How fit are military hyperbaric personnel after an asymptomatic or mild symptomatic COVID-19 infection? A retrospective study

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Abstract
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Introduction: In the diving community there is a special need to know if asymptomatic or mild COVID-19 disease impacts the cardiopulmonary functioning of individuals with occupational exposure to extreme environments. To date, no controlled studies have been conducted comparing COVID-19-infected hyperbaric employees and non-COVID-19-infected peers in a military setting.
Methods: Between June 2020 and June 2021, healthy, hyperbaric, military personnel aged between 18 and 54 years old, who had recovered from asymptomatic or subclinical COVID-19 disease at least one month earlier, were analysed. Non-COVID-infected peers with medical assessments during the same period were used as the control group. Somatometry, spirometry, VO_2 max, and DLCO were measured for each group.
Results: No clinically relevant differences in somatometry, lung function tests, and exercise testing were found between the COVID-19 group and the controls. However, the percentage of individuals with a decrease in estimated VO_2-max of 10% or more was significantly greater in the COVID group than in the control group (24 vs. 7.8%, $P = 0.004$).
Conclusions: After asymptomatic or mild symptomatic COVID-19 infections, military hyperbaric employees are as fit as those who had not encountered COVID-19. As this research was based on a military population, it cannot be extrapolated to a nonmilitary population. Further studies in nonmilitary populations are necessary to determine the medical relevance of the present findings.

Introduction

Since December 2019, the world has faced the spread of the SARS-CoV-2 virus, which causes the coronavirus disease known as COVID-19.[1] Coronaviruses infect epithelial cells throughout the respiratory tract. The majority of patients recover at home with only minor symptoms.[2] Histological research indicates that in patients hospitalised with COVID-19, infection can result in different types of pulmonary damage.[3] Whether this damage is permanent is still a point of debate. High-resolution computed tomography (HRCT) scans three months after discharge still showed radiological evidence of COVID-19 in 78% of severe cases, declining to 48% after six months.[4] Studies have demonstrated decreases in predicted diffusing capacity for carbon monoxide (DLCO), restrictive ventilatory defects, and small airway dysfunction in COVID-19 patients.[5]

Little is known about the extent to which these pathophysiological changes and changes in physiological pulmonary parameters also occur in asymptomatic or subclinical COVID-19 patients. One study reports a reduction in diffusion capacity of carbon monoxide (DLCO) as the main effect,[5] whereas other studies suggest radiological evidence of COVID-19 in asymptomatic and mild disease.[6–9] Furthermore, several studies relating to non-severe COVID-19 found a maximal oxygen uptake (VO_2-max) lower than expected after illness,[10–12] although others report no impairment.[13]

Multiple guidelines for the medical assessment of post-COVID-19 divers have been developed because of the major concern in the diving industry about the risk of COVID-19-induced pulmonary barotrauma (PBt).[14–16] Pathological predispositions to PBt include bullae and blebs.[17–19] Although there have been no published cases of divers

with PBt following COVID-19, numerous case reports have linked COVID-19 to bullae-associated pneumothorax,[20–23] even in mild cases of COVID-19.[24] Based upon the latter, and following DMAC 33 regulations,[15] a tailormade post-COVID-19 dive medical assessment of divers was implemented at the Royal Netherlands Navy Diving and Submarine Medical Centre (DMC).

Since many previous studies investigating the effect of mild COVID-19 on pulmonary function did not include baseline function data, it was not possible to ascertain whether abnormalities found were pre-existing or due to COVID-19. Consequently, there is still uncertainty regarding the long-term effects of COVID-19 on pulmonary function in both military divers and the general public.

The DMC has a large (historical) database of medical assessments relating to different diving- and hyperbaric-related occupations. This database was used to provide matched, non-COVID-19-infected individuals to act as the control group. This retrospective, cross-sectional study aimed to investigate whether changes in cardiopulmonary function occur in hyperbaric personnel after mild and asymptomatic COVID-19.

