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Physical Activity and Work out Capacity after Recovery from COVID-19 Infection

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ABSTRACT

The COVID-19 pandemic is a current worldwide healthcare challenge with a well-documented negative socioeconomic impact. Several long-term complications have been reported particularly in severely infected patients. Lockdowns and prolonged home staying periods greatly affected the physical fitness and general heath state. This cross-sectional self-report study aimed to investigate the long-term effect on physical activity and exercising after recovery from COVID-19. 271 participants enrolled in the study by completing a survey with questions about their workout habits, duration of training sessions, and rest periods required for recovery in-between sessions, in addition to sleeping hours, eating healthy food or snacks, taking multivitamins, and patterns of sporting. After recovery from COVID-19 infection, there was a general tendency towards decrease in the capacity of exercising, prolonged muscle recovery time, extended hours required between exercising sessions, while the number of participants who use multivitamins was significantly increased. In contrary, there was no statistically significant difference before and after COVID-19 infection regarding sleeping patterns, cigarette consuming, self-rating of physical fitness, and self-rating of eating healthy food. Collectively, the long-term effects of COVID-19 involved limited exercising ability and capacity; the issue that shall encourage both physically and non-physically active people to continue or start physical fitness in order to improve their health status through the boosting of immunovigilance.

Keywords: COVID-19, Chronic effect, Physical activity, Exercising, Rest, Muscle
Running title: Exercise capacity after COVID-19 recovery

Introduction

The Coronavirus disease 2019 pandemic, known as COVID-19, is a worldwide healthcare problem, and the mainstream belief is that the severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) infection is an acute condition and full recovery is the typical outcome. Serious long-term complications appeared to be less common but have also been reported, especially in patients with severe COVID-19 infections who required hospitalization, and in those who were critically ill and required mechanical ventilation [1,2]. It was also observed that symptoms may persist for longer duration, and can even become permanent particularly in severely infected patients [3]. These unfortunate outcomes can affect various organ systems in the body including, but not limited to, cardiovascular system and ultimately can result in myocarditis in certain individuals [4]. In fact, one study found that 60 % of patients who recovered from COVID-19 had indications of chronic heart inflammation, which could cause shortness of breath, palpitations, and tachycardia or arrythmia [5]. This phenomenon was later identified as 'post COVID-19 syndrome' and was defined as symptoms which persist twelve weeks after the recovery from COVID-19 infection [6].

It is well known that workout or exercising has become an important part in our life since regular training improves exercising capacity and physical fitness, which can lead to a variety of health benefits. Physically active people appear to have reduced rates of all-cause mortality, which is likely attributable to a reduction in chronic conditions such as coronary artery diseases [7]. Exercising was also linked to the control of blood lipid abnormalities, diabetes, and obesity. In addition, it became an important aspect of lifestyle changes that are seen as a cost-effective strategy to improve health and quality of life. Post-COVID-19 effects also include chronic fatigue syndrome, insomnia, anxiety, headache, and ageusia [8]. In a previous study including 142 patients who had been hospitalized for about two weeks with severe COVID-19 infections, 87 % of these patients had symptoms which did not resolve two months after recovery [8]. Also, pulmonary lesions caused by severe COVID-19 infection can lead to irreversible fibrosis. Although most of lesions are reported to heal with time,

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irreversible fibrosis can cause shortness of breath and hamper physical activities on the long term. Difficulties in breathing is common among COVID-19 recovering patients; being more evident in those who required hospitalization. Persistent pulmonary, muscular, neurological, cardiac, and even psychological effect has also been reported for the post COVID-19 syndrome [9].

In this study, the chronic effects of COVID-19 infections on physical activity were studied. The long-term effects, after recovering from COVID-19 infection, on physical activities, training duration, and other lifestyle habits were evaluated to find out the potential effects.

Materials and Methods

Inclusion criteria were those who were previously infected with COVID-19 and are regularly training or practicing a type of sport. Interested participants completed an online survey delivered to them *via* email or in-person in sporting facilities. To obtain informed consent from participants before commencing the questionnaire, the survey was started with a plain language statement and if a participant agreed to continue. The estimated time for completion of survey questionnaire was 10 minutes. Ethical approval was obtained prior to commencing the study from the research ethics committee at Taibah University (COPTU-REC-24-20211013).

