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Persistent dyspnea, declined moderate to vigorous physical activity, functional status, and quality of life during the post-acute phase of COVID-19 infection: A pilot case control study.

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Abstract

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Purpose: The purpose of this study was to explore the multifaceted impacts of post-acute phase of COVID-19 infection on the sense of dyspnea, select intensities of physical activity, functional, and psychological variables among survivors compared to age matched healthy participants and their implications for rehabilitation programs in this population.

Methods: Seventy-eight (male, female age 30-70 yrs.) participants (39 COVID-infected, CI and 39 age-matched healthy controls, HC). Four questionnaires were used to assess the variables in this study: dyspnea scale of the Modified Medical Research Council (mMRC), International Physical Activity Questionnaire (IPAQ), Functional Status Questionnaire (FSQ), and the RAND-36 measure of health-related quality of life. A Mann Whitney test was used to compare the variables data between HC and CI.

Results: Dyspnea scores in CI group were significantly higher than in HC group (mean = 1.77 vs 0.13). Scores of IPAQ, FSQ and RAND-36 HRQoL questionnaires were also significantly lower in CI than in HC group. However, sitting and walking activity scores of IPAQ were not significantly different between both groups.

Conclusions: The results of the CI group were significantly different than the HC group in all parameters (except sitting and walking components of the IPAQ) of the questionnaires used in this study. Our findings provide the multi-disciplinary rehabilitation professionals the opportunity to tailor their interventions to meet the specific needs of COVID-19 survivors.

Keywords

COVID-19, dyspnea, physical activity, functional status, quality of life

Introduction

The symptoms of COVID-19 infection appear after a period of incubation that lasts approximately 5.2 days (Li et al., 2020; Rothan & Byrareddy, 2020). Common symptoms include fever, cough, and general weakness along with other symptoms including vomiting, headache, sputum production, haemoptysis, diarrhoea, dizziness, chest tightness and dyspnea (Huang et al., 2020; Ren et al., 2020; Shi et al., 2020). According to Shi et al. (2020), dyspnea is among the most common symptoms in these individuals. While the cause of dyspneic symptoms remains poorly understood to date, predominant theories suggest diffuse lung injury, pulmonary inflammation, interstitial edema, and microvascular pulmonary thrombosis are likely responsible (Cascella et al., 2020; Menter et al., 2020; Rubin & Crowe, 2020). In addition, some patients may also present with severe cardiovascular damage (Zheng et al., 2020), neurological concerns such as headache, dizziness, myalgia and/or fatigue, anomia, anorexia, ageusia (Chen et al., 2020; Gupta et al., 2020; Huang et al., 2020), and in some severe cases, presentations such as confusion, and impaired consciousness are also reported (Mao et al., 2020; Pilotto et al., 2020). Furthermore, some patients experience debilitating muscle weakness that occurs particularly in the presence of an acute hospitalization stay (Bagnato et al., 2020; Xiong et al., 2021). Similar to the presentation of acute respiratory distress syndrome, it can be expected that these symptoms may last long into the post-acute care rehabilitation period and contribute to lasting functional decline (Bagnato et al., 2020; De Biase et al., 2020; Herridge et al., 2003; O'Donnell et al., 2019; Pfoh et al., 2016; Woods et al., 2020; Xiong et al., 2021).

It is estimated that 50% of COVID-19 survivors will require some form of medical or social care including rehabilitation for a long period of time after recovery from the initial illness (Thornton, 2020). Rehabilitation services for COVID-19 survivors generally take five forms: exercise to improve cardiorespiratory fitness; performing functional activities; psychosocial interventions; education/self-management; and personalized actions to meet survivors' specific needs (Farkash et al., 2020; Wade, 2020b). During the post-acute phase of COVID-19 infection, fatigue, exertional dyspnea and significant cardiac diastolic abnormalities were the most reported common symptoms after 180 days of discharge from hospital among the survivors of the virus (Fayol et al., 2021; Q. Wu et al., 2021). It has been also reported that after 2-3 days post infection date of COVID-19, 64% of the recovered patients experienced dyspnea and 55% experienced fatigue (Raman et al., 2021).

To date, available literature has reported rehabilitation needs in general terms to address breathlessness, neuropsychological, speech, pain, fatigue, nutrition, daily activities and health-related quality of life among other concerns

(Halpin et al., 2021; Wade, 2020a). As the pandemic continues, more investigations are needed to identify the specific rehabilitation needs and the length of rehabilitation programs for the survivors of the COVID-19. Therefore, there is a lack of studies investigating the multifaceted impact of post-acute phase of COVID-19 infection on the ability to perform different intensities of physical activities, functional status, and quality of life parameters when compared to aged-matched healthy control sample groups. This latter point is specifically important because healthy individuals are also exposed to pandemic-related restrictions and concerns that can also negatively affect their physical and psychosocial wellbeing (Ammar et al., 2020; Hossain et al., 2020). Therefore, the purpose of this study was to explore the multifaceted impacts of post-acute phase of COVID-19 infection on the sense of dyspnea, select intensities of physical activity, functional, and psychological variables among survivors compared to age matched healthy participants and their implications for rehabilitation programs in this population. We hypothesized that COVID-19 infected participants will have deficits in physical, functional performance and some psychological parameters compared with age-matched healthy controls.

Methods

Study design and participants

This was an observational case control cohort study, whereby we recruited participants both with (COVID infected or CI) and without (Healthy Control or HC) a prior diagnosis of COVID-19 infection by word of mouth through posts on social media for a period of two months (October 20th-December 20th, 2020). Due to the limitation set by the pandemic itself, data was collected using a sample of convenience via an online survey. The participants in this study were from five different countries (3 continents) around the world and not limited to Canadians only (n=CA=30, USA=4, UK=3, Iran=1, and Thailand=1). The global participation formed 23% of the total number of the participants. Consenting participants completed an online survey using 4 standardized questionnaires (detailed below). The responses of the participants in both groups to the 4 questionnaires reflected their status at the time of taking the survey and not at the time of infection (i.e., time of infection for CI group only). All cases of infection among the infected participants with COVID-19 were self-reported (i.e., medically diagnosed with positive COVID-19 test). Since the median time from the date of COVID-19 infection and clinical recovery in mild-severe cases is about 2-4 weeks (Callard & Perego, 2021; Greenhalgh et al., 2020), all our infected participants can be considered in their post-acute phase. This study was approved by the University of Saskatchewan Research Ethics Board (Bio-REB ID: 2312).

