

Aerobic training effect on mental health and biological indicators in post-COVID-19 patients Efecto del entrenamiento aeróbico sobre indicadores biológicos y de salud mental en pacientes post-COVID-19

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Abstract. Introduction. One of the aspects of health most affected in patients infected by COVID-19 was mental health. Leading organizations worldwide have recommended physical activity as one of the main actions. Objective. To analyze the effect of a short-term aerobic training program on biological and mental health and quality of life indicators in post-Covid-19 patients. Methods. Symptomatology of depression, anxiety, stress, quality of life, vital signs, physical fitness and body composition were measured in 10 post COVID-19 patients. An aerobic physical exercise program was applied at 40-60% intensity, five days a week, 50 minutes per session for four weeks. Results. A 30% decrease in depression symptomatology, 58% in stress and 44% in anxiety was found during the intervention period ($p < 0.001$). Regarding the perception of quality of life, the psychological area was the one that presented a positive effect during the intervention ($p = 0.035$). An increase in leg strength ($p = 0.018$) and a decrease in body fat ($p = 0.005$) were found during the intervention. Conclusion. A short-term physical exercise program shows benefits in mental health indicators in post-COVID-19 patients.

Key Words: Physical activity; Mental health; Quality of life, COVID-19; Fitness.

Resumen. Introducción. Uno de los aspectos de la salud más afectados en los pacientes contagiados por COVID-19 fue la salud mental. Organizaciones líderes a nivel mundial han recomendado como uno de los principales tratamientos la práctica de actividad física. Objetivo. Analizar el efecto de un programa de ejercicio aerobio de corta duración sobre indicadores biológicos, salud mental y calidad de vida en pacientes post COVID-19. Métodos. Se midió en 10 pacientes post COVID-19 la sintomatología de depresión, ansiedad, estrés, calidad de vida, signos vitales, aptitud física y composición corporal. Se aplicó un programa de ejercicio físico aerobio al 40-60% de intensidad, cinco días a la semana, 50 minutos por sesión durante cuatro semanas. Resultados. Se encontró una disminución de la sintomatología de depresión de un 30%, de estrés un 58% y ansiedad un 44% durante el periodo de intervención ($p < 0.001$). Respecto a la percepción de calidad de vida, el área psicológica fue la que presentó un efecto positivo durante la intervención ($p = 0.035$). Se encontró un aumento en fuerza de piernas ($p = 0.018$) y disminución de grasa corporal ($p = 0.005$) durante la intervención. Conclusión. Un programa de ejercicio físico de corta duración presenta beneficios en indicadores de salud mental en pacientes post COVID-19.

Palabras clave: Actividad física; Salud mental; Calidad de Vida, COVID-19, Aptitud física.

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Introduction

The World Health Organization (WHO) declared the beginning of the Covid-19 pandemic in March 2020, ending the health emergency in May 2023 (WHO, 2023). This pandemic, in addition to causing 6.3 million deaths globally and 2,955,770 deaths in the Americas region (PAHO, 2023) generated mild disease in most cases; however, those cases with more severe disease developed severe hypoxia and required hospitalization and mechanical ventilation (Ochani, Asad, Yasmin, Shaikh, Khalid, Batra et al., 2021), while the majority of cases that developed clinical features of cough, fever, malaise, myalgia, respiratory distress and distress were 96% severe (Ochani et al., 2021).

The American Hospital Association estimates around 202.6 million dollars of lost income, while those in low- and middle-income countries around 52 billion dollars (Kaye, Okeagu, Pham, Silva, Hurley, Arron et al., 2021), in turn, it is evident that the main epidemiological problems that will prevail are those related to mental health at different stages of life derived from social restrictions, deaths due to loved ones and adaptation to the new normal (Panchal, Salazar de Pablo, Franco, Moreno, Parellada, Arango et al., 2023; Ghahramani, Kasraei, Hayati, Tabrizi, & Marzaleh 2023; Zent, Zhao, Yan, Li, Lu, Liu et al., 2023;

Li, Hou, Cheng, Miao, Yeerjang, Sheng et al., 2023).