Methods

According to national law and legislation, retrospective analyses are not required to be evaluated by a medical ethics committee. Nevertheless, this study has been evaluated and granted permission by the Surgeon General of the Netherlands Armed Forces (reference number DOSCO2020036245). Furthermore, the methods used to handle personal details and privacy were in agreement with the guidelines of the Association of Universities in the Netherlands and the Declaration of Helsinki.

Medical assessments of military hyperbaric personnel, i.e., divers, chamber attendants, and submariners, of the Netherlands Armed Forces are performed annually at the DMC. All fitness-to-dive assessments are performed according to European Diving Technology Committee (EDTC) guidelines,[25] except that pulmonary function testing (PFT) results are interpreted relative to the Global Lung Initiative (GLI)-2012 reference set.[26] In June 2020, a post-COVID-19 dive medical assessment, adapted from the DMAC-33 guideline,[15] was adopted by DMC. In this study, we use the term 'hyperbaric' which refers to divers, chamber attendants and submariners.

SUBJECTS

The data used in this study were from participants who underwent a post-COVID-19 dive medical assessment for hyperbaric work in the period from June 2020 to June 2021. The data of subjects who tested positive, using either the reverse transcriptase-polymerase chain reaction test (RT-PCR) or serology for SARS-CoV-2, but were neither hypoxic nor hospitalised were included. Thus, only asymptomatic and mildly symptomatic patients were included. Furthermore, active disease or the absence of a previous record of relevant testing were also reasons for exclusion.

The intention was to couple two to three age-, sex-, and occupation-matched controls, who had never tested positive for COVID-19 but who had undergone their last medical in the same period as the COVID-19 group, to every person included in the COVID-19 group. This ensured that the control group had experienced similar disadvantages (e.g., closure of sporting facilities and working at home) as the COVID-19-positive group during the COVID-19 lockdown periods. In terms of age, a one year difference in birth year was accepted (e.g., someone born in 1990 could be coupled to someone born in 1989, 1990, or 1991).

DIVE MEDICAL ASSESSMENT

Regular annual dive medical assessments typically consist of somatometry, spirometry, and exercise testing, along with an interview and physical examination by the dive medical officer, as specified by EDTC guidelines. Post-COVID-19 dive medical assessment additionally included measurements of diffusing capacity and plethysmography. All personnel who came for a COVID-19 dive medical assessment were asked if their results could, anonymously, be used for research purposes. Only the results of those who agreed were included in this study database.

Spirometry, plethysmography, and diffusion capacity

Forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and DL_{CO} were measured on MS-PFT PRO (Vyaire, the Netherlands). All measurements were carried out by qualified respiratory technicians according to the European Respiratory Society / American Thoracic Society task force guidelines.[27,28] For DLCO, the single-breath method was used and is reported as DLCO corrected for haemoglobin. The predicted FEV_1 and FVC were calculated using the GLI reference values of 2012.[29] Residual volume (RV), vital capacity (VC), and total lung capacity (TLC) plethysmography measurements were carried out in a Vyaire Vyntus Body box (Vyaire, the Netherlands). For plethysmography, the current GLI reference values of 2021 were used.[30] For DL_{CO} predicted values, the GLI 2017 reference values were used.[27] Calibration was performed following the manufacturer's instructions.

Exercise testing

Maximal exercise capacity tests were performed with an Excalibur Sport ergometer (Lode, the Netherlands) based on a weight-dependent protocol in which the test starts with a power of 1 watt·kg^{-1} body weight during the first minute, with incremental increases of 0.5 watt·kg^{-1} body weight and 0.25 watt·kg^{-1} body weight in the second and

third minutes, respectively, until exhaustion. The load was raised once per minute. All testing was done as advised in the American Thoracic Society protocol.[31] In this paper, the term estimated VO_2-max (eVO_2-max) will be used to express the calculated VO_2-max. All electrocardiographs (ECGs) were taken with a Vyaire Vyntus ECG (Vyaire, the Netherlands). Due to COVID-19 regulations, it was not possible to use breath analysis for testing carried out at the beginning of the pandemic. Thus, it was decided to calculate VO_2-max using the formula below developed by the DMC where W_{MAX} = maximal load (Watts), A = age (years), W = weight (kg).

