

# Differences between cardiorespiratory fitness in adult men with asymptomatic or mild SARS-COV-2 infections

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## Abstract

**Introduction.** This study aimed to measure and compare CRF levels between COVID-19-infected adults with asymptomatic and mild symptoms.

**Methods.** The participants in this study included 50 adult men, who were further divided into 2 equal categories: mild symptomatic (MS) and asymptomatic (AS) groups. These participants received a series of anthropometry and Rockport 1.5-mile run tests. During the Rockport 1.5-mile run test, their heart rate (HR) was continuously monitored using a Polar V800 GPS. Following this test, Borg's CR10-scale rating of perceived exertion (RPE) was employed.

**Results.** One-way ANOVA statistical test results showed a significant difference ( $p = 0.007$ ,  $ES = 0.140$ ) between the MS and AS groups, where the  $VO_{2max}$  in the AS group, was greater than the MS group ( $35.7 \pm 7.1$  vs  $29.6 \pm 8.4$  ml/kg/min).

**Conclusions.** Asymptomatic patients had a higher  $VO_{2max}$  level than mildly symptomatic patients. Therefore, moderate-intensity exercise was recommended to increase CRF, thereby enhancing immunity and reducing the risk of contracting COVID-19.

**Key words:** cardiovascular system cardiology, respiratory system pulmonology, sport physiotherapy

## Introduction

COVID-19 was declared a pandemic in March 2020 by the World Health Organization (WHO), and the entire world implemented various measures to reduce the spread of the disease [1]. The impact of this virus has been catastrophic, with over 6 million deaths worldwide [2]. A previous literature review concluded that healthcare workers suffered psychological and health complications when dealing with COVID-19 [3]. Despite realising that in May 2022, most countries have transitioned from a pandemic to an endemic state, the level of vigilance regarding the spread of COVID-19 remains high, while continuing to apply health protocols in daily life [4].

Previous studies showed that COVID-19 can cause multi-organ damage, resulting in a wide spectrum of clinical manifestations [5–7]. Furthermore, cardiovascular (CV) complications are significant concerns in the pathophysiology of the disease and are often observed as the main cause of death [7]. Experts concluded that the presence of comorbidities increases the risk of complications due to COVID-19 [8]. Several symptoms, such as myocardial damage, myocarditis, acute coronary syndromes, respiratory syndrome, arrhythmias, and thromboembolic diseases, have been observed among individuals affected by the virus [9].

The implementation of several government policies aimed at reducing the spread of COVID-19, such as 'work from home' or restrictions on physical activity (PA) [10], caused a decrease in cardiorespiratory fitness (CRF) [11]. Previous literature showed the relationship between CRF and information about health status alongside prognosis during the pandemic [12]. A 3-week cardiac telerehabilitation exercise program improved the CRF and assisted in the rehabilitation of patients with acute COVID-19 due to a history of poor CRF

[13]. To support this finding, experts concluded that CRF plays a crucial role as an indicator of the risk of COVID-19 infection, as its insufficient levels can cause poor host immunity [14, 15].

Previous studies have reported an important correlation of CRF with the risk of being infected with COVID-19 [16–18]. For example, Fikenzer et al. [16] conducted observations between handball athletes with and without a history of COVID-19. The results showed that the maximal oxygen consumption ( $VO_{2max}$ ) in healthy athletes was greater. While these discoveries may still be subject to debate, this study highlights the importance of conducting screening following SARS-CoV-2 infection to identify any performance limitations and ensure readiness for competition.

According to Fikenzer et al. [16], an improvement in CRF level, strengthens host immunity and can reduce the risk of contracting COVID-19 in athletes. Therefore, it could also decrease the symptomatic risk of infected patients. This is supported by the notion that a robust immune response can help prevent excessive symptomatic occurrence [19]. However, there was limited literature available in this specific context. Only the study conducted by Gervasi et al. [19], which focused on soccer players, compared COVID-19 patients with asymptomatic or mild symptoms. However, it was limited to cardiopulmonary testing, and the results showed that players with mild symptoms experienced a statistically significant reduction in almost all spirometry parameters.

There has been no study comparing CRF levels in adults with asymptomatic and mild symptoms of COVID-19. This comparison is essential as the results can help identify performance limitations and guide the safe resumption of exercise. Therefore, this study aimed to measure and compare CRF levels between adult patients with asymptomatic and mild symptoms of COVID-19. Furthermore, it is hoped that the

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results can contribute to the existing scientific literature and provide relevant information to the public regarding exercise intensity recommendations during the pandemic.