It is estimated that more than 340 million people in the world suffer from mental disorders, being the leading cause of disability worldwide (WHO, 2017). Depression and anxiety are two of the most common psychological conditions that emerged as a result of the COVID-19 pandemic (Maggi et al., 2023), so the need to address these health conditions should be part of the priority political and governmental strategies, although there are pharmacological treatments for these affectations, many people do not have access to them, however, physical activity has an effect on biochemical and physiological mechanisms such as the release of endorphins, increased production of neurotransmitters and improved emotional self-regulation (Mikkelsen, Stojanovska, Polenakovic, Bosevski, & Apostolopoulos, 2017). Some of the primary physiological mechanisms in response to physical exercise, which may positively impact mental health, include increased production of endorphins, serotonin, and dopamine, which play a crucial role in regulating mood and promoting a sense of well-being. Additionally, exercise leads to the attenuation of the hypothalamic-pituitary-adrenal axis in response to stress, improved mitochondrial activity, and mitogenesis, and promotes synaptic plasticity in the brain (Mikkelsen et al., 2017). These physiological effects have shown to have an

benefit effect on aspects of mental health such as depression in older adults (Hidalgo et al., 2019), and in adolescents (Dubois, Lambrechts, Grogna, Robert, Jonckheer et al., 2019). Some authors suggest that it may be an auxiliary in supporting mental health as those adults who accumulate the a volume of 8.8 METs hour per week had 25% less risk and potential physiological benefits (Pearce, Garcia, Abbas, Strain, Schuch, Golubic et al., 2022). In a recent overview of systematic reviews, 97 systematic reviews covering 1,039 randomized controlled trials with over 128,119 participants were analyzed. It was found that physical exercise generates a positive effect on anxiety (standardized mean difference (SMD) of -0.42) at different levels of intensity (SMD of -0.47 for moderate intensity), mainly 4-5 days per week (SMD of -0.97) with durations between 30-60 minutes (SMD of -0.60). Meanwhile, on depression, the effect was also moderate (SMD of -0.43), particularly at moderate intensity (SMD of -0.47), carried out 4-5 days per week (SMD of -1.12) (Singh et al., 2023).

In a recent study conducted by Hernández Mata, and Jurado (2023), it was observed in adults how self-efficacy decreased considerably during the pandemic, being classified with low self-efficacy those who before the pandemic presented adequate levels; and in those whose self-efficacy was low, during the pandemic, it decreased to very low. In another recent study, physical activity was found to have a moderating effect on the impact of COVID-19 disease on anxiety. (Morales-Beltrán Hernández-Cruz, González-Fimbres, Rangel-Colmenero, Zazueta-Beltrán, & Reynoso-Sánchez, 2023).

During the pandemic, efforts were made to develop physical intervention strategies through the use of mobile applications; without necessarily observing effects on indicators such as body composition (Colmenero, Zazueta-Beltrán, and Felipe Reynoso-Sánchez, 2023), so that supervised and monitored intervention strategies in controlled environments and in person are necessary, which is crucial due to the adverse effects of confinement, particularly on biological and body composition indicators. For this reason, once the pandemic is over, special emphasis should be placed on the effects, since high rates of long-term psychiatric morbidity are estimated (Piva, Masotti, Raisi, Zerbini, Grazi, Mazzoni et al., 2023), so it is necessary to offer viable alternatives to the population to mitigate the mental sequelae and offer viable treatments for secondary symptoms of anxiety and depression in people who had the post-Covid-19 condition. This is why the present investigation sought to provide safe alternatives in relation to the dose-response of exercise in a short period of time, taking into account the possible sequelae derived from COVID-19 with the intention of presenting physical exercise as a valuable tool to improve symptoms related to physical health, depression and anxiety and thereby promote an active lifestyle derived from the end of the pandemic. Therefore, the aim of the present study is to analyze the effect of a short-term aerobic training program on biological and mental health indicators in post-Covid-19 patients.

Methods

The present quasi-experimental study was approved by the committee of the Faculty of Physical Culture Sciences under folio number 21092022-046. All participants signed informed consent for voluntary participation. All procedures were performed under the guidelines of the Helsinki declaration (AMM 2014) and to the General Health Law on Research. An initial sample of 16 participants was recruited through non-randomized sampling, by volunteers in the city of Chihuahua, Mexico, where they were invited to participate in the project through various media such as radio, social networks and flyers. As inclusion criteria were a) having presented COVID-19 between 3 and 6 months ago, b) persons older than 20 years, c) medical authorization for physical activity; and as exclusion criterion was a) presenting a percentage of attendance of more than 80% to the physical activity program, b) presenting COVID-19 during the intervention period. The final sample that met all the inclusion and exclusion criteria were 10 participants with an age of 49.7 ± 12.9 years.