Characteristics of participants

Characteristics of participants were collected at the beginning of the survey. The questionnaire included age, sex, body mass index (BMI), marital status, daily physical activity, and the symptoms they reported as well as requirement for isolation or hospitalization during the infection time course.

Statistical analysis

Descriptive statistics were presented as mean and standard deviation [10] for normally distributed numerical variables, but as median and interquartile range for non-normally distributed variables, while numbers and percentages were used for the categorical variables. Wilcoxon signed rank test and McNemar test were used to compare between characteristics of the participants before and after COVID-19 infection. IBM® SPSS 28 software was used for the analysis, and a P-value < 0.05 was considered statistically significant.

Results

Characteristics of participants

A total of 271 participants were included in this study. Their basic characteristics are displayed in Table 11.

Table 11: Characteristics of participants (N=271)

		Frequency	Percentage
Sex	Male	76	28%
	Female	195	72%
Marital status	Single	227	83.8%
	Married	38	14%
	Other	6	2.2%
BMI status	<18.5	19	7.1%
	18.5-24.9	150	55.8%
	25-29.9	71	26.4%
	≥30	29	10.8%
Age	Mean [10]	24.5(7.5)	
How active are you during at workplace?	No activity (Office work)	64	23.6%
	Light (like walking)	102	37.6%
	Moderate activity (requires movement more than sitting)	77	28.4%
	High activity (requires effort and physical activity)	28	10.3%
What did you require during your infection?	Mild or moderate symptoms that require home isolation only	231	85.2%
	Hospital visit	28	10.3%
	Admission in the hospital with the addition of oxygen	10	3.7%
	ICU	1	0.4%
	ICU with the addition of ventilator	1	0.4%
Symptoms during COVID-19 infections	Headache	200	74%
	Muscle or body pain	189	70%

Fever	186	69%
Cough	128	47%
Sleeping longer than usual	112	41%
Dyspnea	106	39%
Diarrhea	59	22%
Loss of taste and smell sensations	16	6%

BMI: body mass index, ICU: intensive care unit.

Exercising capacity before and after COVID 19 infection

Frequency of exercising

COVID-19 infection resulted in long term effect on the exercising frequency of participants. Around 52.4 % of the participants used to perform physical exercises once or twice a week before being infected with COVID-19, while after recovery, this percentage was increased to 59.4 %. 26.6 % of the participants used to work out 3 to 4 times a week before being infected with COVID-19. In those who used to have training sessions 3 to 4 times a week, there was almost no changes comparing before and after recovering from COVID-19. A slight decrease (from 21 % to 14.4%) was noted in participants who used a busier training schedules (5 to 7 times a week) COVID-19 (Figure 1). Comparing the overall decrease versus increase in training times per week, there was, a statistically significant difference in exercising times per week (p=0.002). Specifically, 60 participants showed decreased frequency of exercising, 31 showed increased frequency, while 180 had no change (Table 2).

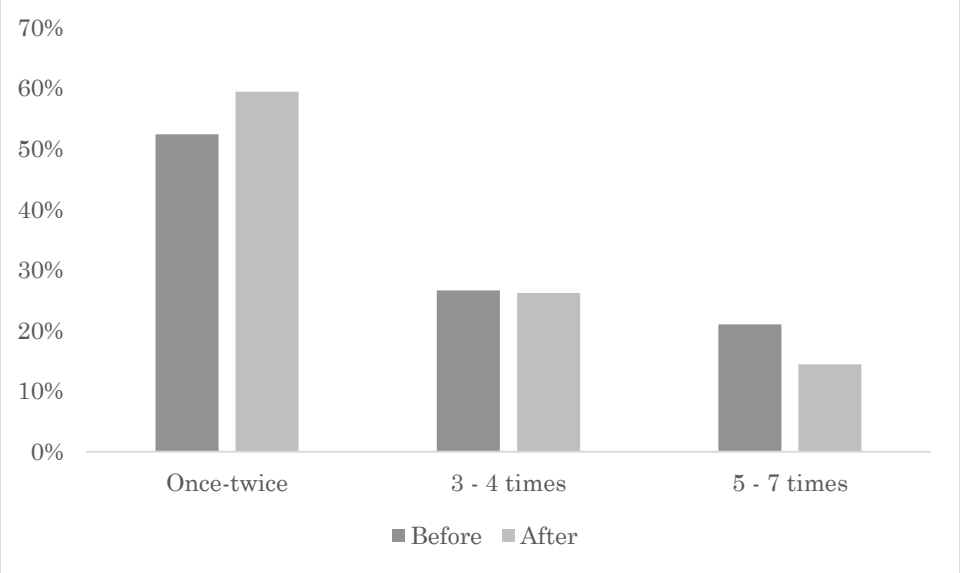

Fig. 11 Frequency of exercising per week before and after COVID-19 infection.

