platforms. Participants anonymously completed the surveys through an online survey distribution platform (wjx.cn). The questionnaire consisted of five sections: basic information (sex, age, education, height, and weight), health status (vaccination status, COVID-19 infection status, basic diseases, and sedentary time), exercise status (exercise intensity, exercise frequency, exercise time, and cardiopulmonary endurance self-assessment), psychological status, and sleep status. Completing the entire survey typically requires around 3–5 minutes (min). Previous studies have extensively utilized sleep and anxiety scales, thoroughly verifying their reliability and validity.

2.3. Ethical approval

This study was approved by the Ethics Committee of Beijing Sport University with the approval number 2023013H.

2.4. Measures

The assessment of cardiopulmonary endurance was adapted from the upstairs experiment.[10] The cardiopulmonary endurance before COVID-19 infection was divided into five levels. These levels range from "very relaxed, not panting at all, basically no feeling" to "feeling very tired, short of breath, experiencing some difficulty, and needing a long period to rest to calm down". The degree increased progressively, while cardiopulmonary endurance declined. After infection, the assessment of cardiorespiratory endurance incorporated the parameter of being "unable to walk up five floors at a normal pace", considering the elderly and individuals with poor physical fitness.

The evaluation of psychological state adopted the General Anxiety Disorder 7-item Scale (GAD-7),[11] a validated instrument tested within clinical settings. GAD-7, a brief anxiety tool with good reliability, offers ease of diagnosis and treatment. It functions as a self-rating scale, evaluating psychological state over the preceding two weeks, with a scoring from 0 to 21. Based on the scale's score, anxiety levels are categorized into four levels: no anxiety (0–4), mild anxiety,[5–9] moderate anxiety[10–14] and severe anxiety.[15–21] Higher scores indicate more severe anxiety.

Sleep quality was assessed using the Pittsburgh Sleep Quality Index[12] (PSQI), with a particular emphasis on sleep disturbances caused by COVID-19 infection. These disturbances include nocturnal bathroom visits and feeling cold or hot. Each component was rated on a 0–3 scale, with the cumulative scores providing an evaluation of sleep quality. This part evaluates weekly sleep patterns, which better correspond to sleep disturbances experienced during infection. Decreasing scores indicate improved sleep quality, whereas increasing scores indicate poorer sleep quality.

2.5. Statistical analysis

Continuous variables were reported as means ± standard deviation (*SD*), and categorical variables were expressed as cases or percentages. The Mann-Whitney *U* test was performed to assess the PSQI scores before and after COVID-19, GAD-7, and PSQI scores across sexes, recovery time, exercise habits, and sedentary status. The Kruskal-Wallis test was utilized to analyze the association between infection status and recovery time, symptoms, and PSQI scores. Pearson's correlation analysis was carried out to verify the association between recovery time and age. The number of symptoms and anxiety, sleep quality, cardiopulmonary endurance, exercise, and recovery time were verified by Spearman correlation analysis. Statistical significance was set at $p < 0.05$. SPSS 26.0 was used for all statistical analysis. GraphPad Prism 9.0 and Excel were utilized for plotting of data.

3. Results

3.1. Patient characteristics

A total of 1 039 questionnaires were distributed. After eliminating 26 invalid questionnaires, 1 013 valid questionnaires were finally collected, with an effective rate of 97.50%. Among the 1 013 participants, males comprised 36.92% and females 63.08%. The age group of 18–25 years constituted the majority at 45.90%. A total of 201 subjects (19.84%) reported a recovery time of 7 days. Fever symptoms were present in 91.21% of the participants, with 30.21% experiencing fever for 2 days. The fever was between 38.1 °C and 39 °C in 45.21% of the participants (Table 1).

3.2. Infection status

The symptoms of 1 013 subjects who recovered from COVID-19 were investigated. Among them, 785 experienced general fatigue, 636 reported arthralgia and myalgia, 646 suffered from sore throat, 739 had stuffy and runny nose, 862 exhibited cough and phlegm symptoms, and 473 encountered decreased taste and smell. A total of 270 patients developed diarrhea and vomiting. The distributions of infections across sexes are shown in Fig. 1.