## Subjects and methods

### Participants

The participants in this observational study were 50 adult men who were further divided equally into 2 categories: mild symptoms (MS) and asymptomatic (AS) groups. They were selected based on the inclusion and exclusion criteria. The inclusion criteria included (1) men with an age range of 40 to 50, (2) absence of musculoskeletal injuries within the last 6 months, (3) non-athletes or individuals without a history of a systematic exercise training system, (4) COVID-19 patients who had recovered at least 3 months before the start of this study, (5) for the MS group, individuals who experienced mild symptoms such as rhinitis, breathing problems, headaches, no sense of taste and/or smell, chest pain, sore throat, cough, sniffles, listlessness, and aching limbs, and (6) for the AS group, those that did not experience any symptoms while suffering from COVID-19. The exclusion criteria included consumption of alcohol, caffeine, supplements, and exercise in the three months preceding the study or during the experimental period. The participants were fully informed about the

objectives, benefits, and risks, and they provided their informed consent before participation.

### Experimental design

The participants for this study were recruited through posters that outlined the inclusion and exclusion criteria. They were required to provide a doctor's certificate as evidence of them being a previous carrier of the disease. A week before the testing phase, a familiarisation session regarding the test implementation protocol was conducted. This study lasted for 10 days (1<sup>st</sup>– 10<sup>th</sup> October 2022), with 5 participants being tested in a day. The participants were divided into two categories, namely MS and AS groups, to receive the Rockport 1.5-mile run test.

Before conducting the Rockport 1.5-mile run test, each participant received anthropometric measurements indoors under the supervision of a male medical representative ( $n = 1$ ) and an administrator ( $n = 1$ ). Their body weight, body mass index (BMI), and fat, were measured using the Omron Digital Weight Scale HN 289, while Seca 214 Portable Stadiometer from Cardinal Health, Ohio, USA, was applied for height measurements. Following this, the Rockport 1.5-mile run test was conducted every morning from 08.00 a.m. to 10.00 a.m. This was performed under specific weather conditions, including temperatures ranging from 24–27°C and relative humidity between 15–23%. During the test, heart rate (HR) was continuously monitored using a Polar V800 GPS. Immediately after, the participants were asked to rate their perceived exertion (RPE) using the modified Borg's CR10-scale, as described by Foster et al. [20]. Figure 1 presents the study design and clinical procedures.

### Safety measures

This study was conducted in early 2022 when the status of the pandemic in Indonesia had become endemic. However, the safety of both the patients and medical staff remained a top priority. Therefore, all testing staff in this personal study