Duration of exercising

The duration of work out was also affected, indicating a trend towards decrease in the duration of exercising sessions. The percentage of those who used to exercise for 30 minutes changed from 42.1% before being infected with COVID-19, to 54.6% after recovering from infection. About 33.6% of participants reported that their training session usually endured for 1 hour before COVID-19 infection, while after recovering the percentage was 28.4% of the participants. 19.9% of the participants used to work out for 2 hours, but after recovering from COVID-19, 14.4% of the participants reported that the work out duration for their exercising sessions was for 2 hours. 4.4% of the participants did exercises for more than 2 hours before getting infected with COVID-19, while after being infected with COVID-19 there were 2.6% of the participants who did exercises for more than 2 hours. Collectively, there was a statistically significant difference in duration of exercise per day (p<0.001) (Table 2). Among participants, 71 showed decreased duration of exercising, 19 of them showed increased duration of working out, while 181 reported no change (Figure 3).

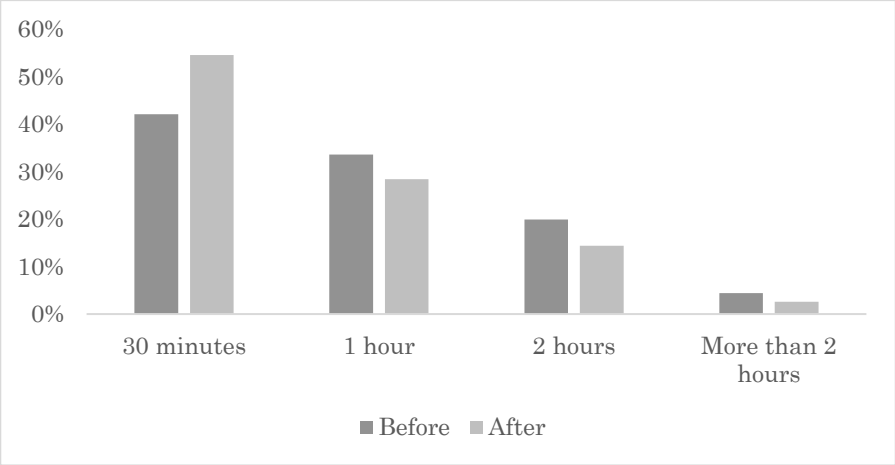

Fig. 2 Duration of exercise per day before and after COVID 19 infection.

Table 2: Comparison between exercising characteristics of the participants before and after COVID-19 infection

			Before		After			
			N	%	N	%	Change	*P*-value
How many times do you exercise in a week?	Once-twice		142	52.4%	161	59.4%	Decreased =60	0.002
	3 - 4 times		72	26.6%	71	26.2%	Increased = 31	
	5 - 7 times		57	21%	39	14.4%	No change =180	
For how long you exercise per day?	30 minutes		114	42.1%	148	54.6%	Decreased = 71	<0.001
	1 hour		91	33.6%	77	28.4%	Increased = 19	
	2 hours		54	19.9%	39	14.4%	No change =181	
	More than 2 hours		12	4.4%	7	2.6%		
How much rest do you get between exercising sessions?	12 hours		44	16.2%	29	10.7%	Decreased = 20	<0.001
	24 hours		116	42.8%	88	32.5%	Increased = 104	
	2 days		66	24.4%	73	26.9%	No change =147	
	3 days		22	8.1%	29	10.7%		
	More than 3 days		23	8.5%	52	19.2%		
How long does it take for your muscles to recover after exercise (no muscle pain or cramping)?	12 hours		109	40.2%	67	24.7%	Decreased = 24	<0.001
	24 hours		67	24.7%	57	21%	Increased = 110	
	2 days		58	21.4%	81	29.9%	No change =137	
	3 days		23	8.5%	38	14%		
	More than 3 days		14	5.2%	28	10.3%		
How many hours do you sleep regularly at night?	4 hours		31	11.4%	43	15.9%	Decreased = 66	0.473
	6 hours		80	29.5%	76	28%	Increased = 73	
	8 hours		100	36.9%	84	31%	No change =132	
	10 hours		27	10%	35	12.9%		
	More than 10 hours		33	12.2%	33	12.2%		
How many cigarettes do you smoke per day? (For smokers)	Approximately 5 cigarettes		4	18.2%	3	13%	Decreased = 8	0.166
							Increased = 2	
	Half a pack		4	18.2%	8	34.8%	No change =12	
	1 pack		12	54.5%	10	43.5%		
	2 packs		2	9.1%	2	8.7%		
How do you evaluate your physical activity during exercises on a scale of 1-10?	Median (IQR)		7 (3)		7 (3)			0.770