Significant differences were found in the recovery time for general fatigue and cough symptoms between different sexes ($p < 0.001$). Significant differences were also noted in recovery time for stuffy and runny noses and decreases in taste and smell ($p = 0.014$), with age-related fatigue and changes in taste and smell requiring extended recovery periods.

The average recovery time for all subjects was (7.46 ± 3.18) days, ranging from a minimum of 2 days to a maximum of 39 days. Among the subjects, 924 individuals (91.21%) experienced fever during the infection period. Of these, 15.91% had temperatures from 37.3 °C to 38 °C, 49.57% recorded temperatures from 38.1 °C to 39 °C, 30.74% had temperatures ranging from 39.1 °C to 40 °C, 3.46% experienced

Table 1
Characteristics of study participants.

Characteristic	Total (n = 1 013) Number of Subjects (% of total)	Male (n = 374) Number of Subjects (% of total)	Female (n = 639) Number of Subjects (% of total)
Age(y)			
≤ 18	31 (3.06)	16 (4.28)	15 (2.35)
18 - 59	960 (94.77)	347 (92.78)	613 (95.93)
≥ 60	22 (2.17)	11 (2.94)	11 (1.72)
BMI			
Underweight (< 18.5)	95 (9.38)	16 (4.28)	79 (12.36)
Normal (18.5 – 23.9)	627 (61.90)	193 (51.60)	434 (67.92)
Overweight (24 – 27.9)	223 (22.01)	129 (34.49)	94 (14.71)
Obesity (≥ 28)	68 (6.71)	36 (9.63)	32 (5.01)
Education			
Below undergraduate	160 (15.79)	66 (17.65)	94 (14.71)
Bachelor or above	853 (84.21)	308 (82.35)	545 (85.29)
Vaccination			
Unvaccinated	19 (1.88)	9 (2.41)	10 (1.56)
One dose	10 (0.99)	7 (1.87)	3 (0.47)
Two doses	155 (15.30)	57 (15.24)	98 (15.34)
Three doses	803 (79.27)	291 (77.81)	512 (80.13)
Four doses	26 (2.57)	10 (2.67)	16 (2.50)
Underlying disease			
Yes	122 (12.04)	55 (14.71)	67 (10.49)
No	891 (87.96)	319 (85.29)	572 (89.51)
Tobacco use			
Yes	109 (10.76)	88 (23.53)	21 (3.29)
No	904 (89.24)	286 (76.47)	618 (96.71)
Number of symptoms			
≤ 4	525 (51.83)	221 (59.09)	304 (47.57)
> 4	488 (48.17)	153 (40.91)	335 (52.43)
Regular exercise			
Yes	319 (31.49)	151 (40.37)	168 (26.29)
No	694 (68.51)	223 (59.63)	471 (73.71)
Sedentary			
Yes	402 (31.49)	136 (40.37)	266 (26.29)
No	611 (68.51)	238 (59.63)	373 (73.71)
GAD-7 score			
0 - 4	685 (67.62)	258 (68.98)	427 (66.82)
5 - 9	211 (20.83)	78 (20.86)	133 (20.81)
10 - 14	72 (7.11)	27 (7.22)	45 (7.04)
15 - 21	45 (4.44)	11 (2.94)	34 (5.32)

Legend: BMI = body mass index, GAD-7 = General Anxiety Disorder 7-item, y = years, n = numbers.

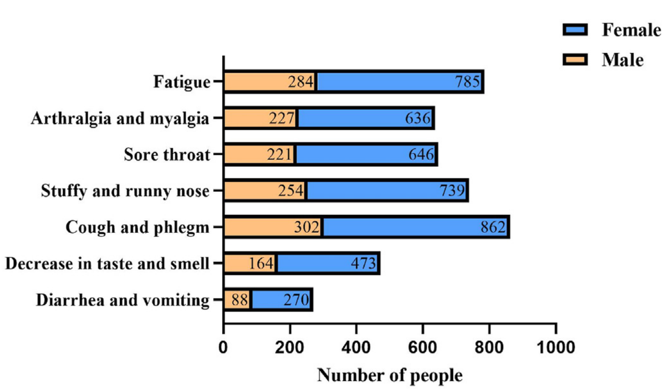

Fig. 1. Distributions of infections across sexes.

temperatures of 40.1 °C – 41 °C, and only 0.32% reported temperatures exceeding 41 °C. The average fever duration was (2.43 ± 1.24) days. Eighty-nine individuals (8.79%) experienced no fever during the infection. As shown in Table 2, the duration of symptoms after recovering from COVID-19 was significantly correlated with age and showed statistical significance with some symptoms.