Participants underwent baseline measurement (measurement 1) of body composition, vital signs, physical fitness, quality of life and mental health. A period of four weeks was allowed to elapse during which the participants did not perform any type of physical activity, nutritional or psychological intervention; this period was considered the "control period". Immediately after this period, the same aforementioned assessments were performed (measurement 2) and the intervention was continued with the physical exercise program for four weeks, considered as the "experimental period". Once the intervention was concluded, the evaluations were carried out immediately (measurement 3).

	Frequency	Intensity	Time	Type
Week 1	Treadmill: 2 days Arm crank ergometer: 3 days	40%	30 min	Aerobic - Continue
Week 2	Treadmill: días Arm crank ergometer: 2 days	50%	30 min	Aerobic - Continue
Week 3	Treadmill: 3 days Arm crank ergometer: 2 days	40 - 60% (1 min) 3-min-40%, 1-min-60%	30 min	Aerobic - Intercal
Week 4	Treadmill: 2 days Arm crank ergometer: 3 days Elyptic: 5 days	40 - 70% (1 min) 3-min-40%, 1-min-40%	40 min	Aerobic - Intercal

Figure 1. Exercise Training Program Prescription according to FITT model.

Physical exercise program

The intervention lasted four weeks, with a frequency of five sessions per week, at a moderate-vigorous intensity of 40% - 70% of the reserve heart rate, 30-40 minutes of aerobic exercise and 20 minutes of pulmonary breathing exercises. Aerobic training was performed on treadmills, arm crank ergometer and elliptical machines (Fig. 1). All workloads were individualized based on the initial assessment of basal heart rate. Work intensity during the sessions was

measured using a Polar Team Pro heart rate monitoring system (including sensors, monitors and software) and the Borg Perception of Exertion Scale.

Body composition

Height, triceps and subscapular fold were measured through the anthropometric technique proposed by the International Society for the Development of Cineanthropometry (ISAK) (Esparza-Ross, Vaquero-Cristóbal, & Marfell-Jones, 2019) by two level 1 certified anthropometrists. Based on the triceps and subscapular fold, body fat was estimated using Siri's formula (1961). Likewise, muscle mass and segmental fat mass were measured through bioelectrical impedance (InBody model 230. USA).

Vital Signs

At rest, the heart rate was measured with a Polar FT4 heart rate monitor, respiratory rate, manual blood pressure with a baumanometer and stethoscope, and oxygen saturation with a ChoiceMMed oximeter.

Physical fitness

To measure cardiovascular capacity, the YMCA bench test was applied, which consisted of raising and lowering a bench at a height of 30 cm guided by a metronome set at 96 beats per minute for three minutes. The heart rate response was measured every minute and one minute after the end of the test, the latter value being precisely the one that was compared with reference values established for age and sex to establish the recovery capacity and infer aerobic capacity. To measure the muscular strength of the arms, a TAKEI dynamometer model SMEDLEY T-19 was used in both hands, considering the best attempt of two possible attempts for each hand. Likewise, upper body strength was measured based on the "Sit to Stand" test of the Seniorfitness battery, which consists of getting up and sitting on a chair (with backrest and without armrests) for one minute, counting the maximum number of attempts.

Quality of Life

Quality of life was measured using the WHOQOL-Brief instrument (WHOQOL Group, 1998) structured in 26 items that are scored on a Likert-type scale from 1 to 5 points and measure four dimensions: physical health, psychological health, social relations and environmental health; it also allows an estimate of overall quality of life. A higher score reflects a higher quality of life. It has showed a Cronbach's alphas ranged from 0.65 to 0.82 in the Physical scale, 0.68 to 0.88 for the Psychological scale, 0.63 to 0.79 for the Social scale, and 0.70 to 0.83 for the Environmental scale, in Iberoamerican countries, including Mexico (Benítez-Borrego et al., 2016).

Mental Health

The CES-D scale (Radloff, 1977) was used to measure the symptomatology of depression based on the last two weeks, which consists of 20 items that are answered on a

Likert-type scale of five possible responses, where a score of less than 16 indicates the absence of symptoms below the threshold of depression. In the Mexican population, the 20-item version has presented a Cronbach's Alpha of 0.84; and, based on factor analysis, a capacity to explain variability of 50.6% for the items grouped into four factors (Chapela and Salgado, 2009).