On a scale of 1-10 do you eat healthy food?	Median (IQR)	6 (4)	6(3)	0.054
How many times a day do you usually eat (including snacks)?	Median (IQR)	3[11]	3(2)	<0.001

Wilcoxon signed rank test was used to compare between characteristics of the participants before and after COVID-19 infection. IQR: the interquartile range.

Duration of rest between excessing sessions

Participants were asked how much time they require to recover from a training session and be able to undertake another work out session. This served as an indication of the ability of the body to recover from physical activity. The results showed that 16.2% of participants required to rest for 12 hours in between training sessions, while after recovering from COVID-19 there were 10.7% of participants who reported resting for 12 hours. 42.8% of the participants required to rest for 24 hours before undertaking another training session, while after recovering from COVID-19, 32.5% of participants reported the same. 24.4% of the participants used to rest for 2 days in between training sessions before COVID-19 infection, while after recovery, 26.9% of the participants reported requiring 2 days to recover in between two training sessions. 8.1% of the participants required resting for 3 days before getting infected with COVID-19, while after recovering, there were 10.7% of participants who needed resting for 3 days. Only 8.5% of the participants used to rest for more than 3 days in between training sessions, while after recovering from COVID-19, this percentage was increased to 19.2% of participants. Twenty participants reported decreased resting duration in between training sessions, 104 of them showed increased duration while 147 had no change. Comparing these three groups, a significant difference in the duration of rest between exercises (p <0.001) indicating an increased need for time to recover from a training session in individuals who has been previously infected with COVID-19 (Table 2). (Figure 4).

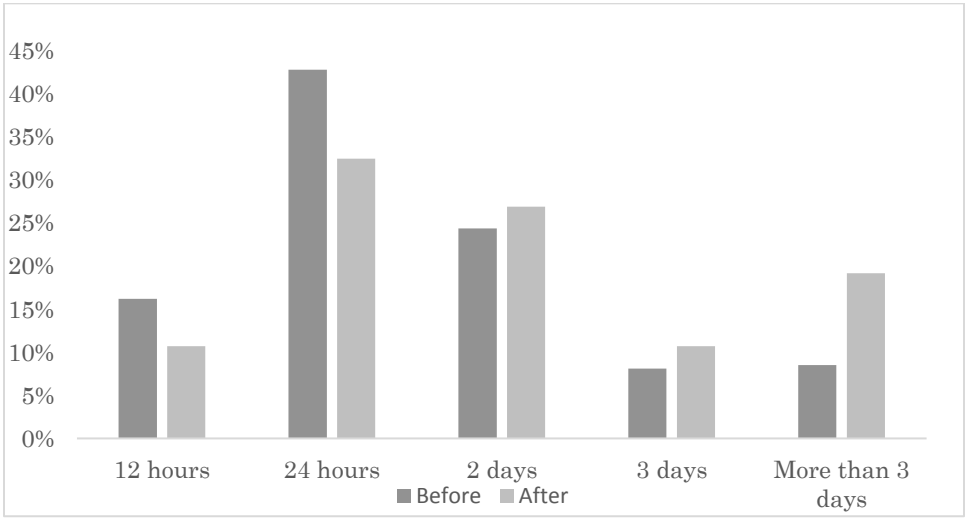

Fig. 3 Duration for recovery between exercises before and after COVID-19 infection.