Table 2
The duration of symptoms after recovering from COVID-19 in subjects.

Symptoms	Avg days	SD	n (%)	r	p
Fatigue	5.80	4.48	696 (68.71)	0.213[b]	< 0.01[b]
Muscular arthralgia	3.56	3.07	617 (60.91)	0.100[a]	< 0.01[b]
Sore throat	5.10	3.59	618 (61.01)	0.051	0.405
Stuffy and runny nose	5.66	3.60	635 (62.69)	−0.043	0.007[b]
Cough and phlegm	8.75	5.22	574 (56.66)	0.184[b]	< 0.01[b]
Changes in taste and smell	7.23	5.32	390 (38.50)	0.176[b]	0.014[a]
Diarrhea and vomiting	3.33	3.66	251 (24.78)	0.026	< 0.108

Legend: Avg = average, SD = standard deviation, n = number, r = correlation coefficient.
[a] $p < 0.05$ considered statistically significant.
[b] $p < 0.01$ considered extremely significant. The Kruskal-Wallis test was utilized to analyze the association between recovery time and age groups.

Table 3
The recovery time in different cardiopulmonary endurance levels.

cardiopulmonary endurance level	Total (n)	Recovery Avg days	Recovery SD	r	p
Grade 1	67	6.85	2.78	0.64	0.041
Grade 2	190	7.14	2.84		
Grade 3	336	7.55	3.77		
Grade 4	240	7.79	2.93		
Grade 5	128	7.36	2.67		
Grade 6	52	7.48	2.71		

n = numbers, r = correlation coefficient, Avg = average, SD = standard deviation. Cardiorespiratory endurance was evaluated by scale, Grade 1 = very relaxed, not panting at all, basically no feeling. Grade 2 = Relatively relaxed, a little faster heartbeat feeling, but not heavy breathing. Grade 3 = Rapid heart rate, slight shortness of breath. Grade 4 = Heart rate was markedly increased, breath heavily, took a few minutes to calm down. Grade 5 = Feel very tired, short of breath, experiencing some difficulty, and needing a long time to calm down. Grade 6 = Unable to walk up five floors at a normal pace.

3.3. Physical and mental health

The cardiopulmonary endurance level was significantly lower after infection than before infection ($p < 0.001$). It was significantly higher before and after infection in males than in females ($p < 0.001$). Table 3 shows a correlation between higher levels of cardiopulmonary endurance after infection and shorter recovery times. A positive correlation was found between cardiopulmonary endurance level after infection and recovery time ($r = 0.64$, $p = 0.041$).

Among all participants who recovered from the infection, 67.62% exhibited no anxiety, whereas 20.83% experienced mild anxiety, 7.11% reported moderate anxiety, and 4.44% manifested severe anxiety. The mean GAD-7 score during infection was 3.70 ± 4.82. Women displayed higher levels of anxiety (3.92 ± 4.97) than men (3.33 ± 4.54, $p = 0.015$). The number of symptoms significantly differed from the GAD-7 scores. With an increase in symptoms during infection, the GAD-7 scores also increased, indicating increased levels of anxiety in the infected individuals ($r = 0.224$, $p < 0.001$).

The PSQI score was significantly higher after infection (8.27 ± 7.05) than before infection (4.17 ± 4.97, $p < 0.001$). No sex differences were found before infection ($p = 0.465$), however, after infection, the PSQI score was higher in females (8.87 ± 7.02) than in males (7.25 ± 7.00, $p <$

0.001). A positive correlation was noted between the number of symptoms and sleep quality ($r = 0.306$, $p < 0.001$). Fig. 2 shows that with an increase in the number of symptoms, sleep quality deteriorates accordingly.