To assess anxiety symptoms, the Hamilton scale (Hamilton, 1959) was used, which has been validated in Spanish population (Cronbach alpha of 0.9) consisting of 14 items scored from 0 to 4, where a total score <8 indicates no anxiety, 8 to 13 mild, 14 to 18 moderate, 19 to 22 severe, and >23 very severe symptoms (Herrero et al., 2003).

Likewise, the DASS (Depression, anxiety and stress scales) -21 (Lovibond & Lovibond, 1995) was used to assess mainly stress symptomatology, as well as anxiety and depression; It consists of 21 items that are scored on a Likert-type scale from 0 to 3 points, where a score of items belonging to the stress dimension <8 indicates no symptomatology, 8 to 9 mild, 10 to 12 moderate, 13 to 16 severe and <16 very severe stress symptomatology. During the pandemic, this scale showed good reliability in the Mexican population, with a Cronbach's Alpha of 0.95 and a variance explained by 70% based on confirmatory factor analysis (Sallinas-Rodríguez et al., 2023).

Statistical analysis

A normality analysis was carried out using the Shapiro-Wilk test, observing that the main variables did not show a normal distribution ($p < 0.05$). All variables were presented as medians and interquartile range. The Friedman test was applied with Post-Hoc adjustment with Wilcoxon signed-rank test for pairwise comparison, to analyze the differences between the three measurements (measurement 1 vs 2 for control period and measurement 2 vs 3 for experimental period). A Spearman correlation was performed to analyze the relationship between changes during the intervention with disease severity. Finally, the relative risk of the dependent variables during the control and experimental periods was estimated.

All tests were performed with a confidence level of 95%.

Qualitative approach

Finally, to elicit in-depth insights an open-ended question was asked to each participant individually: "The key question was "What impact did the program have on your health-related quality of life?", as the starting point for each interview. These interviews were meticulously recorded using a voice recorder to capture participants' responses in their entirety. Subsequently, the recorded interviews were transcribed verbatim, providing us with a textual corpus for analysis. Through qualitative content analysis, we identified and categorized essential themes and patterns related to the perceived impact of the intervention on health-related quality of life. Among the criteria for the generation of the essential categories, we

considered for each category, its pertinence and relevance in relation to the study objective, they were sufficiently exhaustive, and that they presented conceptual depth. To generate the essential categories, the information was first transcribed. Subsequently, codes were established to identify initial patterns, and from these, general categories were derived.

These categories underwent further refinement and grouping until the essential categories were ultimately obtained. In the present study, due to the presence of only one specific triggering question, the depth of iteration in the grouping of categories was not as extensive.

Results

Table 1. Median and interquartile range of body composition, vital signs, physical fitness, quality of life, and mental health variables before and after a physical exercise program in post-COVID patients.