$$Male: VO_2max\ (ml\ O_2 . kg^{-1} . min^{-1}) = \frac{(10.00 * Wmax) - (7.71 * A) + 738.77}{W}$$

$$Female: VO_2max\ (ml\ O_2 . kg^{-1} . min^{-1}) = \frac{(10.78 * Wmax) + 175.76}{W}$$

STATISTICAL ANALYSIS

As only a handful of studies have been published with subclinical COVID-19 patients, the sample size estimation was rather difficult. The threshold for the COVID-19 group was set at a minimum of 50 subjects since the sample size of other studies at the time of data gathering was at least 33.[5]

Analysis of data was blinded and performed with SPSS Statistics 23 (IBM Corporation), VassarStats (http://vassarstats.net) and SISA (https://www.quantitativeskills.com/sisa/). The latter two were used for their Freeman-Halton extension of Fisher's exact test. All data were first tested for normality using the Shapiro-Wilk test. Continuous variables were compared using an independent or two-tailed-sample, *t*-test, or a rank-sum test in the case of nonparametric data. Finally, a linear regression analysis was performed to test whether changes were time-dependent. A probability (*P*) value of less than 0.05 was considered significant.

Results

Fifty-one post-COVID-19 subjects and 125 healthy controls were included in this study. The baseline characteristics of the post-COVID-19 and control groups were not statistically different (Table 1); however, those in the post-COVID-19 group had their latest dive medical assessment significantly later than those in the control group (1.5 y [IQR 1.75 y] vs 1 y [IQR 1 y], respectively; $P = 0.023$). On average, the post-COVID-19 group had their post-COVID-19 dive medical assessment 1 month (IQR 2.0 months) after their positive COVID-19 test.

SOMATOMETRY

The post-COVID-19 group had a significantly higher body fat percentage (Δfat percentage 2.1% [SD 3.1]) than the control group (0.6% [2.4]; $P = 0.002$). However, the skinfold thickness measurement method has an error of up to 3.5% for women and up to 5% for men.[32]

LUNG FUNCTION TESTING

None of the pre-post parameters for diffusion capacity and plethysmography varied significantly between the COVID-19 and control groups. This was also the case for spirometry except for the change in FEV_1 (ΔFEV_1), which had a significantly greater decline in the control group than in the post-COVID-19 group (Tables 2 and 3). However, this difference in ΔFEV_1 falls within the coefficient of variation.[33] Finally, there was no correlation between DLCO % of predicted or change in DLCO % of predicted (ΔDL_{CO}) and either age or months after illness.

EXERCISE TESTING

The absolute value of eVO_2-max did not differ significantly between the two groups. By contrast, compared with baseline, there was a significant decline in eVO_2-max (ΔeVO_2-max) in the post-COVID-19 group (-0.99 $mL \cdot kg^{-1} \cdot min^{-1}$, IQR 5.93) when compared to the control group (+0.13 $mL \cdot kg^{-1} \cdot min^{-1}$, IQR 3.12; $P = 0.020$). This was also the case for the percentage change (post-COVID-19: -2.4%, IQR 13.9; control: +0.3%, IQR 3.12; $P = 0.028$). Although these differences are statistically significant, they are nevertheless small in absolute terms. Interestingly, the proportion of subjects with a decrease of more than 10% in eVO_2-max was significantly higher in the post-COVID-19 group than in the control group (24% vs 7.8%, $P = 0.004$). It is important to mention that although 24% of our COVID-19 positives had a decrement of more than 10% in eVO_2-max, all were still fit enough to pass their assessment for hyperbaric work. All other categories and parameters were statistically equivalent between the groups. Finally, there was no correlation between ΔeVO_2-max and the time elapsed since COVID-19 infection (Figure 1).