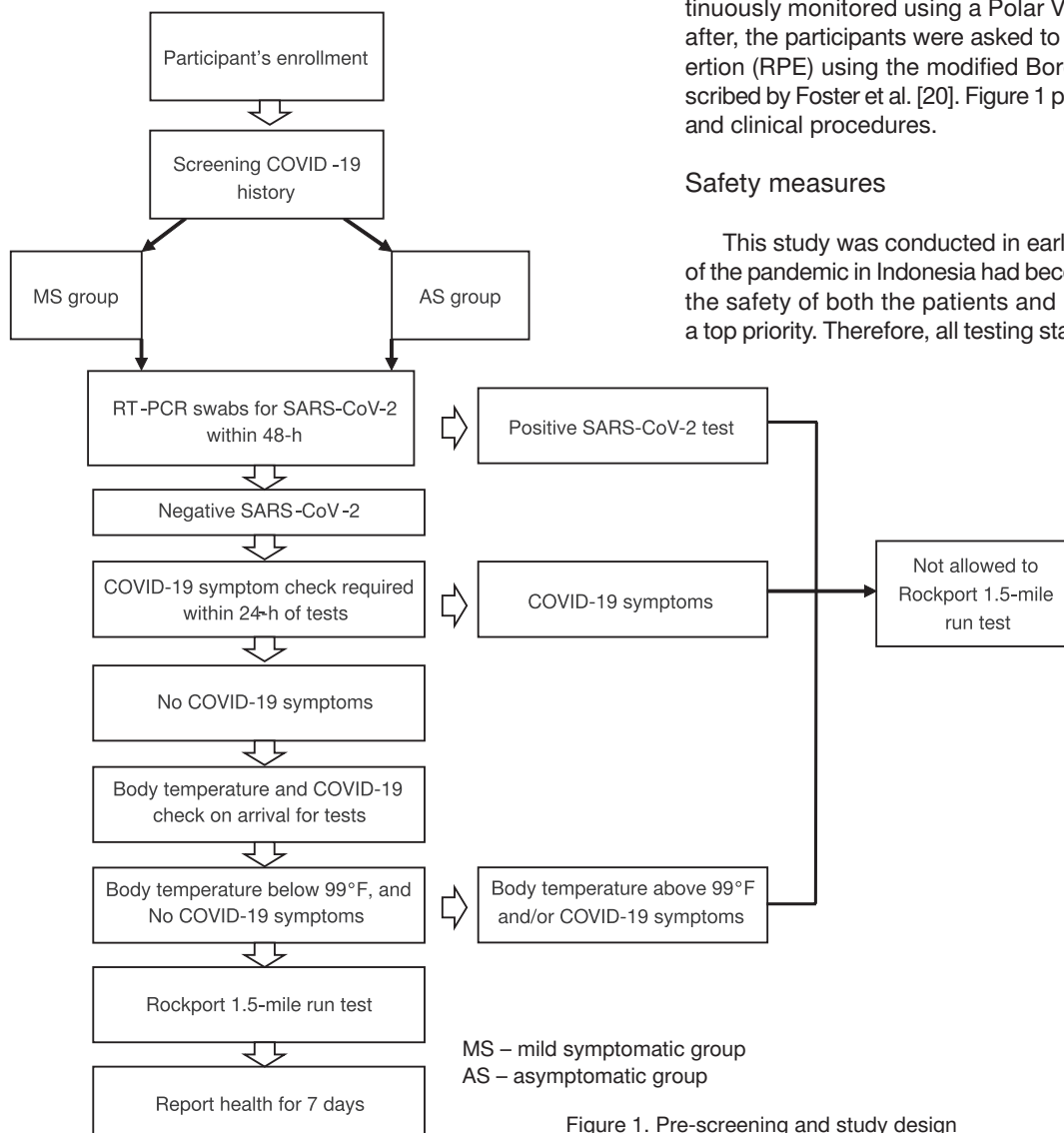


Figure 1. Pre-screening and study design

were required to comply with the protective equipment (PPE) guidelines set forth by the Indonesian Ministry of Health. This included the use of an N95 mask, face shield, gown, and gloves during the testing process. Before conducting the test, the entire committee ensured that all equipment was properly sterilised by thoroughly disinfecting them with an appropriate spray.

All participants and testing staff were required to perform 2 consecutive negative RT-PCR swabs for SARS-CoV-2 at least 48 hours apart before the test began. During the Rockport 1.5-mile test, the distance was set at 2 m between participants. Furthermore, drinking water ad libitum was allowed to maintain hydration. However, it was required that drinking bottles not be shared, and any damaged or worn-out pieces used were promptly replaced. Participants were instructed to immediately report to the medical staff when they experienced any symptoms suggestive of COVID-19 within the following 7 days.

**Physiological and RPE-BORG scale measurements**

Before the CRF level test, the blood pressure (BP) of each participant was measured using the Omron Wrist Blood Pressure Monitor HEM-6181. CRF level was measured by applying the Rockport 1.5-mile run test, a method that was adopted by previous studies [21, 22]. The timing gate system (Smart Speed Fusion, Australia) was employed at the start gate (point 0 meters) and finish gate (point 2,414 meters) to measure the time taken to complete the test. Participants were instructed to walk as fast as possible while keeping 1 foot in contact with the ground. To measure the final HR, a Polar V800 GPS was placed on the participant’s chest. Immediately after the test, RPE values were determined using Borg’s CR10-scale RPE value. The divisions of the scale were 0, 1, 2, 3, 4, 5, 6–7, and 8–10, all indicating rest, very easy, easy, moderate, somewhat, hard, very hard, and maximum, respectively.