Duration of muscles recovery after exercise

There was a statistically significant difference in the duration muscles take to recover from muscle pain or cramps after exercising (p<0.001). The results showed that recovery from muscle strains after training can take longer time in individuals recovering from COVID-19 (Table 2). Twenty-four participants showed decreased recovery duration, 110 showed increased recovery duration while 137 reported no change (p <0.001). Looking into detailed results, 40.2% of the participants reported that they require 12 hours for their muscles to recover after exercises, while after recovering from COVID-19, only 24.7% of participants reported the same duration. 24.7% of the participants used to require 24 hours to recover after exercises before being infected with COVID-19, however, after full recovery from COVID-19, 21% reported 24 hours recovery time in between exercises. A total of 21.4% indicated that their muscles need 2 days to recover after exercising session before being infected with COVID-19, the same recovery time was reported by 29.9% of participants after recovering from COVID-19. Only 8.5% of participants reported that they need 3 days to recover from a working out session, while 14%

reported the same after recovering from COVID-19. Finally, 5.2% of the participants answered that their muscles need more than 3 days to recover after exercises before getting infected with COVID 19, while after full recovery from COVID 19, there were 10.3% who indicated a training session recovery period of more than 3 days (Figure 5).

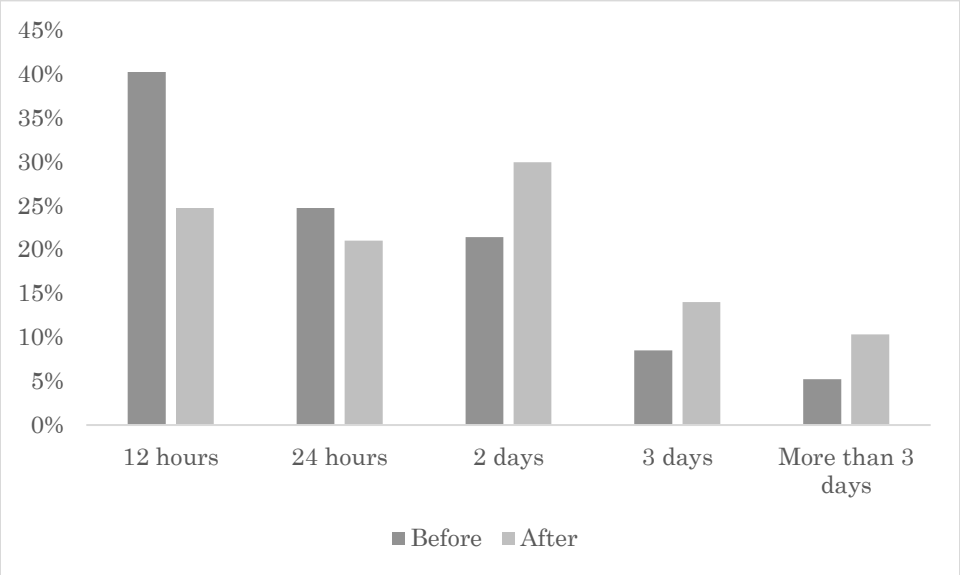

Fig. 5 Duration of muscles recovery after exercise before and after COVID-19 infection.

The long-term effects of COVID19 on sporting activity, diet and supplement taking

There were no significant differences before and after recovering from COVID-19, regarding awareness of diet content of calories or changing the eating habits in those who recovered from COVID-19. However, there was a statistically significant increase (p<0.001) by 24 % in taking multivitamins or other dietary supplements after infection compared to before infection (Table 3). Rationally, the percentage of people who are not taking multivitamins or other dietary supplements before being infected was significantly decreased by also 24 % as shown in Figure (6). There were also no changes noted on the type of exercising, either it was walking, jogging, cardio, stretching, swimming, ball sports, or group training (Figure 7).

Table 3: Calories intake and the use of multivitamins or supplements before and after COVID-19 infection.

		Before		After		*P*-value
		Frequency	Percentage	Frequency	Percentage	
Do you know how many calories you eat daily?	Yes	75	27.7%	71	26.2%	0.617
	No	196	72.3%	200	73.8%	
Did you take a multivitamin or other dietary supplement?	Yes	109	40.2%	174	64.2%	< 0.001
	No	162	59.8%	97	35.8%	

McNemar test was used to compare characteristics of the participants before and after COVID-19 infection.