Variables	Control period (4 weeks)									p value
	Measurement 1			Experimental Period (4 weeks)						
	\bar{x}	P25	P75	Measurement 2		Measurement 3				
	\bar{x}	P25	P75	\bar{x}	P25	P75	\bar{x}	P25	P75	
Body Composition										
TBF Siri (%)	35.5	31.0	40.3	38.0	33.5	41.8	37.5	32.3	40.3	0.004
TBF BI (%)	42.7	34.7	45.8	42.3	33.9	45.6	42.9	33.4	45.3	0.118
Trunk BF BI (%)	43.5	35.8	45.6%	42.8	35.7	45.5	43.3	34.9	46.0	0.097
Lean Mass (kg)	25.8	22.0	33.7	26.0	21.4	33.4	26.2	22.1	34.0	0.452
Vital signs										
SBP (mm/hg)	123.0	108.5	132.5	130.0	110.0	134.0	122.0	115.5	128.0	0.131
DBP (mm/hg)	84.0	67.5	92.5	76.0	69.0	85.0	79.0	68.5	84.0	0.819
Resting HR (beats/min)	79.0	76.0	91.0	81.0	73.0	81.0	79.0	68.0	86.0	0.323
RR (breaths /min)	16.0	15.0	19.0	16.0	15.0	17.0	14.0	12.0	16.0	0.179
Oxygen saturation (%)	95.5	94.0	96.3	94.5	92.8	96.3	95.0	93.0	97.3	0.135
Fitness										
HR 1-min (beats/min)	128.0	114.0	146.0	118.0	101.0	137.0	130.0	119.0	148.0	0.690
HR 2min (beats/min)	144.0	133.0	170.0	150.0	148.0	166.0	148.0	140.0	162.0	0.651
HR 3-min (beats/min)	148.0	135.0	176.0	170.0	151.0	177.0	163.0	148.0	174.0	0.065
Recovery HR (beats/min)	127.0	99.5	146.3	118.0	97.3	134.0	113.5	103.0	134.3	0.273
DH Dynamometry (kg)	27.0	13.5	33.1	28.0	17.8	34.5	28.0	21.5	35.0	0.227
NDH Dynamometry (kg)	23.7	19.8	31.7	26.0	19.0	36.0	25.0	22.5	33.5	0.819
Seat to Stand (repeticiones)	11.0	10.0	12.8	12.0	10.5	14.8	14.0	11.5	17.5	0.002
Quality of Life										
QoL WHOQOL-BREF	4.0	3.0	5.0	3.5	3.0	4.0	4.0	3.8	4.0	0.04
PH WHOQOL-BREF	63.0	56.0	82.8	66.0	56.0	72.0	69.0	63.0	88.0	0.237
PsH WHOQOL-BREF	78.0	59.8	88.0	69.0	61.3	81.0	84.5	73.5	94.0	0.035
SR WHOQOL-BREF	72.0	54.5	79.8	72.0	50.0	76.5	75.0	56.0	95.5	0.261
Environment WHOQOL-BREF	66.0	59.8	79.8	69.0	56.0	81.0	81.5	67.5	94.0	0.205
Mental Health										
Total score Minimental	34.0	32.8	35.0	34.0	32.0	34.5	34.5	33.8	35.0	0.191
SA Hamilton	5.0	3.0	8.0	6.0	3.0	9.0	3.0	1.8	4.5	0.023
PA Hamilton	10.0	4.5	12.5	8.0	6.3	11.5	4.5	3.0	6.0	0.004
Total Anxiety Hamilton	17.0	7.5	21.5	15.5	9.3	22.8	8.5	5.5	10.3	0.004
CES-D Depresión Total	11.0	8.5	21.5	10.0	5.5	22.8	7.0	3.8	11.0	0.007
Stress DASS	6.0	5.0	10.8	6.0	3.5	8.5	2.5	1.5	4.3	0.001
Anxiety DASS	4.5	1.8	6.3	3.0	0.5	5.5	2.5	1.0	4.3	0.058
Depression DASS	3.0	1.0	5.0	2.0	0.5	4.5	1.0	0.0	1.8	0.109
Total score DASS	14.0	8.5	22.3	10.0	5.5	16.5	5.5	3.5	10.5	0.008

TBF= Total Body Fat; BI= Bioelectrical impedance; SBP= Systolic Blood Pressure; DBP= Dyastolic Blood Pressure; RR= Respiratory Rate; HR= Heart rate; DH= Dominant Hand; NDH= Non-dominant hand; QoL= Quality of Life; PH= Physical Health; PsH= Psychological Health; SR= Social Relationships; SA= Somatic Anxiety; PA= Psychic Anxiety.

In the area where the physical exercise program was most effective was in the area of mental health. Based on the Hamilton scale score to assess general, psychic and somatic anxiety during the control period no changes were observed ($p>0.637$), while during the intervention period they decreased by 46%, 44% and 50% respectively ($p<0.05$). The score on the CES-D scale to assess depression also showed a decrease during the intervention period of 30% ($p=0.017$), with no changes observed during the control

Table 1 shows the medians and interquartile range of the different variables evaluated in this study. Among the main findings we can observe an improvement in the sit to stand test during the intervention period ($\bar{x}= 12.0$, RIC= 2.3 vs $\bar{x}= 14.0$, RIC= 6.0, $p=0.018$) while in the control period there was no change (0.346); likewise, in the percentage of body fat estimated by anthropometry, it was observed that during the control period body fat increased ($\bar{x}= 35.5$, RIC= 9.3 vs $\bar{x}= 38.0$, RIC= 8.3, $p=0.005$) and during the intervention it slightly decreased ($\bar{x}= 38.0$, RIC= 8.3 vs $\bar{x}= 37.5$ RIC= 8.0, $p=0.010$).

period ($p=0.362$), as well as in the stress dimension of the DASS scale, where it decreased by 58% ($p=0.013$), with no changes during the control period ($p=0.289$). These changes in the mental health indicators did not correlate with the level of perceived severity of COVID-19 disease, except in the anxiety area of the DASS scale, where the correlation was 0.67 ($p=0.047$); that is, there was a greater decrease in anxiety symptomatology in those who presented greater perceived severity of COVID-19.