**Statistical analysis**

This study utilised IBM SPSS software, V.25.0, to perform statistical analysis tests. Specifically, the formula proposed by Kline et al. [23] was employed to estimate the Predicted  $VO_{2max}$  based on the 1-mile walk of each participant.

$$VO_{2max} = 132.853 - (0.0769 \times WT) - (0.3877 \times AGE) + (6.315 \times SEX) - (3.2649 \times TIME) - (0.1565 \times HR)$$

where WT – weight (lb), SEX – males, 1 and females, 0, TIME – walking time (min), and HR – final heart rate (bpm). All data were tested for normal distribution using the Shapiro–Wilk test and Levene’s statistics. To examine differences in blood lactate and RPE variables, a one-way ANOVA with Independent *t*-test was conducted. Confidence intervals (95% CI) were calculated to indicate the magnitude of change, while statistical significance was determined at the  $p < 0.05$  level.

**Results**

Table 1 provides a comparison of anthropometry and BP between the MS and AS groups. Table 2 and Table 3 show the percentage of symptoms observed in the MS group, and the corresponding mean time, respectively. Figure 2 presents differences in several variables, such as  $VO_{2max}$ , final HR, and RPE, between the MS and AS groups.

The results of anthropometry analysis showed that there were no significant differences between the two groups.

Table 1 Characteristics of participants, divided by groups

Variable	MS group (mean ± SD)	AS group (mean ± SD)	p-value	Effect size
Age (years)	44.2 ± 4.0	45.8 ± 3.7	0.147	0.043
Weight (kg)	65.8 ± 11.5	64.1 ± 7.5	0.524	0.008
Height (cm)	162.5 ± 9.1	161.2 ± 9.5	0.61	0.005
BMI (kg/m <sup>2</sup> )	24.9 ± 3.8	24.7 ± 2.8	0.838	0.001
Systolic (mm Hg)	129.4 ± 11.4	124.2 ± 13.4	0.146	0.044
Diastolic (mm Hg)	82.7 ± 8.0	80.2 ± 8.4	0.292	0.023

BMI – Body mass index, MS – mild symptomatic group, AS – asymptomatic group, BP – blood pressure  
 Statistical analysis with One-way ANOVA with independent *t*-test

Table 2. Characteristics of symptom history in the MS group

Symptom parameter	Percentage 100% (n = 25)
Rhinitis	20%
Breathing problems	40%
Headache	92%
No sense of taste and/or smell	88%
Chest pain	44%
Sore throat	40%
Cough	80%
Sniffles	68%
Listlessness	72%
Aching limbs	96%

Data were presented by percentage (%) of 25 participants in the MS group.

Table 3. Time taken to perform the Rockport 1.5-mile run test

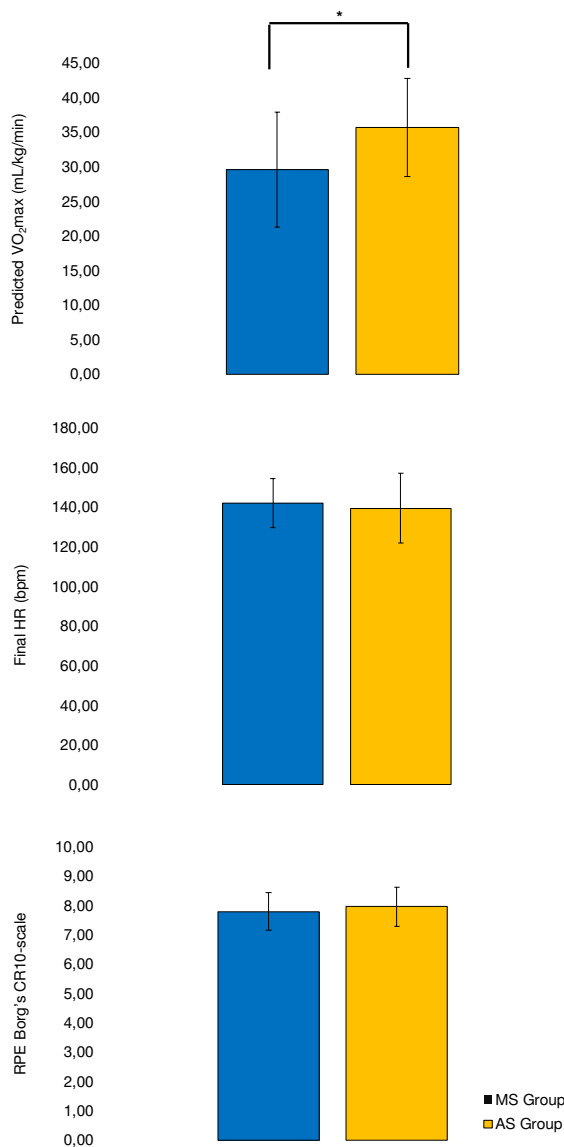
Variable	MS group (mean ± SD)	AS group (mean ± SD)	p-value	Effect size
Time (min)	17.3 ± 1.9	15.5 ± 1.2	0.001*	0.262