Inclusion criteria stated that any individual who survived the COVID-19 infection (male and female) between 30-70 years can participate in this study. The rationale behind choosing this age range was based on an epidemiological summary findings (n = 8 614) in Canada showed that individuals at age ranges (40-59, 20-39 and 60-79 years-old) had the highest infection cases (35%), (28%) and (24%), respectively (Notes, 2020)**.** For the healthy control group, subjects were age-matched (30-70 years) but not gender-matched due to difficulties of recruiting participants and the time-sensitive nature of the current study. Participants with pre-existing chronic cardiovascular, pulmonary (other than being infected with COVID-19 and survived the illness for the infected group), musculoskeletal disorders were excluded from starting the study. Questionnaires were delivered electronically (SurveyMonkey Inc., San Mateo, California, USA) to participants following digital provision of informed consent. To ensure attaining reliable and accurate data (i.e., responses) from the participants, a detailed instruction on how to complete the survey were provided both in the consent form and before giving their responses in each section in each questionnaire used in the survey. In addition, participants were instructed to ask any questions on how to complete the survey from the research team via email or direct phone calls before taking the survey.

Modified Medical Research Council Dyspnea Scale (mMRC). The mMRC scale (Doherty,2006) is a modified version of the original MRCDS (Fletcher et al., 1959) which utilizes the same descriptors as the original MRC scale. Specifically, the mMRC scale has descriptors numbered from 0-4 and is used for calculation of BODE index (Munari et al., 2018). The mMRC has been validated to assess the dyspneic symptoms of chronic obstructive pulmonary disease (COPD) (Munari et al., 2018). Since COVID-19 and COPD patients each suffer from dyspnea, (Beauchamp et al., 2010; O'Donnell, 2006; Shi et al., 2020) it is reasonable to use this scale/questionnaire to assess the impact of COVID-19 on the lungs among the survivors of this disease, although it has not been validated specifically for COVID-19 survivors. The mMRC has shown to be superior compared to COPD assessment test (CAT) in predicting the level of physical activity in a daily life (PADL, a measure that is associated with lung function) among COPD patients (Munari et al., 2018). The minimal clinical importance difference (MCID) value for this scale was reported as 0.5 unit when it was used to monitor improvement after 3 weeks of pharmacological treatment in patients with acute exacerbations of COPD (Araújo Oliveira et al., 2017).

The International Physical Activity Questionnaire (IPAQ). The IPAQ (Deng et al., 2006) was used to obtain internationally comparable data on health-related physical activity. The IPAQ (short, self-administered methods) contains 7 questions related to 3 categories of moderate, high, and vigorous activity levels. For IPAQ scoring, the total MET-minutes/week was calculated as walk (METs=3.3×min×days) + moderate activity (METs=4.0×min×days) + vigorous

activity (METs=8×min×days) (Deng et al., 2006). Since COVID-19 infected individuals usually experience symptoms such as general weakness, chest tightness and dyspnea (Huang et al., 2020; Ora et al., 2020; Ren et al., 2020; Shi et al., 2020; Zhang et al., 2020) and these can negatively affect the ability of these individuals to perform physical activity, it is rational to utilize this questionnaire for the purpose of assessing the ability for performing physical activity. Validity of the moderate and vigorous activity portions were reported as (r = .430–.557) and (r = .702) for sedentary behaviours during the weekdays among older adults (Cleland et al., 2018). MCID values were not available for IPAQ at the time of writing this research.

The Functional Status Questionnaire (FSQ). The FSQ (Jette et al., 1986) is a short-self-administered questionnaire used for functional assessment of ambulatory patients seen in primary care. It provides comprehensive information related to patient's physical function in the activities of daily living, psychological, social and role functions and variety of performance measures. This questionnaire is designed for initial screening of disability and for monitoring meaningful changes in patients' clinical status over time. It was developed by groups of researchers from Boston's Beth Israel Hospital and the University of California at Los Angeles. We selected this questionnaire because it provides useful information about an array of physical and psychosocial parameters that get unfavorably affected in individuals infected with COVID-19 (Bohmwald et al., 2018; Huang et al., 2020; Ora et al., 2020; Ren et al., 2020; Shi et al., 2020; Zhang et al., 2020)**.** In a reliability study, the six scales in this questionnaire achieved internal consistency ranging from 0.64 to 0.82 (Jette et al., 1986). MCID values were not available for the FSQ at the time of writing this research.

The RAND-36 measure of health-related quality of life questionnaire. The RAND-36 (Hays et al., 2016) is a widely used generic health related quality of life (HRQoL) survey instrument. It includes 36 items which evaluates eight health related concepts: physical functioning, role limitations caused by physical health problems, energy/fatigue, pain, emotional wellbeing, role limitations caused by emotional problems, social functioning, and general health perceptions. In addition, this questionnaire is a profile that provides two summary scores for physical and mental health (Hays et al., 2016). The rationale behind using this questionnaire was due it offering valuable data about parameters that FSQ did not cover; such as energy/fatigue, pain, emotional wellbeing that adversely affected in infected people with COVID-19 (Huang et al., 2020; Mechanisms, 2019; Mullen et al., 2011; Ora et al., 2020; Ren et al., 2020; Shi et al., 2020; Sun et al., 2020; Zhang et al., 2020)**.** This questionnaire was scored by linear transformation of each item to a 0–100 range (% of total possible score) and averaged (Hays et al., 2016)]. The MCID values for this questionnaire's eight parameters were reported as (10, 12.5, 12.5, 10, 10, 8.3, 12.5, and 10 point/100) for the physical functioning, role limitations

caused by physical health problems, energy/fatigue, pain, emotional wellbeing, role limitations caused by emotional problems, social functioning, and general health perceptions, respectively when it was utilized to detect improvements in COPD patients (Wyrwich et al., 2005).