3.4. Recovery and exercise habits

Exercise habits before infection, including exercise frequency, intensity, and duration, were investigated in all participants who recovered from the COVID-19 pandemic. Among them, 269 (26.55%) reported never engaging in exercise before infection, whereas 345 (34.06%) exercised 1 – 2 times a week, and 399 (39.39%) exercised at least 3 times a week. Regular exercisers are defined as those who exercise three or more times a week, with each session lasting 30 min or more, sustained for more than three months.[13] A total of 319 individuals (31.49%) had regular exercise habits, and 694 (68.51%) had irregular exercise habits. 763 participants (75.32%), stopped exercising after contracting COVID-19.

The duration of symptoms was used as an indicator of recovery ability, with individuals infected for shorter periods potentially exhibiting better recovery. A negative and weak correlation was observed between regular exercise and recovery time for general fatigue during infection, notably, the regular exercise group displayed a shorter recovery time ($r = -0.109$, $p = 0.001$). Additionally, the regular exercise group (5.27 ± 4.37) significantly exhibited a shorter duration of general fatigue than the irregular exercise group (6.02 ± 4.50, $p = 0.004$). Moreover, the exercise group experienced a shorter duration of diarrhea or vomiting than the no-exercise group ($p = 0.026$).

According to the 24-hour (h) exercise guidelines for adults issued by the Canadian Health Authority, individuals who sit for more than 8 h are classified as sedentary.[14] The average sedentary duration among all participants was (6.5 ± 2.77) h, with 402 individuals (39.68%) falling into this sedentary category.

According to the exercise conditions, no significant difference was found in fever temperature between the regular and irregular exercise groups, and no significant difference was observed in recovery time between the two groups (7.18 ± 3.04, 7.54 ± 3.23, $p = 0.171$). However, the duration of fever remission (1.81 ± 1.91) was significantly shorter in the regular exercise group than in the irregular exercise group (2.02 ± 1.95, $p = 0.021$). In Fig. 3, based on the sedentary behavior, the duration of recovery was significantly shorter in the active group (7.32 ± 3.24) than in the sedentary group (7.66 ± 3.06, $p = 0.035$). The duration of fever was significantly shorter in the active group (1.88 ± 1.95) than in the sedentary group (2.07 ± 1.91, $p = 0.033$).

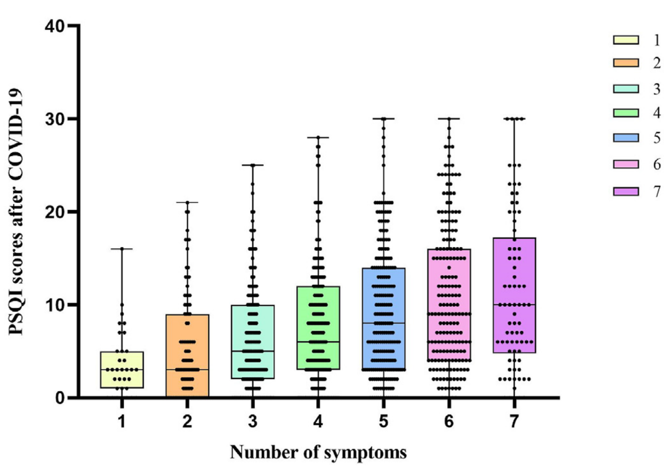

Fig. 2. Box plots for the number of different symptoms and PSQI scores after infection.
Legend: PSQI = Pittsburgh Sleep Quality Index. The number of symptoms: 1 (n = 33), 2 (n = 99), 3 (n = 175), 4 (n = 218), 5 (n = 223), 6 (n = 187), 7 (n = 78). PSQI scores after COVID-19 in different numbers of symptoms used the Kruskal-Wallis test for analysis. There were significant differences in symptoms group: 1 vs. 4 ($p = 0.016$), 1 vs. 5 ($p < 0.001$), 1 vs. 6 ($p < 0.001$), 1 vs. 7 ($p < 0.001$), 2 vs. 4 ($p = 0.020$), 2 vs. 5 ($p < 0.001$), 2 vs. 6 ($p < 0.001$), 2 vs. 7 ($p < 0.001$), 3 vs. 5 ($p < 0.001$), 3 vs. 6 ($p < 0.001$), 3 vs. 7 ($p < 0.001$), 4 vs. 6 ($p < 0.001$), 4 vs. 7 ($p = 0.027$).