MS – mild symptomatic group, AS – asymptomatic group  
 Statistical analysis with One-way ANOVA with Independent *t*-test  
 \* statistically significant differences between MS and AS groups ( $p < 0.05$ )

Similarly, during the Rockport 1.5-mile run test, the ANOVA indicated no significant differences in RPE ( $p = 0.396$ , ES = 0.015) and HR ( $p = 0.563$ , ES = 0.007) variables. However, differences were observed in the duration of the Rockport 1.5-mile run test ( $p = 0.001$ , ES = 0.262). These were followed by the  $VO_{2max}$  results ( $p = 0.007$ , ES = 0.140), which indicated a higher level of fitness in the AS group.

**Discussion**

The primary result of this study indicated that asymptomatic subjects, particularly males, have the highest  $VO_{2max}$  value, surpassing those who are healthy. This is indicative of a high CRF level [6], which is related to the normal/optimal functioning of the immune system [7, 8]. These support the study of Le Bert et al. [24], that asymptomatic individuals have mounted a highly functional virus-specific cellular



MS – mild symptomatic group, AS – asymptomatic group  
 Statistical analysis with One-way ANOVA with Independent *t*-test  
 \* statistically significant differences between the MS and AS groups ( $p < 0.05$ )

Figure 2. Physiological differences between the AS and MS groups

immune response. Additionally, the conclusions of Long et al. [25] that asymptomatic individuals have a weaker immune response to SARS-CoV-2 infection, were refuted.

CRF is an indicator in determining the risk level for developing certain diseases [26, 27]. Specifically, it is often implemented in  $VO_{2max}$  calculations, and is a special attraction for study analysts as a focal point for investigation [28]. The primary objective was to establish a reference value of  $VO_{2max}$  within a given population, enabling the determination of health status [28–32]. For example, Sloan et al. [28] conducted a study involving 100 participants, employing the non-exercise fitness assessment (NEFA) method to measure  $VO_{2max}$ . The results showed values of  $35.2 \pm 5.0$  ml/kg/min and  $26.9 \pm 4.6$  ml/kg/min, for males and females, which indicated the standard for a healthy category within the Singaporean population.

Lee et al. [29], on the other hand, specifically stated that a low CRF can increase the risk of CV disease, type 2 diabetes mellitus, cancer, poor mental health, falls, and premature

death. Therefore, it was recommended that measures, such as exercise, be conducted to increase this index [28, 29]. Previous studies, including Sloth et al. [30], indicated that performing sports three times a week can increase  $VO_{2max}$ . Specifically, it was stated that exercise with an intensity of 60–80% of HRmax is effective in increasing the level of CRF. This statement is essential, as it aligns with other literature, such as the World Health Organization [26, 31].

This study represents the first attempt to measure the fitness level of COVID-19 patients with MS and asymptomatic conditions using the Rockport 1.5-mile run test. The selection of this test was based on its endorsement in previous studies as the safest fitness assessment [33]. This study provides quantitative evidence supporting previous observations that COVID-19 patients had a better fitness level. For example, Severa et al. [34] showed that asymptomatic patients have good immune resistance, explaining their lack of symptoms despite being infected. According to the results of this study, it appears that good immunity is produced by the presence of a high CRF level [19, 34].

This study, which was conducted in 2022, encouraged individuals to prioritise and enhance their CRF levels through regular exercise. Furthermore, it is believed to increase overall immunity, thereby reducing the risk of contracting COVID-19. However, the results support previous studies that by increasing immunity through exercise, the risk of contracting various diseases can be lower. Additionally, a study conducted by Ramania et al. [35] serves as a valuable reference for sports enthusiasts, emphasising the significance of enjoying physical activities while benefiting from positive social interactions and supportive environments. Such factors contribute to reduced cortisol levels and enhance the effectiveness of sports engagement.

The several limitations of this study include the limited size and sex distribution of COVID-19 samples that meet the criteria for this study, as they have to fit the number of patients under isolation on the day of data collection. The substantial number of asymptomatic patients, who are allowed to be discharged when the second swab test is negative, poses a challenge in recruiting an adequate sample size. Furthermore, it was realised that other factors, such as nutrition, psychology, and the circadian cycle of the participants, have not been thoroughly reviewed. Therefore, further studies are required to address aspects that have not been investigated.