Statistical analyses

Statistical analyses were be performed using SPSS version 26 (IBM Corp., Armonk, New York, USA). Demographic data was presented as mean and SD. Non-parametric data obtained for the questionnaires and demographics are reported as medians, ranges, interquartile range (IQR) and percentages. A Mann-Whitney test was used to compare the variable data between the two groups. Statistical significance was determined when $p < 0.05$.

Results

One hundred and eighty-eight individuals accessed the survey over the period of 2 months (between October and December 2020). Participants with incomplete responses were excluded leaving 39 COVID-19 infected and 75 healthy controls. From the healthy control group, 39 control participants were randomly selected based on age matching (Table 1). The percentage of males vs females were 18% versus 82% and 25% versus 75% in the IC and HC groups, respectively. The dates of infection of the participants in the experimental group occurred between January 2 and November 23, 2020. The average recovery period was (187 ± 88 days) from the date of infection till the date of taking the survey by infected participants. Nine of these participants were hospitalized (hospitalization periods ranged from 1-14 days, only 2 participants were in ICU for 4 and 23 days) while the other 30 were not hospitalized. All hospitalized participants confirmed that they were hospitalized as a result of being infected with COVID-19. The final sample size for the RAND-36 (HRQoL) questionnaire, however, was 76 participants (38 participants for each group) due to an incomplete response by a participant in the infected group.

Table 1. *Demographics information for the CI and HC groups presented as mean and SD values*.

Demographics	CI n = 39 & 38	HC n = 39 & 38
Age/yrs.	47.4 ±8.2	46.1 ±9.0
Weight/kg	77.6 ±14.9	79.5 ±24.6
Height/cm	169.2 ±8.7	167.3 ±9.0

CI: COVID-19 infected, HC: Healthy control.

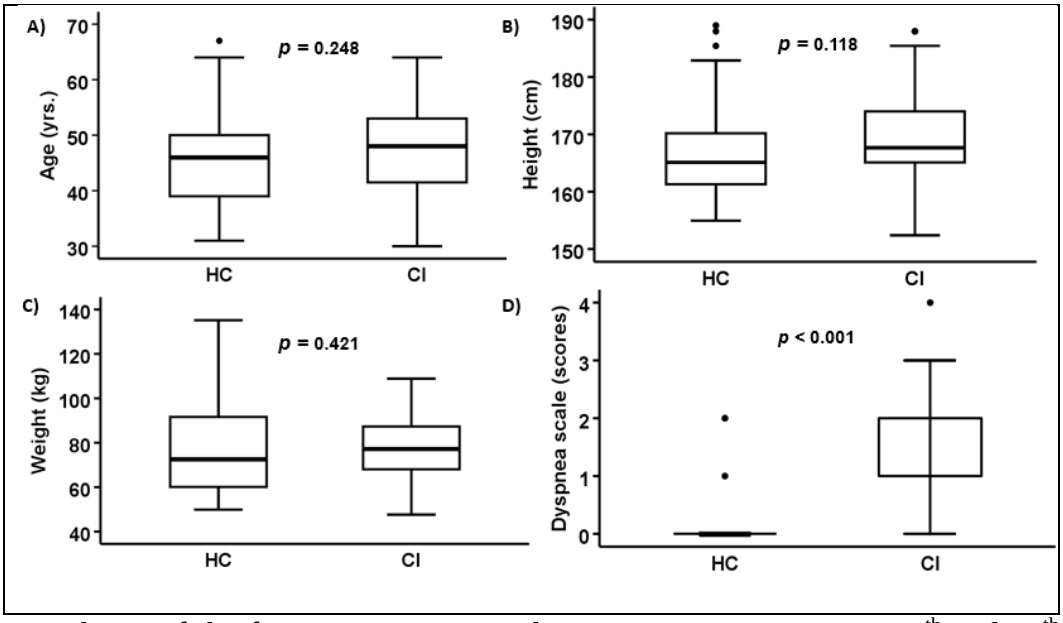
Mann-Whitney test indicated that there were no significant differences in age, weight, and height between the HC and CI groups. As for mMRC, CI group scored significantly higher than HC group (Table 2 and Fig. 1).

Table 2. *Demographics of the participants and the results of dyspnea scale of the mMRC in CI (n=39) and HC (n=39) groups.*

Variable	CI median	HC median	*U* value	*p* value	*r*
Age (yrs.)	48	46	659.5	= 0.312	.11
Weight (kg)	77	80	696.5	= 0.522	.07
Height (cm)	168	167	608.0	= 0.125	.17
mMRC (scores)	2	0	163.0	< 0.001	.74

Data are presented as median, *U*, *p*, and *r* values. Mann-Whitney test was used to explore statistically significant differences between the two groups. Modified Medical Research Council: mMRC, CI: COVID-19 infected, HC: Healthy control.

Fig. 1 *Demographics of the participants and the results of dyspnea scale of the mMRC in CI (n=39) and HC (n=39) groups*.



Boundaries of the figures represent, median, minimum, maximum, 25th and 75th percentiles, and the sign • indicates outliers. Mann-Whitney test was used to explore statistically significant differences between the two groups. HC: Modified Medical Research Council: mMRC, CI: COVID-19 infected, HC: Healthy control.

In the IPAQ questionnaire, the CI group scored significantly lower than the HC group in vigorous, moderate, and combined physical activity scores. However, there were no significant differences between the groups for walking and sitting parameters (Table 3 and Fig 2).