Discussion

The present study showed no clinically relevant differences in somatometry, lung function, or exercise testing between a post-COVID-19 group and a previously uninfected control group. However, the number of subjects with more than a 10% reduction in their eVO_2-max relative to their baseline data was significantly higher in the post-COVID-19-group than in the control group.

To the best of our knowledge, this is the first study to compare the pre-post effect of COVID-19 on lung function and exercise testing in hyperbaric workers previously infected with COVID-19 and in a previously uninfected control group. By contrast, several studies on the effect of COVID-19 on lung function parameters in patients or athletes have been published. Pre- and post-COVID spirometry data showed no significant difference in FEV_1 or FVC between COVID-19 and uninfected controls.[12,13,34,35] Indeed, in a previous review paper, it was stated that spirometry indices appear to be well preserved.[5] Thus, the results of our study align with these previous findings.

Table 1

Main baseline characteristics of the two study groups; data are mean (SD) for normally divided parameters and median (IQR, μ = mean) for non-normal parameters; DLCO – diffusing capacity for carbon monoxide; FEV_1 – forced expiratory volume in one second; FVC – forced vital capacity; HRmax – maximum heart rate; IQR – interquartile range; SD – standard deviation; TLC – total lung capacity; VC – vital capacity; eVO_2max – estimated maximum rate of oxygen consumption

Parameter	COVID+ (*n* = 51)	CONTROL (*n* = 125)	*P*
Age	30.00 (IQR 8, μ = 31.78)	31.00 (IQR 11, μ = 32.66)	0.497
Male Female	49 (96.1%) 2 (3.9%)	123 (98.4%) 2 (1.6%)	0.581
Height (cm)	183 (SD 7.6)	184 (SD 6.8)	0.726
Weight (kg)	86.0 (SD 12.5)	86.6 (SD 11.5)	0.767
Body mass index ($kg \cdot m^{-2}$)	25.4 (SD 2.4)	25.6 (SD 2.7)	0.962
Fat percentage *n*	15.8 (IQR 5.5, μ = 16.4) 48	15.8 (IQR 6.2, μ = 16.5) 111	0.754
Occupation *Diver* *Submariner* *Special Forces* *Other*	 32 (62.7%) 10 (19.6%) 7 (13.7%) 2 (3.9%)	 77 (61.6%) 27 (21.6%) 19 (15.2%) 2 (1.6%)	0.804
Smoking status *Never* *Active* *Former*	 32 (62.7%) 10 (19.6%) 9 (17.6%)	 71 (56.8%) 22 (17.6%) 32 (25.6%)	0.527
Smoking pack years *n*	3.5 (IQR 6.45, μ = 4.19) 19	4.05 (IQR 5.63, μ = 5.33) 54	0.330
FEV_1 (L) FEV_1 Z-score *n*	4.63 (SD 0.58) -0.14 (SD 0.78) 51	4.74 (SD 0.61) 0.0 (SD 0.80) 123	0.316 0.275
FVC (L) FVC Z-score *n*	5.96 (SD 0.82) 0.25 (SD 0.82) 51	6.01 (SD 0.76) 0.27 (SD 0.83) 123	0.679 0.841
FEV_1/FVC FEV_1/FVC Z-score *n*	77.78 (SD 4.48) -0.65 (SD 0.64) 51	78.90 (SD 4.55) -0.48 (SD 0.68) 123	0.141 0.118
RV (L) *n*	1.65 (SD 0.48) 27	1.53 (SD 0.31) 21	0.314
VCmax (L) *n*	6.17 (SD 0.77) 30	6.51 (SD 0.83) 21	0.138
TLC (L) *n* TLC % of predicted *n*	7.90 (SD 1.09) 27 105.5 (IQR 14.6, μ = 104.9) 26	8.03 (SD 1.00) 21 104.6 (IQR 17.0, μ = 105.0) 21	0.666 0.856
DLCO ($mmol \cdot min^{-1} \cdot kPa^{-1}$) DLCO % of predicted *n*	11.67 (SD 1.90, n = 32) 101.7 (SD 14.4) 32	12.13 (SD 1.68, n = 33) 102.3 (SD 8.7) 33	0.306 0.838
Wmax (watt) *n*	324 (SD 50) 50	324 (SD 45) 122	0.920
eVO_2-max ($ml \cdot kg^{-1} \cdot min^{-1}$) *n*	43.69 (IQR 6.52, μ = 43.78) 50	42.68 (IQR 6.63, μ = 43.10) 122	0.284
HRmax ($beats \cdot min^{-1}$) *n*	186 (IQR 20, μ = 184) 50	185 (IQR 11, μ = 186) 122	0.550