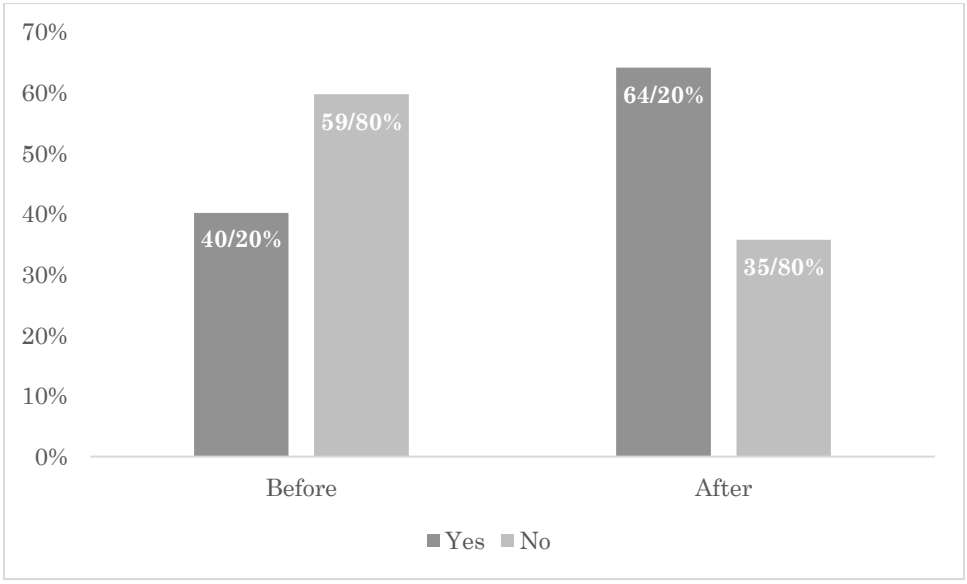

Fig. 6 Participant administered multivitamins or other dietary supplements before and after COVID-19 infection

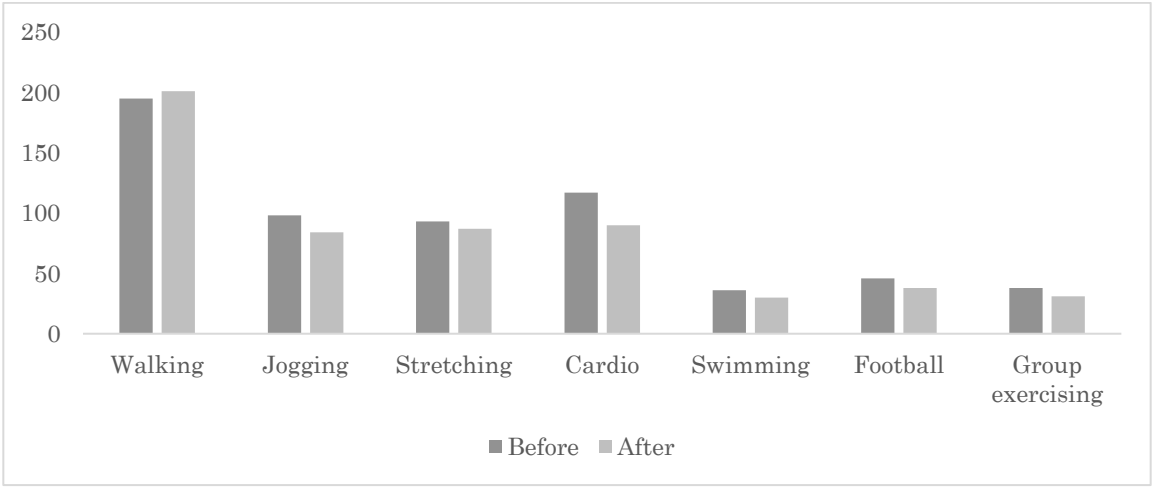

Fig. 12 Pattern of sporting before and after COVID-19 infection

The long-term effects of COVID19 on sleeping, smoking, and eating habits

There were no statistically significant differences before and after COVID-19 infection regarding hours of sleep (Figure 8.a), number of cigarette smoking (Figure 8.b), self-rating of physical activity (Figure 8.c), and self-rating of healthy food eating (Figure 8.d). Perversely, there was a significant difference in the number of meals taken per day, including snacks, as it showed a decrease after COVID-19 infection ($p < 0.001$) as presented in (Figure 8.e).