For the analysis of a real change due to the effect of the period of exposure to the physical exercise program, the variables were analyzed categorically to identify those persons who were classified in a category without risk, estimating the relative risk (Table 2). Based on the classification of the CES-D scale, during the control period four out of nine people presented symptoms of depression and after the physical intervention period only one person continued to present depressive symptoms, obtaining a protection factor of 75% due to the effect of the intervention. Similar results were obtained for the psychological health perception classification based on the WOQOL-BREF scale, Systolic Blood Pressure (SBP) classification and physical fitness classification for the "Sit to Stand" test where a reduction of people with poor psychological health perception, high SBP and poor physical fitness were 66.7%, 75% and 40% respectively, being classified after the intervention period as good psychological health perception, normal SBP and good physical fitness.

Table 2. Frequency and estimated relative risk in Post COVID-19 individuals with and without the risk condition during the control and experimental period.

"Sit to Stand" test					
	Poor	Good	Total	RR	RRR
Experimental	3	6	9	0.600 [0.200 – 1.790]	0.400
Control	5	4	9		
Total	8	10	17		
Systolic Blood Pressure					
	High	Normal	Total	RR	RRR
Experimental	1	8	9	0.250 [0.034 – 1.823]	0.750
Control	4	5	9		
Total	5	13	18		
CES-D Scale Classification					
	With DS	Without DS	Total	RR	RRR
Experimental	1	8	9	0.250 [0.034 – 1.823]	0.750
Control	4	5	9		
Total	5	13	18		
Psychological Health Perception WHO					
	Poor	Good	Total	RR	RRR
Experimental	2	8	10	0.333 [0.87 – 1.272]	0.667
Control	6	4	10		
Total	8	12	20		

RR= Relative Risk; RRR= Relative Risk Reduction (1-RRR); DS= Depression Symptomatology.

Finally, an open-ended question was developed based on "What impact did the program have on your health-related quality of life?", obtaining as the main essential categories 1) better physical condition, 2) better sleep quality, and 3) reduction of anxiety and stress (Fig. 2). In relation to the category of 'better physical condition,' 80% of the sample reported an improvement in muscle strength, as well as an ability to climb/lower stairs and perform supermarket shopping—activities they couldn't do before. As for the 'better sleep quality' category, five of the ten participants mentioned experiencing an increase in the number of hours of sleep and/or uninterrupted sleep following the physical exercise program. An interesting observation was that, following the physical activity program, two participants started spending more time with friends and family and exhibited increased motivation to engage in recreational and social activities. In addition, Fig. 3 shows some of the main direct quotations obtained from the open-ended question.



Figure 2. Frequency of essential categories related to the question "What impact did the program have on your health-related quality of life?"

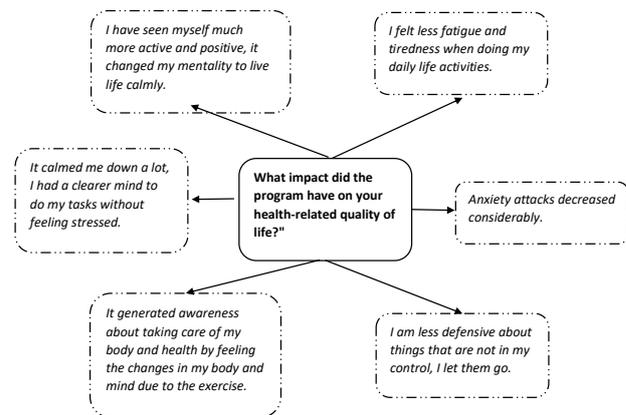


Figure 3. Open-ended responses from participants to open-ended question.

Discussion

In the present study, the effect of a short-duration aerobic physical exercise program of moderate intensity on biological indicators such as vital signs, body composition, physical fitness and aspects related to mental health and quality of life in health was analyzed, and improvements were observed in the latter two aspects. There was a decrease in somatic and psychological anxiety, depression and stress, as well as an increase in lower body strength and a decrease in total body fat.