Table 2

Main post-measurement characteristics of the two study groups; data are mean (SD) for normally divided parameters and median (IQR, μ = mean) for non-normal parameters; DLCO – diffusing capacity for carbon monoxide; FEV_1 – forced expiratory volume in one second; FVC – forced vital capacity; HRmax – maximum heart rate; IQR – interquartile range; SD – standard deviation; TLC – total lung capacity; VC – vital capacity; eVO_2max – estimated maximum rate of oxygen consumption

Parameter	COVID+ (*n* = 51)	CONTROL (*n* = 125)	*P*
Age	31.0 (IQR 9, μ = 33.9)	32.0 (IQR 10, μ = 34.5)	0.609
Years since previous medical *n*	1.50 (IQR 1.75, μ = 2.17) 51	1.00 (IQR 1.00, μ = 1.69) 124	0.023
Months since infection	1.0 (IQR 2.0, μ = 2.5)	N/A	N/A
Weight (kg)	87.4 (SD 12.3)	86.6 (SD 11.6)	0.773
Body mass index ($kg \cdot m^{-2}$)	26.3 (IQR 3.4, μ = 25.9)	25.4 (IQR 3.4, μ = 25.6)	0.340
Fat percentage *n* Δ Fat percentage *n*	18.4 (IQR 4.4, μ = 18.0) 47 2.1 (SD 3.1) 46	16.8 (IQR 6.2, μ = 17.5) 117 0.6 (SD 2.4) 105	0.165 **0.002**
FEV_1 (L) *n* FEV_1 Z-score *n* ΔFEV_1 (L) *n*	4.62 (SD 0.57) 50 -0.04 (SD 0.81) 50 -0.01 (SD 0.31) 50	4.62 (SD 0.57) 123 -0.13 (SD 0.74) 123 -0.12 (SD 0.21) 121	0.953 0.476 **0.023**
FVC (L) *n* FVC Z-score *n*	5.94 (SD 0.75) 50 0.31 (SD 0.78) 50	5.92 (SD 0.72) 123 0.17 (SD 0.80) 123	0.898 0.320
FEV_1/FVC *n* FEV_1/FVC Z-score *n*	77.76 (SD 5.67) 50 -0.58 (SD 0.82) 50	78.25 (SD 5.17) 123 -0.51 (SD 0.76) 123	0.583 0.619
RV (L) *n*	1.59 (SD 0.39) 50	1.56 (SD 0.45) 13	0.815
VCmax (L) *n*	6.04 (SD 0.77) 50	6.08 (SD 1.00) 13	0.891
TLC (L) *n*	7.62 (SD 0.95) 50	7.63 (SD 1.24) 13	0.959
DLCO ($mmol \cdot min^{-1} \cdot kPa^{-1}$) *n*	11.26 (SD 1.69) 50	11.70 (SD 2.66) 18	0.519
Wmax (Watt) *n*	320 (SD 53) 51	328 (SD 44) 119	0.325
eVO_2-max ($ml \cdot kg^{-1} \cdot min^{-1}$) *n* Δ eVO_2-max ($ml \cdot kg^{-1} \cdot min^{-1}$) *n* % change eVO_2-max Categorial % change eVO_2-max *>-10%* *-10 to 0%* *0 to 10%* *>10%*	42.41 (IQR 4.88, μ = 42.23) 46 -0.99 (IQR 5.93, μ = -1.57) 50 -2.4% (IQR 13.9, μ = -3.0) 12 (24%) 18 (36%) 17 (34%) 3 (6%)	42.20 (IQR 6.74, μ = 43.35) 118 0.13 (IQR 3.12, μ = 0.22) 115 0.3% (IQR 7.3, μ = 0.59) 9 (7.8%) 39 (33.9%) 58 (50.4%) 9 (7.8%)	0.435 **0.020** **0.028** **0.004** 0.795 0.053 0.683
HRmax ($beats \cdot min^{-1}$) *n*	185 (IQR 16, μ = 183) 51	184 (IQR 11, μ = 183) 118	0.742