Table 3. *The outcome scores of the IPAQ parameters for CI (n=39) and HC (n=39) groups.*

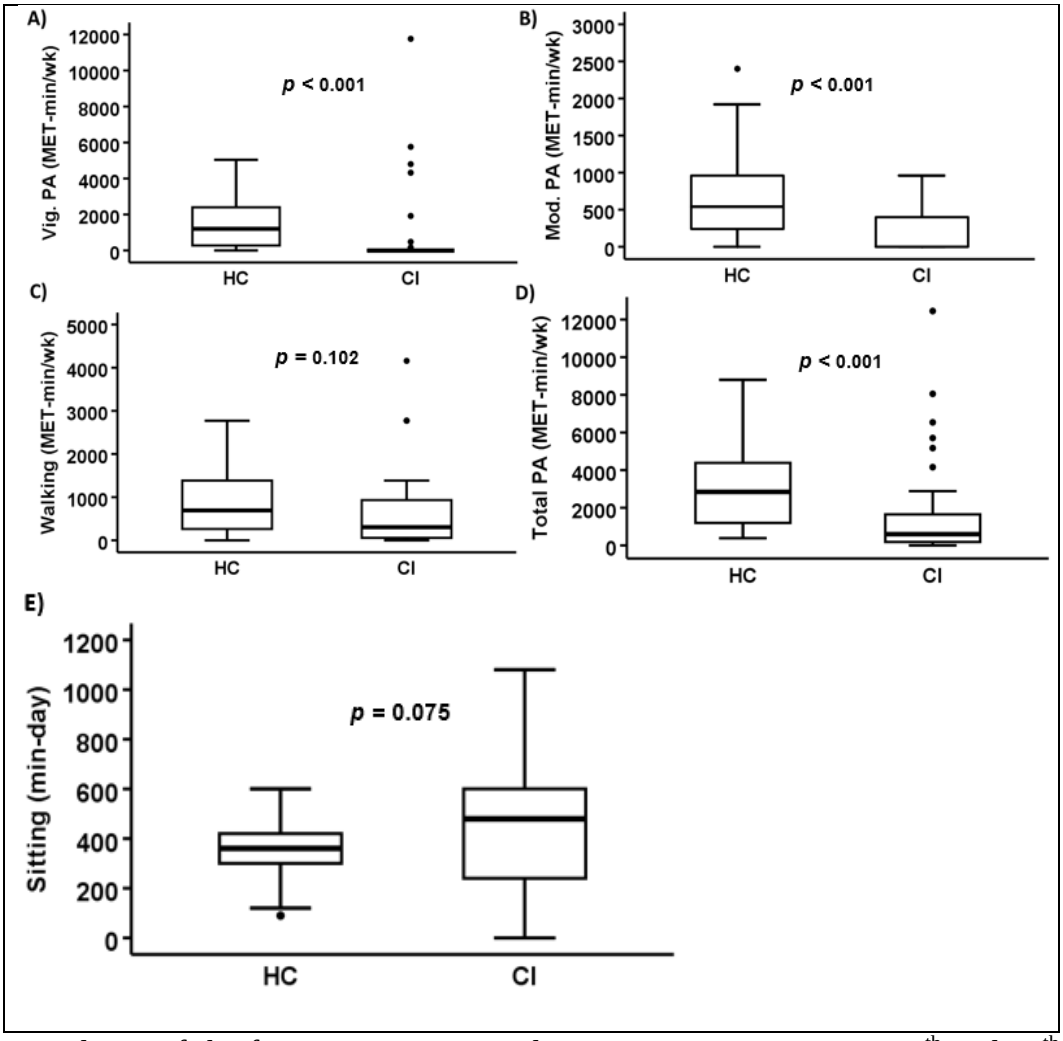
Variable	CI median	HC median	*U* value	*p* value	*r*
Vigorous PA (min/MET/wk)	0	1200	314.0	< 0.001	.54
Moderate PA (min/MET/wk)	0	540	291.5	< 0.001	.54
Combined PA (min/MET/wk)	594	2845	375.5	< 0.001	.44
Walking (min/MET/wk)	303	693	597.5	= 0.102	.19
Sitting (min/wk)	480	360	583.5	= 0.075	.20

Data are presented as median, *U*, *p*, and *r* values. Mann-Whitney test was used to explore statistically significant differences between the two groups. IPAQ: International Physical Activity Questionnaire. CI: COVID-19 infected, HC: Healthy control, PA: physical activity

The CI group scored significantly lower than HC group in basic ADL, intermediate ADL, mental health, work performance, social activities, and quality of interactions parameters of FSQ (Table 4 and Fig 3). As for the single items included in the FSQ, (Table 5) shows the results for both groups as percentages.

In the RAND-36 HRQoL questionnaire, the CI group reported lower scores compared to HC group in physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, emotional well-being, social functioning, pain, and general health parameters (Table 6 and Fig 4).

Fig. 2 *The outcome scores of the IPAQ parameters for CI (n=39) and HC (n=39) groups.*