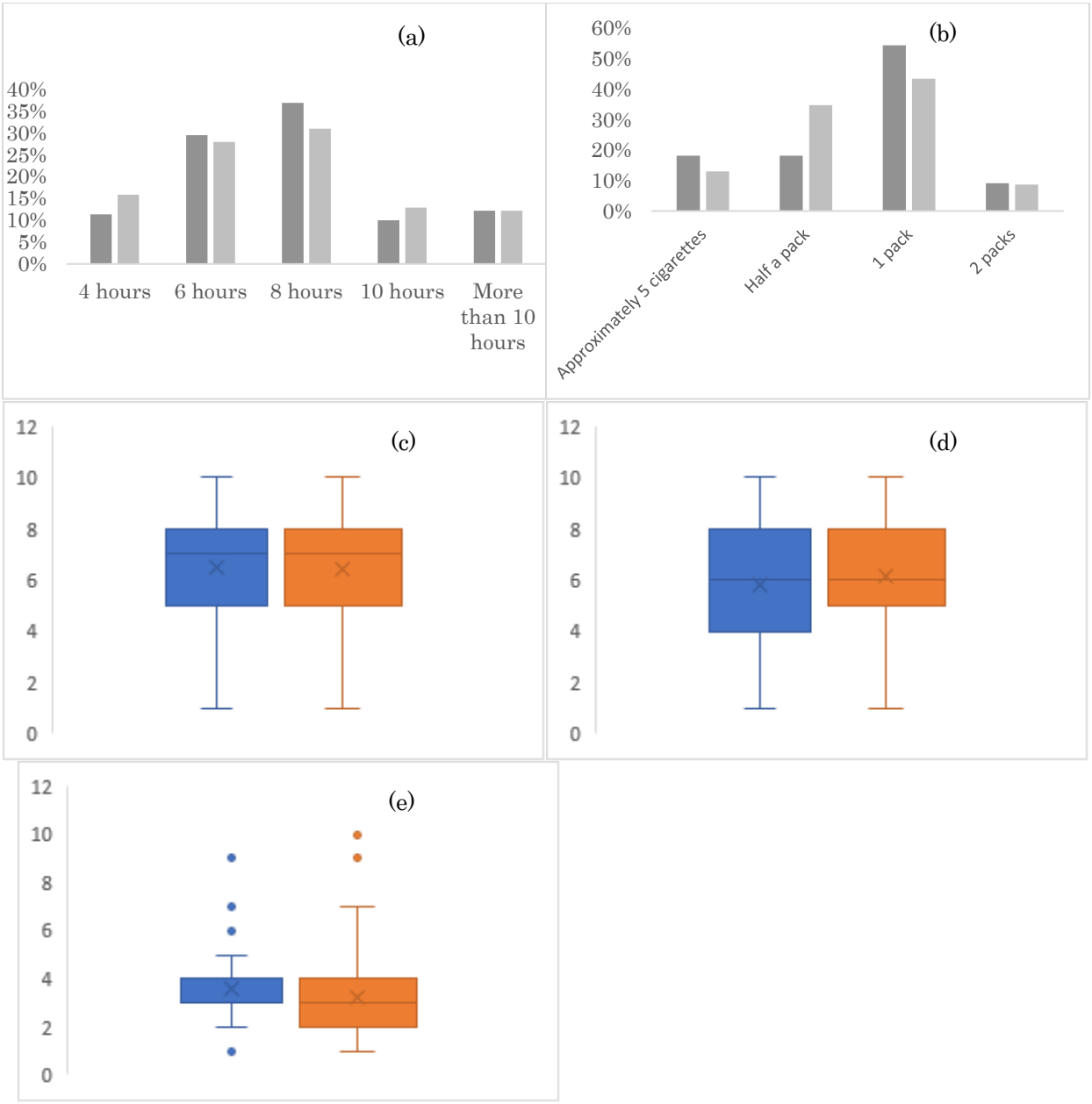

Fig. 8 Long-term effects of COVID-19 on sleeping, smoking, and eating habits. (a): duration of sleep ($p = 0.473$), (b): number of cigarettes the patient smoke ($p = 0.166$), (c): self-evaluation of physical activity during exercise, (d): box plot for scale of frequency of eating healthy food, and (e): box plot for frequency of eating. The blue bars indicate before infection, the orange bars indicate after infection.