## Conclusions

Asymptomatic patients performed the Rockport 1.5-mile better than mildly symptomatic patients indicating asymptomatic patients had a higher  $VO_{2max}$  level than mildly symptomatic patients. Therefore, moderate-intensity exercise is recommended to increase CRF, thereby enhancing immunity and reducing the risk of contracting COVID-19. This study encourages people to adopt a healthy lifestyle by paying attention to the CRF level as an indicator of healthy behaviour.

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## Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the local Clinical Research Ethical Com-

mittee POLTEKKES Bandung (approval No.: 04/KEPK/EC/III/2021). Additionally, approval was given for data collection by prioritising strict health protocols based on rules issued by the West Java Health Agency, according to the Indonesian Ministry of Health.

### Informed consent

Informed consent has been obtained from all individuals included in this study.

### Disclosure statement

No author has any financial interest or received any financial benefit from this research.

### Conflicts of interest

The authors state no conflicts of interest.

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### References

- [1] Liang C, Zhang W, Li S, Qin G. Coronary heart disease and COVID-19: a meta-analysis. *Med Clin*. 2021;156(11):547–54; doi: 10.1016/j.medcli.2020.12.017.
- [2] Cascella M, Rajnik M, Aleem A, Dulebohn SC, Di Napoli R. Features, Evaluation, and Treatment of Coronavirus (COVID-19). In: *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing; 2023.
- [3] Poon YR, Lin YP, Griffiths P, Yong KK, Seah B, Liaw SY. A global overview of healthcare workers' turnover intention amid COVID-19 pandemic: a systematic review with future directions. *Hum Resour Health*. 2022;20(1):70; doi: 10.1186/s12960-022-00764-7.
- [4] Ioannidis JPA. The end of the COVID-19 pandemic. *Eur J Clin Invest*. 2022;52(6):e13782; doi: 10.1111/eci.13782.
- [5] Chen Y-M, Zheng Y, Yu Y, Wang Y, Huang Q, Qian F, Sun L, Song Z-G, Chen Z, Feng J, An Y, Yang J, Su Z, Sun S, Dai F, Chen Q, Lu Q, Li P, Ling Y, Yang Z, Tang H, Shi L, Jin L, Holmes EC, Ding C, Zhu T-Y, Zhang Y-Z. Blood molecular markers associated with COVID-19 immunopathology and multi-organ damage. *EMBO J*. 2020;39(24):e105896; doi: 10.15252/embj.2020105896.
- [6] Piotrowicz K, Gałowski J, Michel JP, Veronese N. Post-COVID-19 acute sarcopenia: physiopathology and management. *Aging Clin Exp Res*. 2021;33(10):2887–98; doi: 10.1007/s40520-021-01942-8.
- [7] Yong SJ. Long COVID or post-COVID-19 syndrome: putative pathophysiology, risk factors, and treatments. *Infect Dis*. 2021;53(10):737–54; doi: 10.1080/23744235.2021.1924397.
- [8] Moghimi N, Di Napoli M, Biller J, Siegler JE, Shekhar R, McCullough LD, Harkins MS, Hong E, Alaoui DA, Mansueto G, Divani AA. The Neurological Manifestations of Post-Acute Sequelae of SARS-CoV-2 infection. *Curr Neurol Neurosci Rep*. 2021;21(9):44.; doi: 10.1007/s11910-021-01130-1.
- [9] Ejaz H, Alsrhani A, Zafar A, Javed H, Junaid K, Abdalla AE, Abosalif KOA, Ahmed Z, Younas S. COVID-19 and comorbidities: deleterious impact on infected patients. *J Infect Public Health*. 2020;13(12):1833–9; doi: 10.1016/j.jiph.2020.07.014.