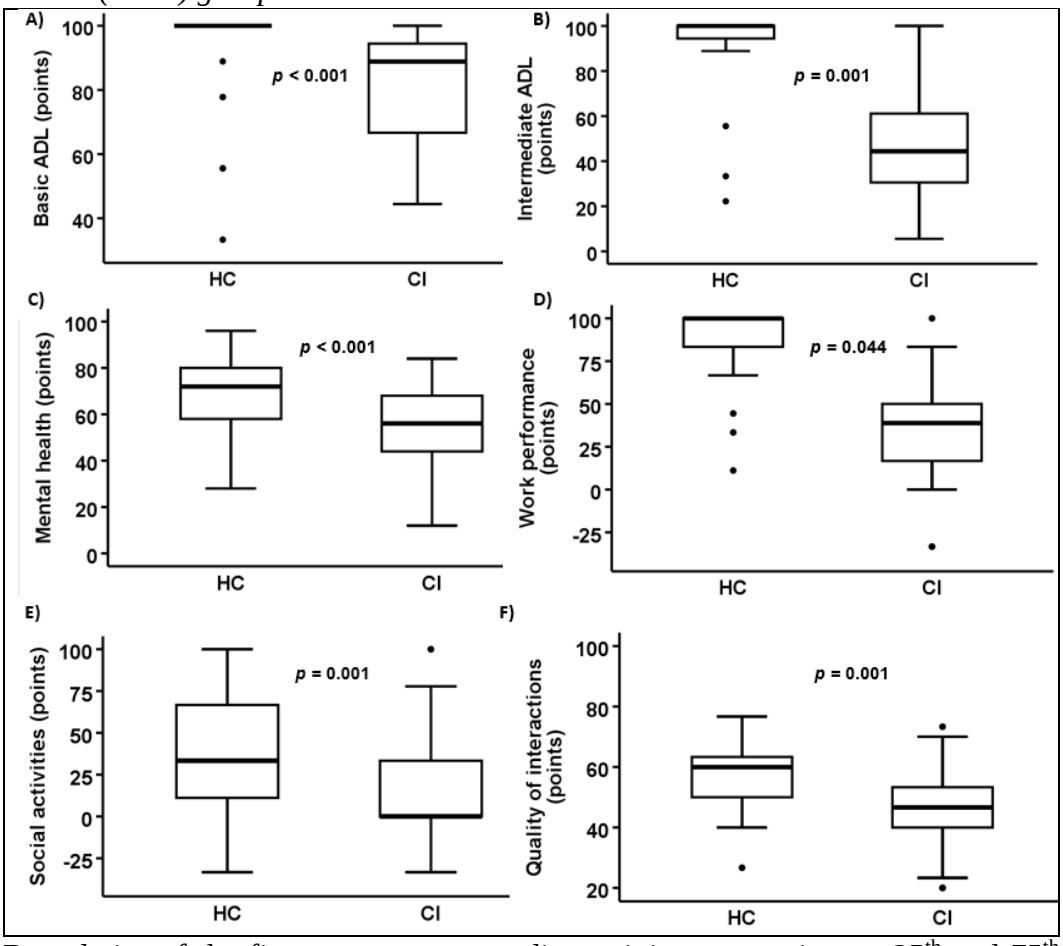
Boundaries of the figures represent, median, minimum, maximum, 25th and 75th percentiles, and the sign • indicates outliers. Mann-Whitney test was used to explore statistically significant differences between the two groups. IPAQ: International Physical Activity Questionnaire. CI: COVID-19 infected, HC: Healthy control, Vig. PA: vigorous physical activity, Mod. PA: moderate physical activity.

Table 4. *The outcome scores of the FSQ parameters for CI (n=39) and HC (n=39) groups.*

Variable 100 point/scale	CI median	HC median	*U* value	*p* value	*r*
Basic ADL	89	100	338.0	< 0.001	.52
Intermediate ADL	44	100	115.5	= 0.001	.74
Mental health	56	72	413.5	< 0.001	.39
Work performance	39	100	108.5	= 0.044	.74
Social activities	0	33	560.5	= 0.001	.22
Quality of interactions	47	60	419.5	= 0.001	.38

Data are presented as median, *U*, *p*, and *r* values. Mann-Whitney test was used to explore statistically significant differences between the two groups. ADL, activities of daily living, FSQ: Functional Status Questionnaire, CI: COVID-19 infected, HC: Healthy control.

Fig. 3 *The outcome scores of the FSQ parameters for CI (n=39) and HC (n=39) groups.*



Boundaries of the figures represent, median, minimum, maximum, 25th and 75th percentiles, and the sign • indicates outliers. Mann-Whitney test was used to explore statistically significant differences between the two groups. FSQ: Functional Status Questionnaire, CI: COVID-19 infected, HC: Healthy control.

Table 5. *Single items' results of the Functional Status Questionnaire in CI and HC groups presented as percentages.*

Single Items		CI	HC
1- Work situation	Working full-time	25.6 %	66.6 %
	Working part-time	17.9 %	20.5 %
	Unemployed looking for work	2.5 %	2.5 %
	Unemployed because of my health	33.3 %	5.1 %
	Retired because of my health	5.1 %	0.0 %
	Retired for some other reason	15.4 %	5.1 %
2- During the past month, how many days did illness or injury keep you in bed all or most of the time?		26.4% out 31-day period	2.8% out 31-day period
3- you cut down on the things you usually do for one-half day or more because of your illness or injury?		66.7% out 31-day period	8.7% out 31-day period
4- During the past month, how satisfied were you with your sexual relationships?	Very satisfied	2.6%	10.3%
	Satisfied	15.4%	41.0%
	Not sure	5.1%	10.3%
	Dissatisfied	10.3%	20.5%
	Very dissatisfied	15.4%	0.0%
	Did not have any sexual relationships.	51.3%	17.9%
5- How do you feel about your health?	Very satisfied	0.0%	23.1%
	Satisfied	7.7%	56.4%
	Not sure	10.3%	5.1%
	Dissatisfied	20.5%	12.8%
	Very dissatisfied	61.5%	2.6%
6- During the past month, about how often did you	Every day	10.3%	15.4%
	Several times /wk.	12.8%	15.4%

get together with friends or relatives, such as going out together, visiting in each other's home, or talking on the telephone?	About once /wk.	17.9%	10.3%
	2 or 3 times a month	28.2%	30.8%
	About 1 a month	12.8%	10.3%
	Not at all	17.9%	17.9%