4. Discussion

This is a survey on recovery after COVID-19 infection, including the symptoms after infection, and the impact on psychology and sleep. The results showed that 91.21% experienced fever after infection. Additionally, a majority of participants reported experiencing fatigue, muscle and joint pain, sore throat, stuffy and runny nose, cough, and sputum. Kessel et al.[15] also categorized the symptoms observed in patients with COVID-19 into physical, mental, and social manifestations. In addition, the persistent symptoms after COVID-19 can significantly affect work and daily life. Previous studies showed that for certain infected individuals, symptom recovery may extend beyond 60 days.[16,17] The most common symptoms include fatigue, muscle soreness, etc., with older individuals, women, and those with pre-existing conditions facing a higher risk of fatigue.[18] Furthermore, coughing, expectoration, and diminished taste and smell are identified as additional common symptoms.

In this survey, recovery times after infection varied from 2 to 39 days, with 71.27% of infected people experiencing recovery within about a week, while a minority required more than 20 days. Numerous studies reported that individuals require one to two weeks to recover from the virus. For moderate cases, the virus persists in the body for one to two weeks, while severe cases may require up to six weeks.[19] Regular physical exercise can help prevent infection and reduce infection symptoms,[20] which corroborates the results of this study.

Singh et al. also reported a significantly lower cardiorespiratory endurance level after COVID-19 infection than before infection.[21] Patients who had recovered from COVID-19 exhibited significantly lower peak oxygen uptake than their pre-infection states, indicating a decrease in cardiopulmonary endurance levels. In this study, individuals with higher levels of cardiorespiratory endurance after infection required shorter recovery times, indicating a significant positive correlation between cardiorespiratory endurance after infection and recovery time. Brawner et al. found that individuals with COVID-19 and poor cardiorespiratory endurance have a higher risk of hospitalization.[22] Therefore, more attention should be focused on cardiopulmonary function, and

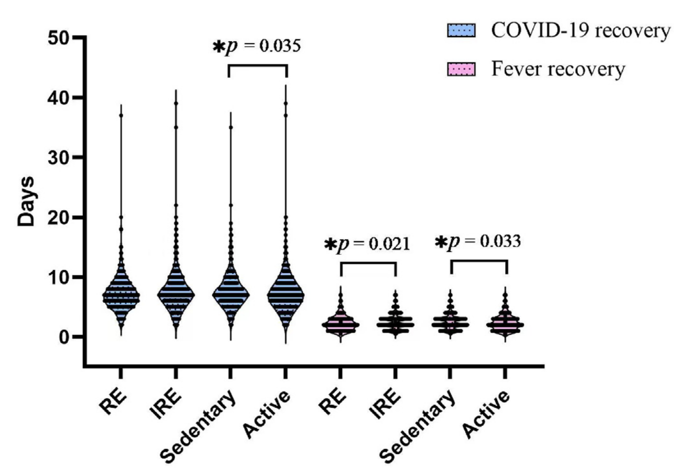

Fig. 3. Violin plots for recovery time between different exercise and sedentary groups.
Legend: RE = regular exercise, IRE = irregular exercise. COVID-19 recovery: RE (n = 319), IRE (n = 694), Sedentary (n = 402), Active (n = 611).
Recovery time between different exercise and sedentary behaviors used the Kruskal-Wallis test for analysis.

individuals who have not been infected with COVID-19, should be urged to participate in regular exercise. Those who are infected or have previously been infected with the virus are advised to gradually adopt healthier lifestyles and incorporate exercise. Thus, enhancing awareness of cardiorespiratory endurance and its associated health benefits is crucial.

Anxiety surveys have shown a higher prevalence of anxiety among women compared with men, potentially attributable to their higher psychological susceptibility.[23] Previous investigations into survivors of SARS reported higher levels of stress, anxiety, and depression among women.[24] A significant difference was found between the number of infection symptoms and the GAD-7 scores. The greater the number of symptoms during infection, the higher the GAD-7 scores, indicating higher levels of anxiety in the infected individual. A meta-analysis showed that at least one symptom persists among the surveyed patients, which is a common occurrence.[25] Therefore, attention should focus on mental health problems caused by COVID-19, especially for those at risk. Sleep quality significantly decreased after infection, a trend more significant in women, similar to anxiety. In a previous survey, sleep quality was also found to be correlated with mental health,[26] which aligns with the results of the present study.