- [10] Chen X, Hong X, Gao W, Luo S, Cai J, Liu G, Huang Y. Causal relationship between physical activity, leisure sedentary behaviors and COVID-19 risk: a Mendelian randomization study. *J Transl Med*. 2022;20(1):216; doi: 10.1186/s12967-022-03407-6.
- [11] Clavario P, De Marzo V, Lotti R, Barbara C, Porcile A, Russo C, Beccaria F, Bonavia M, Bottaro LC, Caltabellotta M, Chioni F, Santangelo M, Hautala AJ, Griffo R, Parati G, Corrà U, Porto I. Cardiopulmonary exercise testing in COVID-19 patients at 3 months follow-up. *Int J Cardiol*. 2021;340:113–8; doi: 10.1016/j.ijcard.2021.07.033.
- [12] Alawna M, Amro M, Mohamed AA. Aerobic exercises recommendations and specifications for patients with COVID-19: a systematic review. *Eur Rev Med Pharmacol Sci*. 2020;24(24):13049–55; doi: 10.26355/eurrev\_202012\_24211.
- [13] Fanget M, Bayle M, Labeix P, Roche F, Hupin D. Effects of cardiac telerehabilitation during covid-19 on cardiorespiratory capacities in patients with coronary artery disease. *Front Physiol*. 2022;13:837482; doi: 10.3389/fphys.2022.837482.
- [14] Besnier F, Bérubé B, Malo J, Gagnon C, Grégoire C-A, Juneau M, Simard F, L'Allier P, Nigam A, Iglésies-Grau J, Vincent T, Talamonti D, Dupuy EG, Mohammadi H, Gayda M, Bherer L. Cardiopulmonary rehabilitation in Long-COVID-19 patients with persistent breathlessness and fatigue: the COVID-rehab study. *Int J Environ Res Public Health*. 2022;19(7):4133; doi: 10.3390/ijerph19074133.
- [15] Stavrou VT, Vavougios GD, Boutlas S, Tourlakopoulos KN, Papayianni E, Astara K, Stavrou IT, Daniil Z, Gourgoulis KI. Physical fitness differences, amenable to hypoxia-driven and sarcopenia pathophysiology, between sleep apnea and COVID-19. *Int J Environ Res Public Health*. 2022;19(2):669; doi: 10.3390/ijerph19020669.
- [16] Fikenzler S, Kogel A, Pietsch C, Lavall D, Stöbe S, Rudolph U, Laufs U, Hepp P, Hagendorff A. SARS-CoV2 infection: functional and morphological cardiopulmonary changes in elite handball players. *Sci Rep*. 2021;11(1):17798; doi: 10.1038/s41598-021-97120-x.
- [17] Moulson N, Petek BJ, Drezner JA, Harmon KG, Kliethermes SA, Patel MR, Baggish AL; Outcomes Registry for Cardiac Conditions in Athletes Investigators. SARS-CoV-2 cardiac involvement in young competitive athletes. *Circulation*. 2021;144(4):256–66; doi: 10.1161/CIRCULATIONAHA.121.054824.
- [18] Singh TK, Zidar DA, McCrae K, Highland KB, Englund K, Cameron SJ, Chung MK. A post-pandemic enigma: the cardiovascular impact of post-acute sequelae of SARS-CoV-2. *Circ Res*. 2023;132(10):1358–73; doi: 10.1161/CIRCRESAHA.122.322228.
- [19] Gervasi SF, Pengue L, Damato L, Monti R, Pradella S, Pirroni T, Bartoloni A, Epifani F, Saggese A, Cuccaro F, Bianco M, Zeppilli P, Palmieri V. Is extensive cardiopulmonary screening useful in athletes with previous asymptomatic or mild SARS-CoV-2 infection?. *Br J Sports Med*. 2021;55(1):54–61; doi: 10.1136/bjsports-2020-102789.
- [20] Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, Doleshal P, Dodge C. A new approach to monitoring exercise training. *J Strength Cond Res*. 2001;15(1):109–15.
- [21] Papini GB, Carder C, Lightfoot CJ, Kubis HP, Bonomi AG, Sartor F. Quarter-mile walk test sensitive to training-induced fitness changes. *J Sports Med Phys Fitness*. 2019;59(11):1820–7; doi: 10.23736/S0022-4707.19.09445-3.
- [22] Weiglein L, Herrick J, Kirk S, Kirk EP. The 1-mile walk test is a valid predictor of  $VO_{2max}$  and is a reliable alternative fitness test to the 1.5-mile run in U.S. Air Force