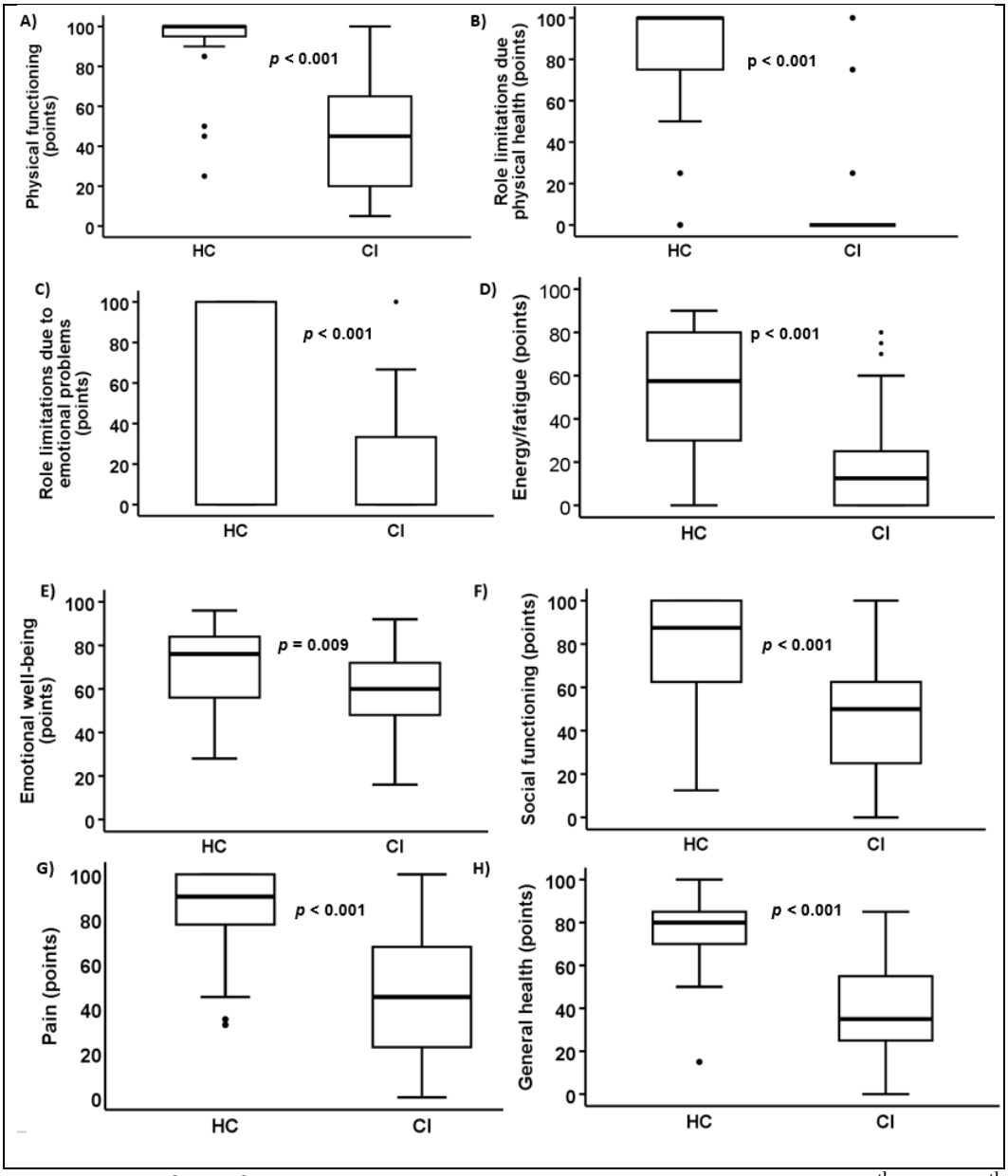
CI: COVID-19 infected, HC: Healthy control.

Table 6. *The outcome scores of the RAND-36 questionnaire (HRQoL) parameters CI (n=38) and HC (n=38) groups*.

Variable 100 point/scale	CI median	HC median	*U* value	*p* value	*r*
Physical functioning	45	100	116.0	< 0.001	.74
Role limitation due to physical health	0	100	106.5	< 0.001	.79
Role limitations due to emotional problems	0	100	392.0	< 0.001	.42
Energy/fatigue	13	58	187.5	< 0.001	.64
Emotional well-being	60	76	469.5	= 0.009	.30
Social functioning	50	88	264.0	< 0.001	.55
Pain	45	90	181.5	< 0.001	.65
General health	35	80	135.0	< 0.001	.70

Data are presented as median, *U*, *p*, and *r* values. Mann-Whitney test was used to explore statistically significant differences between the two groups. HRQoL: Health related quality of life, CI: COVID-19 infected HC: Healthy control.

Fig. 4 *The outcome scores of the RAND-36 questionnaire (HRQoL) parameters CI (n=38) and HC (n=38) groups*.



Boundaries of the figures represent, median, minimum, maximum, 25th and 75th percentiles, and the sign • indicates outliers. Mann-Whitney test was used to explore statistically significant differences between the two groups. HRQoL: Health related quality of life, HC: Healthy control, CI: COVID-19 infected.

Discussion

We sought to determine the differences in quality of life, physical activities, functional performance, and symptoms of dyspnea between individuals previously infected with COVID-19 and age-matched healthy individuals. Our novel findings are that: 1) dyspnea was greater in the COVID-19 infected group compared to the healthy control group; and 2) outcomes related to the questionnaires of IPAQ (measures walking, moderate, vigorous and combined activity levels), FSQ (measures physical function in the ADL, psychological, social and role functions and variety of performance measures), and RAND-36 HRQoL (measures physical functioning, role limitations caused by physical health problems, energy/fatigue, pain, emotional wellbeing, role limitations caused by emotional problems, social functioning, and general health perceptions) in the CI group were significantly lower than the scores achieved by the HC group. Interestingly, we found no significant differences in sitting and walking activity scores for IPAQ between the two groups. Together, our findings suggest that COVID-19 infected individuals experience higher levels of dyspnea and reduction in quality of life, functional status, and moderate to vigorous physical activities following recovery from COVID-19 infection.