Discussion

There is no doubt that the pandemic of COVID-19 has negatively affected several aspects of our routine daily life including exercising and working out. However, exercise should be continued as much as possible throughout this crisis to avoid health concerns such as obesity, depression, infections, and cardiovascular illnesses. In addition, it was recently shown that exercise can enhance the antibody response to COVID-19 vaccine, without altering side effect [13], however, the effect of COVID-19 on exercising capacity was not investigated thoroughly, and therefore, is the focus of this study. Patients who had been hospitalized with COVID-19 because of severe illness or respiratory symptoms were shown to have lower exercising capacity, however, no difference were reported in respiration efficiency between those who required intensive care unit (ICU) and those who did not [14]. Exercising capacity after full recovery from COVID-19 largely depend on each case, with negative effects more evident in the case of the presence of respiratory symptoms during the course of infection [15].

Regarding the molecular basis of the effects occurring due to the inflammatory factor in COVID-19 infection, inflammation mediators are main players.

Cytokines are categorized into anti-inflammatory or pro-inflammatory. Interleukin 10 (IL-10) and transforming growth factor-beta (TGF-β) as are anti-inflammatory cytokines that inhibit the development of pro-inflammatory cytokines, which are IL-6, IL-1, IL-2, IL-12, IL-18, interferon-gamma (IFN-γ), and tumor necrosis factor-alpha (TNF-α). Hormonal abnormalities, oxidative stress, and physical activity can alter cytokine production [16] since muscle contraction causes the release of anti-inflammatory and pro-inflammatory cytokines, which varies depending on the amount of contractile mass involved as well as the length and intensity of exercise.

The temporary rise in circulating levels of IL-6 is caused by muscle contraction, which is proportional to the length of physical activity and the amount of muscle mass recruited [17]. Increases in anti-inflammatory cytokines such as IL-10, released by innate immunity cells, is responsible for fostering an anti-inflammatory environment by inhibiting inflammatory mediators to reduce tissue harm. Also, IL-10 has been linked to improved insulin sensitivity and glycemic control. Good glycemic regulation has been linked to a better prognosis in COVID-19 participants with type 2 diabetes mellitus and new coronavirus infection. In addition, physical activity can help to lower high levels of the pro-inflammatory adiponectin and increase leptin and insulin sensitivity [16].

On the other hand, increased immune surveillance against infections has been suggested as a method for strengthening the immune response. Increased level of the circulating immune cells, immunoglobulins, and anti-inflammatory cytokines occur because of moderate-intensity physical activity, which can minimize the impact of invading pathogen on the body organs, including the lung being the most affected organ by COVID-19, and that decrease the risk of lung damage. Furthermore, inflammatory response and production of stress hormones are reduced during daily physical activity; however, lymphocytes, natural killer (NK) cells, immature B cells, and monocytes are at high levels [18]. Therefore, there is an increase in immunovigilance as well as a decrease in the systemic inflammatory process, all of which are reasons that support the idea that daily physical activity strengthens the immune system while, at the same time, preventing respiratory diseases and as a result can protect against COVID-19 infection [19].

It is worth mentioning that catecholamines play an interesting role since they facilitate the mobilization and redistribution of lymphocytes during exercises that cause cardiorespiratory overload. This activity mainly activates lymphocyte subtypes and recruit them from reservoirs such as blood vessels, spleen, and bone marrow to lymphoid tissues and organs like the upper respiratory tract, lungs, and intestines in order to fight pathogens; thereby, boosts immune surveillance and enhancing antiviral response.

Conclusion

The pandemic of COVID-19 has a negative impact on multiple life aspect. This surveillance study proved the undesirable long-term effect of infection with COVID-19 on physical activity and exercising. There was a general tendency toward decreased capacity of exercising, duration, and recovery before next physical session after COVID-19 infection. The results of our study shall encourage people to continue their physical fitness even during lockdowns and constrained workout conditions in order to enhance their immunovigilance.

Conflict of interest

All authors declare no financial and personal relationships with other people or organizations that could inappropriately influence their work.

Ethical approval statement

Ethical approval was obtained prior to commencing the study from the research ethics committee at Taibah University (COPTU-REC-24-20211013).

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