- males. *Mil Med.* 2011;176(6):669–73; doi: 10.7205/milmed-d-10-00444.
- [23] Kline GM, Porcari JP, Hintermeister R, Freedson PS, Ward A, McCarron RF, Ross J, Rippe JM. Estimation of  $VO_{2max}$  from a one-mile track walk, gender, age, and body weight. *Med Sci Sports Exerc.* 1987;19(3):253–9.
- [24] Le Bert N, Clapham HE, Tan AT, Chia WN, Tham CYL, Lim JM, Kunasegaran K, Tan LWL, Dutertre C-A, Shankar N, Lim JME, Sun LJ, Zahari M, Tun ZM, Kumar V, Lim BL, Lim SH, Chia A, Tan Y-J, Tambyah PA, Kalimuddin S, Lye D, Low JGH, Wang L-F, Wan WY, Hsu LJ, Bertolotti A, Tam CC. Highly functional virus-specific cellular immune response in asymptomatic SARS-CoV-2 infection. *J Exp Med.* 2021;218(5):e20202617; doi: 10.1084/jem.20202617.
- [25] Long QX, Tang XJ, Shi QL, Li Q, Deng H-J, Yuan J, Hu J-L, Xu W, Zhang Y, Lv F-J, Su K, Zhang F, Gong J, Wu B, Liu X-M, Li J-J, Qiu J-F, Chen J, Huang A-L. Clinical and immunological assessment of asymptomatic SARS-CoV-2 infections. *Nat Med.* 2020;26(8):1200–4; doi: 10.1038/s41591-020-0965-6.
- [26] Kaminsky LA, Arena R, Myers J. Reference standards for cardiorespiratory fitness measured with cardiopulmonary exercise testing: data from the fitness registry and the importance of exercise national database. *Mayo Clin Proc.* 2015;90(11):1515–23; doi: 10.1016/j.mayocp.2015.07.026.
- [27] Ismail AMA. Physical training and ocular yogic exercise in home: good alternative options to control the high-tension form of primary open angle glaucoma during the repeated COVID-19 waves. *Int Marit Health.* 2021;72(3):243–4; doi: 10.5603/IMH.2021.0046.
- [28] Sloan RA, Haaland BA, Leung C, Padmanabhan U, Koh HC, Zee A. Cross-validation of a non-exercise measure for cardiorespiratory fitness in Singaporean adults. *Singapore Med J.* 2013;54(10):576–80; doi: 10.11622/smedj.2013186.
- [29] Lee DC, Artero EG, Sui X, Blair SN. Mortality trends in the general population: the importance of cardiorespiratory fitness. *J Psychopharmacol.* 2010;24(4 Suppl):27–35; doi: 10.1177/1359786810382057.
- [30] Sloth M, Sloth D, Overgaard K, Dalgas U. Effects of sprint interval training on  $VO_{2max}$  and aerobic exercise performance: a systematic review and meta-analysis. *Scand J Med Sci Sports.* 2013;23(6):e341–52; doi: 10.1111/sms.12092.
- [31] Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, Carty C, Chaput J-P, Chastin S, Chou R, Dempsey PC, DiPietro L, Ekelund U, Firth J, Friedenreich CM, Garcia L, Gichu M, Jago R, Katzmarzyk PT, Lambert E, Leitzmann M, Milton K, Ortega FB, Ranasinghe C, Stamatakis E, Tiedemann A, Troiano RP, van der Ploeg HP, Wari V, Willumsen JF. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med.* 2020;54(24):1451–62; doi: 10.1136/bjsports-2020-102955.
- [32] Ismail AMA. Online exercise rehabilitation to stable COPD patients during the second COVID wave: are physiotherapists able to help?. *Adv Rehabil.* 2020;34(4):48–9; doi: 10.5114/areh.2020.101592.
- [33] Rintala P, McCubbin JA, Downs SB, Fox SD. Cross validation of the 1-mile walking test for men with mental retardation. *Med Sci Sports Exerc.* 1997;29(1):133–7; doi: 10.1097/00005768-199701000-00019.
- [34] Severa M, Diotti RA, Etna MP, Rizzo F, Fiore S, Ricci D, Iannetta M, Sinigaglia A, Lodi A, Mancini N, Criscuolo E, Clementi M, Andreoni M, Balducci S, Barzon L, Stefanelli P, Clementi N, Coccia EM. Differential plasmacytoid dendritic cell phenotype and type I Interferon response in asymptomatic and severe COVID-19 infection. *PLoS Pathog.* 2021;17(9):e1009878; doi: 10.1371/journal.ppat.1009878.
- [35] Ramanian N, Iwo M, Apriantono T, Winata B. The effect of social interaction and environment on aerobic dance on salivary cortisol. *Physiother Q.* 2020;28(3):14–20; doi: 10.5114/pq.2020.95770.