The results of dyspnea scale of the mMRC showed that the CI group had significantly higher scores than the HC group (M = 1.77 vs 0.13). Further, in CI group, 33 out 39 experienced different levels of dyspnea vs only 3 out of 39 in HC group. The findings of our study are in agreement with what is reported by Wu and colleagues stating that exertional dyspnea was one of the common symptoms even after 6 months of discharge from hospital among the survivors of the virus (Q. Wu et al., 2021). Raman et al. (2021), also indicated that 64% and 55% of the recovered patients experienced dyspnea, after 2-3 months from the infection date with the virus (Raman et al., 2021). Based on our study results and those of others (Fayol et al., 2021; Raman et al., 2021; Q. Wu et al., 2021), it is important to emphasize dyspnea as one of the most common symptoms among the COVID-19 infected individuals. Therefore, addressing dyspnea should be one of the primary goals in any long-term rehabilitation programs designed for the individuals who survived the COVID-19 infection.

The IPAQ results showed that the CI group achieved significantly lower scores than the HC group in vigorous (by ≈ 200%), moderate (by ≈ 260%), and combined physical activities (by ≈180%), but not in sitting and walking activity. The lower scores achieved by the CI group might have occurred due to several factors: dyspnea/chest tightness, fatigue, and/or general weakness (Fayol et al., 2021; Raman et al., 2021; Q. Wu et al., 2021). The lack of significant differences in our study between the CI and the HC groups for walking and sitting scores could be due to the COVID-19 pandemic itself. To slow infection rates of COVID-19, most of the authorities and governments around the world applied policies such

shelter in place, lock downs, and extensive social distancing (Hossain et al., 2020) which, in turn, significantly lowered outdoor physical activities such as walking and increased the hours of sitting at home. A study examining the effects of COVID-19 home confinement on physical activity and eating behavior showed that home confinement had a noticeable deleterious effect on all intensities of physical activities and walking as well as increasing daily sitting time from 5 to 8 hours per day (Ammar et al., 2020). Despite that the pandemic negatively affected all physical activity intensities performed by people world-wide as reported by Ammar and his colleagues, our study was able to show significant differences between HC and CI groups in vigorous and moderate physical activity scores favoring HC group. This could be because our study was conducted during the end of the first year of the pandemic unlike the study conducted by Ammar and colleagues after passing the first 3-4 months of the pandemic. During the end of 2020, people were informed more about the importance of performing physical activities and follow the guidelines to prevent the spread of the virus. This crucial up-to-date information came from national/local authorities, healthcare systems and media (Natalucci et al., 2020).

In the FSQ, the CI group scored significantly lower than the HC group in all parameters within this questionnaire. The lower scores for basic (by ≈ 18%), intermediate ADL (by ≈ 93%) and work performance (by ≈ 260%) in the CI group may resulted from symptoms commonly experienced in individuals infected with this virus, symptoms such as dyspnea/chest tightness, fatigue (Fayol et al., 2021; Raman et al., 2021; Q. Wu et al., 2021).These results have important potential implications on rehabilitation of the survivors of this virus. Improving intermediate ADL and work performance may take longer than just a few rehabilitation visits to address the basic physical activity needs. Furthermore, the recovery time of CI participants varied from 1 to ≈ 11 month before participating in our study, yet they had significant persisting reduction in quality of life, functional status, and moderate to vigorous physical activity compared to aged-matched healthy individuals. Poor scores in mental health, social activities and quality of interactions parameters of FSQ in CI group might be due to certain long-lasting psychopathological negative consequences that are commonly associated with respiratory viral infectious diseases (Cheng et al., 2004). Other factors that might reflect these poor scores could be social isolation, stigma, fear of disease, future insecurity, and traumatic experiences of severe illness during the infection with COVID-19 (Mechanisms, 2019; Sun et al., 2020). Furthermore, several studies reported that SARS survivors present with psychiatric symptoms such as obsessive-compulsive disorder (OCD), panic disorder, depression, and post-traumatic stress disorder (PTSD) (Cheng et al., 2004; Sun et al., 2020; Y. Wu et al., 2020). Mazza et al. (2020) also indicated that COVID-19 survivors (n = 402) presented with OCD, PTSD, depression, insomnia, and anxiety symptoms after a month of being

discharged from treatment in the hospital. Results here also give the multi-disciplinary rehabilitation professionals the chance to tailor their interventions to meet the specific needs of COVID-19 survivors. This can be as easy as encouraging survivors to connect with friends and extended family members through social media, virtual meetings a gathering outdoors while maintaining appropriate physical distancing to prevent the spread of the virus during the time of this pandemic.

Single item questions in FSQ showed noticeable differences in work situation, number of days illness kept the person in bed and cutting down on the things a person usually does for one-half day or more because of illness or injury during the past month, satisfaction of sexual relationships, and the feeling of overall health favoring HC group over CI group. These findings could be due to the physical and the psychological symptoms associated with being infected with COVID-19 (Fayol et al., 2021; Halpin et al., 2021; Mullen et al., 2011; Raman et al., 2021; Sun et al., 2020; Wyrwich et al., 2005). Furthermore, COVID-19 may show some manifestations that can adversely affect patient's sexual drive and/or deter the partner from having any sexual relationship despite the full recovery of the their partners from the illness (Abbas et al., 2020). The social activities item discussing getting together with friends or relatives, going out, visiting in each other's home, or talking on the telephone resulted in similar percentages between both groups. This similarity could be due to the social distancing and lockdown policies that affected everyone (i.e., infected and non-infected individuals) worldwide (Hossain et al., 2020).