A survey on regular exercise and sedentary situations showed that 31.49% of participants had regular exercise habits, while 39.68% were classified as sedentary. After the COVID-19 infection, 75.32% discontinued their original exercise habits, potentially influenced by widespread media reports suggesting that exercising immediately after infection is inappropriate. Visible, after COVID-19, people's lives will more or less change, exercise is one of the factors affected. Our research suggests that the recovery time and fever decrease are significantly longer in sedentary individuals than in active individuals. The time to decrease fever in individuals who exercise irregularly is significantly longer than in those who exercise regularly. Chen et al. conducted a study on physical activity and the risk of hospitalization for COVID-19,[27] which showed that sedentary behaviors, such as watching TV, have a causal relationship with the risk of hospitalization for COVID-19 and the risk of severe illness. This suggests that increasing physical activity in daily life, reducing sedentary time, and engaging in moderate exercise can improve physical fitness. Other recent studies have shown that low energy expenditure, indicated by a higher BMI is highly associated with the risk of hospitalization and severe complications of COVID-19.[28] However, our study did not support this view, which may be related to the fact that the population we investigated included patients with mild COVID-19 infection. The benefits of increased physical activity may not end there. Meyer's investigation[29] pointed out that maintaining and strengthening physical activity participation and reducing screen time during the COVID-19 pandemic may reduce mental health hazards. Moreover, increasing physical activity is an effective strategy to address the physical and mental health risks of the COVID-19 pandemic.[30] This has also been demonstrated at the molecular mechanism level.[31]

To properly evaluate the results of this study, several limitations should be considered. First, this study used an anonymous online questionnaire survey, with respondents primarily aged 18–25 years and possessing high levels of education. Second, this survey employed a cross-sectional design, lacked follow-up data, and relied on a scale rather than face-to-face interviews. Therefore, it can only indicate the presence of anxiety or sleep problems to a certain degree, without the ability to provide a medical diagnosis. Moreover, the long-term impact of COVID-19 on mental health may be due to the infection of the people around them or socioeconomic problems. Follow-up studies are required to investigate these psychological changes. Third, since the online questionnaire survey relied on smartphones, relatively little data is available on teenagers or the elderly. Fourth, the sample size was not sufficiently large, and some correlations exist between variables that were not observable. Fifth, the proportion of women in this survey was higher than that of men, which compensates for the lack of female data in previous articles. However, there may have been some bias in this study owing to the large sample size of women. In addition, the subjects in this study primarily consisted of individuals who were asymptomatic or had mild Omicron variants infections of the novel coronavirus, which may not fully reflect the condition of patients with severe or critical illness.

5. Conclusion

This study confirmed the persistence of certain symptoms in individuals who recovered from COVID-19 over an extended period, with fatigue emerging as a prevalent manifestation of the infection. After the infection, participants exhibited worsened cardiopulmonary endurance and sleep compared with pre-infection, levels. Anxiousness was more pronounced among women than among men. The symptoms were significantly related to mental health and sleep; higher symptom counts corresponded to poorer scores on the GAD-7 and PSQI scales. In addition, the sedentary and irregular exercise groups required longer to recover from COVID-19 than the active and regular exercise groups. This study suggests that exercise may expedite recovery to some degree during the COVID-19 pandemic. Given the ongoing health challenges posed by COVID-19 in the 21st century, further investigation is warranted.

Submission statement

All authors have read and agree with manuscript content. While this manuscript is being reviewed for this journal, the manuscript will not be submitted elsewhere for review and publication.

Ethical approval statement

This research was approved by Beijing Sport University Ethics Committee (Protocol number: 2023013H). All participants gave their consent and agreed to participate in the study.

CRediT authorship contribution statement

Aiyi Zhou: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Yuncan Xia:** Writing – original draft, Investigation, Formal analysis, Data curation. **Peng Pi:** Investigation, Data curation. **Zhengzhen Wang:** Writing – review & editing. **Hongmei Huang:** Writing – review & editing. **Yan Wang:** Writing – review & editing.

Conflict of interest

All the authors declare no direct or indirect interests that are in direct conflict with the conduction of the study.

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