Table 3
Before and after spirometric parameters for COVID-19+ subjects; data are mean (SD); FEV_1 – forced expiratory volume in one second; FVC – forced vital capacity; TLC – total lung capacity

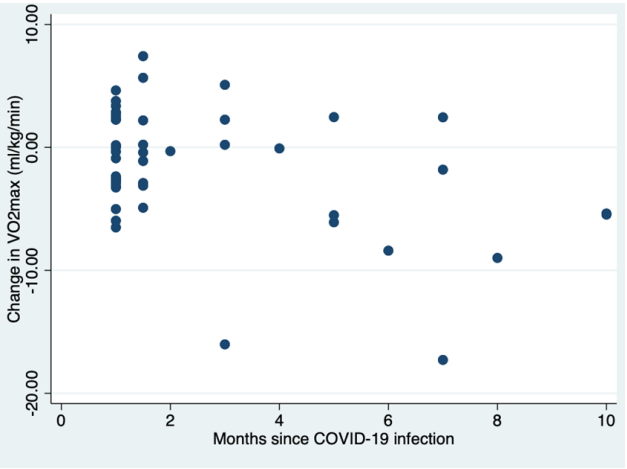
Parameter	COVID +		*P*
	Pre	Post	
FEV_1 (n = 50)	4.63 (0.59)	4.62 (0.57)	0.852
FVC (n = 50)	5.94 (0.81)	5.94 (0.75)	0.298
TLC (n = 26)	7.80 (0.96)	7.85 (0.83)	0.358

Consistent with the spirometry data, we did not find any indication of restriction or alteration in TLC after mild or asymptomatic COVID-19. This is in contrast to recent studies that found restriction and decrease in TLC as the most common abnormalities.[5] However, the subjects in those studies were severe, hospitalised patients, whereas our subjects consisted of asymptomatic or only mild symptomatic COVID-19 patients, which suggests that mild COVID-19 does not generate any restriction or changes in TLC. This has been supported by studies that suggest that restriction worsens with increasing severity of COVID-19.[5]

In the present study, DL_{CO} was unaffected by COVID-19 infection, which is comparable to those of some previous studies.[36,37] Although this seems to contradict the common finding that DL_{CO} is decreased in COVID-19 patients one has to keep in mind that the percentage of DL_{CO} predicted (%DL_{CO} pred) was unaffected in patients with mild illness but was lower in patients with severe illness.[37] Furthermore, in most studies, the mean age of subjects was higher than that of the subjects in our study, which could have influenced DL_{CO} values since increased age is associated with a graver course of COVID-19.[38] In addition, most studies were conducted at the time of patient discharge or within 30 days after discharge. It is possible that DL_{CO} improves most in the months immediately after COVID-19 infection.[39,40] Our study does not support this as we found no linearity or statistical significance in %DL_{CO} pred or difference between individual pre-COVID-19 and post-COVID-19 values, for any period of time after infection or for any age.