The RAND-36 HRQoL questionnaire scores showed that the CI group scored significantly lower than the HC group in physical functioning, role limitations due to physical health, role limitations due emotional problems, energy/fatigue, emotional well-being, social functioning, pain, and general health parameters. Our findings here too are in agreement with several studies that reported persisting symptoms related to the parameters in this questionnaire (Cheng et al., 2004; Fayol et al., 2021; Mechanisms, 2019; Raman et al., 2021; Sun et al., 2020; Q. Wu et al., 2021; Y. Wu et al., 2020). Ren et al. (Ren et al., 2020), and other investigators (Mechanisms, 2019; Sun et al., 2020) found that muscle pain (i.e., myalgia) and soreness which is commonly mediated by Interleukin-6 (IL-6) is the most common cause (36% of patients) of pain among COVID-19 survivors specifically at the first the onset of the infection with the virus (Li et al., 2020; Mechanisms, 2019; Sun et al., 2020). It has been also reported that infected individuals of COVID-19 presented with persistent chest pain, fatigue, myalgia, cognitive impairment, as well as anxiety, depression, sleep disturbances and PTSD during the post-acute phase of COVID-19 infection (Nalbandian et al., 2021). The isolation that is required as a result of being infected with COVID-19 may certainly cause an increased stress and anxiety which, in turn, can worsen the perception of

pain among other symptoms in these individuals (Mazza et al., 2020). The results of the RAND-36 HRQoL questionnaire in this study further signifies its implications on professionals in all levels of the multi-disciplinary rehabilitation programs. Addressing the physical deficiencies and related social and emotional concerns should be the primary focus areas in rehabilitation for COVID-19 survivors. Also, educating these individuals about the short- and long-term effects of this virus on their bodies would be an appropriate approach to address future uncertainty and anxiety concerns. Further, encouraging survivors to keep in touch with family and loved ones via virtual meetings and safe gathering outdoors may also help in the process of long-term rehabilitation.

We investigated the multifaceted impacts of post-acute phase of COVID-19 infection on the sense of dyspnea, select physical, functional, and psychological variables among survivors compared to age matched healthy participants and their implications for rehabilitation programs in this population. One of the strengths of this study is the age matched healthy control group, which provides robustness by comparing results from the CI patients with matched HC. Another strength is the use of 4 standardized, validated questionnaires to collect data about physical and psychosocial parameters among HC and CI groups. Although we did not perform any lab-based tests, the questionnaires used in this study covered a wide spectrum of important physical, functional, and psychosocial important parameters. Furthermore, providing online questionnaires for the participants ensured their safety from getting exposed to the virus again. Additionally, non-Canadian participants formed 23% of the total number of the participants. Though this a percentage is small, however, it is still considered a strength for this study given that the experience between the Canadians, Americans, and citizens of other countries maybe was different (Yoo et al., 2020).

Our study was not without limitations. While we have assessed the survey responses of the individuals based on their symptoms and status at the time of completing the survey, we do not have data measuring their pre-COVID status, nor their change in status since infection. It is possible that our data capture merely a snapshot in time, and do not account for pre-COVID concerns. For example, in the CI group, differences in pre-COVID physical activity, pre-existing co-morbidities, or psychological concerns may have impacted the severity and/or duration of symptoms. For the HC group, these differences may mean the ‘pandemic influenced’ responses may be quite different than their normal responses. While these factors may alter the differences observed between the CI and HC groups, we believe this snapshot at the point of survey completion reflects the reality of pandemic-related changes that may have occurred in both groups. Another limitation of this study is that the participants in CI group were only matched by age, and not gender, with the participants in HC group. Because of the time-sensitive nature of this research during the COVID-19 pandemic, we limited

recruitment to a 2-month period which limited the number of participants we could recruit. It is possible that the results of our study do not adequately account for gender-related differences. The date of the infection of COVID-19 survivors ranged from 1 to ≈ 11 month which lends to a varied recovery time. This large variation in recovery time occurred because of our limited recruitment window due to the time-sensitive nature of the research as described above. Therefore, to maximize potential recruitment, we opened the inclusion to anyone who had symptoms beyond 28 days from the date of infection. Despite this, the average period of (187 ± 88 days) from the time of infection until the date of taking the survey provides valuable information about the extent of the persisting nature of these limitations during the post-acute phase of the illness. In addition, we did not notice any trend indicating that the participants who were infected in earlier dates (i.e., long time before the survey date) had different symptoms than the participants who were infected in later dates (i.e., closer to survey date); however, it is possible that our sample was not large enough to capture any differences. The severity of illness during infection was determined only be self-report, and therefore, it may be difficult to generalize our findings to all COVID-19 survivors. In addition, small number (9 out of 39) of the infected participants have been hospitalized while the others never been hospitalized due to being infected with the virus. Consequently, most of the infected participants in this study can be considered mild cases. However, it is important to acknowledge that the vast majority of patients affected by COVID-19 were not ever hospitalized. Further, this study had only 2 hospitalized participants who were admitted to ICU due to being infected with COVID-19, therefore, we suggest that the infected sample of participants in our study does not represent individuals who are more severely affected by COVID-19 illness.

We report that COVID-19 survivorship is associated with ongoing functional and psychological deficits. Scores of dyspnea in the CI group were significantly higher than in the HC group. Scores of the vigorous, moderate, and combined physical activities were significantly lower in the CI group than in the HC group but both groups achieved similar scores for sitting and walking activity. Scores related to quality of life, functional status, psychosocial and emotional parameters within both FSQ and RAND-36 HRQoL questionnaires also showed that the CI group achieved significantly lower than the HC group. Further research is needed to better understand the reasons for these negative impacts of COVID-19 on the survivors. These studies can focus on more lab-based testing for the cardiopulmonary, neuromuscular systems and or to study the pace of recovery among the COVID-19 survivors.

Clinical messages

1- Persistent dyspnea, declined moderate to vigorous physical activity, functional status and quality of life parameters were noticed after an average of 6 months of infection date with COVID-19.
2- Majority of the infected cases in this study can be categorized as mild cases since they were never hospitalized.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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