During the COVID-19 contingency, the American College of Sports Medicine (ACSM) and the WHO recommended as a priority to maintain or increase the volume of physical activity to mitigate the negative biological and mental effects of sedentary lifestyles and social isolation (Denay, Breslow, Turner, Nieman, Roberts, & Best, 2020). It is well known that physical exercise has multiple health benefits in the different systems of the organism; however, due to the multifactorial nature of COVID-19 disease, the important thing is to find the most efficient physical intervention program, i.e., the one that generates the greatest benefits with the least risks in the shortest possible time (Cattadori, Di Marco, Baravelli, Picozzi, & Ambrosio, 2022).

Among the most important findings observed in the

present study was the decrease in anxiety and depression symptomatology, based on a physical exercise program aligned with the most recent physical activity recommendations of the WHO (WHO, 2020). These changes observed in mental health indicators occurred regardless of the level of perceived severity of COVID-19, except for the anxiety indicator of the DASS scale where greater positive changes were observed in those who presented more severe COVID-19. It has been observed that patients with ventilator use are more affected in their mental health (Ahmed, Inam, Belli, Ahmad, Khalil, & Jafar, 2021) and the effect of physical exercise may be greater precisely in these patients. Ahmed et al. (2021), found a 42% improvement in mental health indicators from a physical exercise program in patients who needed ventilator and a 39% improvement in patients who did not use a ventilator.

However, regardless of the severity of the disease, physical exercise has a positive effect on mental health; where a low but significant effect size of physical exercise on the reduction of depression and anxiety symptoms in healthy adults with a non-communicable disease has already been observed in randomized controlled trials (Piva et al., 2023). Regarding the effect in post-COVID-19 patients, Ahmadi-Hekmatikar, Ferreira-Júnior, Shahrbanian, & Suzuki (2022), conducted a systematic review in 2022 and analyzed seven studies where concurrent training (aerobic and resistance training) was applied in post-COVID-19 patients, observing among the main changes an improvement in quality of life and reduction of anxiety and stress levels (Ahmadi-Hekmatikar et al., 2022). The studies analyzed in that systematic review had a duration of 8 to 12 weeks; whereas, in our study, there was a significant decrease in the levels of anxiety, stress and depression in four weeks of physical exercise, which is novel and demonstrates efficiency in this type of program. Another important factor to consider was that in most of the seven studies reviewed by Ahmadi-Hekmatikar et al. (2022), the frequency of training ranged from 2 to 4 days, while in our study the frequency was five days per week.

The positive effect of exercise on mental health and health-related quality of life should be prioritized in the main intervention strategies in post-COVID-19 patients. Mainly because failure to address the symptoms of anxiety, depression or stress could lead to a chronic clinical condition that could lead to future non-communicable diseases. During the severe acute respiratory syndrome (SARS) epidemic that began in Hong Kong in 2002, it was found that 30 months after contracting the disease, there was a 33% prevalence of psychiatric disorders in patients, with post-traumatic stress disorder and depression being the main disorders (Mak, Chu, Pan, Yiu, & Chan, 2009).

On the other hand, it has been observed that among the main factors that generate adherence to physical activity programs, the presence of low or no levels of depressive symptomatology stands out (Picorelli et al., 2014). Machaczek, Allmark, Goyder, Grant, Ricketts, & Pollard (2018), from a literature review, found that the presence of

moderate depression interferes with the willingness or motivation to engage in physical activity; however, a low volume of physical activity at the beginning of the intervention may favor adherence to the program. In the present study, it was also observed from a qualitative analysis, how the participants not only perceived a decrease in anxiety and depression as a result of the physical exercise program, but also perceived greater motivation and concentration, important aspects that favor the ability to perform daily activities and maintain an active lifestyle. In a study on chronic obstructive pulmonary disease (COPD) patients, physical exercise was deemed crucial for sustaining an active lifestyle post-pulmonary rehabilitation. Participants emphasized a strong desire for continued rehabilitation, citing improved exercise tolerance and daily functioning as key benefits. Factors like routine, exercise facility, confidence, and peer support were identified as crucial for maintaining physical activity. However, health status, symptom variability, unpredictability, and energy levels posed significant barriers. The findings highlight the importance of ongoing support and structured exercise sessions to preserve the benefits gained from pulmonary rehabilitation (Hogg, Grant, Garrod, and Fiddler, 2012). In the literature it has been reported that physical exercise has many health benefits; however, one of the problems is precisely the lack of physical exercise in the population, and as mentioned above, one of the main factors is the lack of motivation or the lack of visibility of the priority of physical exercise. During the pandemic, this problem increased further. Kaur, Singh, Arya and Mittal (2020) observed in people who habitually exercised before the pandemic, how during confinement they experienced negative situational perception, mental health problems and a lack of motivation for physical exercise which reduced their levels of physical activity; however, in this same study, people gradually adapted to exercise at home, perceiving benefits in their physical and mental health, emphasizing mainly social support, self-perception, reflection on the benefits of physical exercise, and development of effective coping strategies as the main aspects that favored adherence to physical exercise.