In the present study, we did not find a significant difference in eVO_2-max between the COVID-19 population and the control group. This is in line with a recent study that found that mild or asymptomatic COVID-19 does not influence average VO_2-max.[13] One can hypothesize that the mild course of the disease in asymptomatic or mild symptomatic patients may have enabled them to restart training faster and recuperate more quickly from the detraining effect of COVID-19 illness than severe symptomatic patients. Indeed, a previous study reported that post-COVID-19 subjects who received six weeks of rehabilitation improved their six-minute walking distance (6MWD) by 50 metres, while no improvement was observed for the group who did not undergo rehabilitation, which supports the detraining hypothesis.[40]

Figure 1
Correlation between ΔVO_2-max (ml $O_2 \cdot kg^{-1} \cdot min^{-1}$) and months since infection with COVID-19 in the COVID+ group



Recently, it was reported that the percentage of recruits who had a decline of more than 10% in VO_2-max was significantly higher in a COVID-19 symptomatic group than in either COVID-19 asymptomatic or noninfected groups (18.8% vs 1.9% and 0%).[11] The reverse applied to recruits with an increase of more than 10% in their VO2-max; while none of the COVID-19 symptomatic recruits had an increase of more than 10%, the noninfected and asymptomatic groups had increases of 13.9% and 7.6%, respectively. Similar results were obtained in the present study; while 24% of the COVID-19-positive group had a decreased eVO_2-max of more than 10%, only 7.8% of the COVID-19-negative group had a decreased eVO2-max of 10% or more. By contrast, the proportion of individuals with an eVO_2-max increase of more than 10% was not statistically significantly different between the two groups. We suggest that the non-significant increase in VO_2-max could be because subjects did not engage in sports on a daily basis, which is in contrast to military recruits who perform basic military training regularly.[41]

Based on the above, we hypothesize that the significant increase in the proportion of hyperbaric personnel who showed a > 10% decrease in eVO_2-max in the COVID-19 group in this study was not due to COVID-19 directly but to a detraining effect. Dive medical assessments in the future are needed to test this hypothesis. Yet, more importantly, the present results underline the importance to use exercise capacity as a parameter for returning to hyperbaric work as has been suggested by others.[42]

The strengths of this study include its study design, sample size, the inclusion of only asymptomatic or mild

symptomatic hyperbaric personnel, the use of a control group, and practical relevance for professional hyperbaric work. Nevertheless, the study has some limitations.

First, our subjects were stratified based on the result of their PCR test. Asymptomatic subjects were only included in the COVID-19 group if they had undergone a PCR test for other purposes (e.g., travel or part of contact tracing research) and had tested positive. Asymptomatically infected individuals who had not undergone a PCR test could have been erroneously assigned to the control group. As we do not know to what extent this occurred, it is possible that this oversight could have biased the results of the control group. For the purpose of this study, we had to rely on the honesty of divers to report any illnesses and the results of their PCR tests.

Second, for some outcome measures, data were unavailable for subjects in the control group because not all measurements are standardly performed at every regular dive medical assessment. For example, data for only a small group of control subjects were available for determining the pre-post values of both DL_{CO} and plethysmography.

Third, it should be considered that our data gathering was performed during the period when the Alpha and Delta SARS-Cov-2 variants were most prevalent, and most people were not vaccinated. Vaccination status and virus variants could influence clinical outcomes and thus lung function outcomes. A follow-up study with enhanced knowledge of patient infection and vaccination status may shed light on this limitation.

Finally, the vast majority of our study population was male, with only two females in the COVID-19 group and two female matched-controls. We do not think this biased our results as it was reported that age, but not gender, had an impact on the recovery of mild-to-moderate COVID-19 patients.[43] However, to investigate any gender influence, a more balanced male-female population would be needed in future studies.

Conclusion

The present study is the first to measure pre-post changes, relating to lung function and exercise testing, in asymptomatic or mild symptomatic COVID-19 hyperbaric personnel and a matched control group. Based on the results of this study, we concluded that there are no negative effects on either lung function or exercise testing due to asymptomatic or mild symptomatic COVID-19 infection. Since our study population primarily comprised male, hyperbaric employees who were in good physical condition before being infected by COVID-19, this conclusion cannot be generalised to the whole hyperbaric population. Further studies with different populations will be necessary to determine the dive medical relevance of the present findings.

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