Based on the above, intervention based on physical activity in post-covid-19 patients is a priority, since mental health was one of the areas most affected during the COVID-19 pandemic and at the same time is apparently the one that shows the earliest positive changes because of physical activity. This was demonstrated in the present study with an intervention of short duration, which may lead to greater adherence to physical exercise and consequently to more benefits at the biological level in other areas.

On the other hand, one of the main indicators that did not change in the present study was aerobic capacity assessed by recovery heart rate from the YMCA 3-minute bench test and by resting heart rate. This may have been due to the duration of the study, which did not allow for the necessary physiological adaptations, or possibly the indicator used, which, in this study, was the recovery heart rate. In a study by García-Suárez, Aburto-Corona, Rentería,

Gómez-Miranda, Moncada-Jiménez, Lira et al. (2022), in healthy adults during COVID-19 confinement, they applied a training program based on high-intensity circuits of 10 minutes each session, three sessions per day for 12 days, without observing any changes in the variability of the resting heart rate during the intervention period.

However, other studies that have used others measurement indicators have observed improvements. In a study carried out by Ahmed et al. (2021), they found improvements in aerobic capacity after a 5-week aerobic training program in post-covid patients using as an indicator of aerobic capacity the distance covered in meters from the 6-minute walking test, which may have contributed to finding significant changes, since the distance covered is a methodological indicator, whereas in our study we used as an indicator the heart rate, which is a biological indicator. Similar results were found by Araújo, Barros, Nunes, Remígio de Aguiar, Mastroianni, & de Souza (2023), after applying a physical exercise program of 12 sessions, twice a week in post-COVID-19 patients, finding an increase in peak VO_2 of $3.6 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and in the 6-minute-walking test. In relation to muscle strength, an increase in lower body strength was observed in the present study. Similar results have been observed by Chang, Chiang, & Chien (2023), from a 16-week comprehensive physical intervention in older adults during the COVID-19 pandemic. On the other hand, through qualitative analysis, people perceived an improvement in their physical fitness both to perform activities of daily living and in the execution of the physical tests performed after the aerobic program intervention, mainly in the YMCA bench test to measure cardiovascular capacity. In the analysis of essential categories, the category that presented the greatest weight was "Better physical condition", with eight of the ten participants expressing it as the area or dimension that most improved of their health-related quality of life. This may serve as an incentive for participants to continue exercising, since participants who improve their fitness experience less difficulty in establishing and maintaining regular exercise in their daily lives compared to those who experience a reduction in fitness after an exercise intervention program (Quist et al., 2022).

One of the main limitations of the present study was the sample size; however, the literature has shown similar sample sizes in this population group. In addition, this study takes a qualitative approach to the aspects of improvement perceived as a result of the physical exercise program, albeit not in an exhaustive manner, as it was not the primary objective. However, to derive significant insights from the focal question, it is recommended to conduct a more in-depth exploratory qualitative study using focus groups, additional triggering questions, and participant observation during the physical exercise sessions.

Conclusion

In conclusion, the present study based on a short-term aerobic physical exercise program of moderate vigorous

intensity generated a positive impact on mental health and biological indicators in individuals who have recovered from COVID-19. The study found that the program was effective in reducing depression, stress, and anxiety symptoms, while also improving leg strength and reducing body fat. These findings are consistent with the recommendations of the WHO and the ACSM, which suggest that physical activity can mitigate the negative biological and mental effects of sedentary lifestyles and social isolation during the COVID-19 pandemic.

Is important to consider physical exercise programs to the specific needs of post-COVID-19 patients, taking into account their individual physical and mental health status, as well as their perceived severity of COVID-19. Further research is warranted to explore the long-term effects of physical exercise on post-COVID-19 patients and to identify the physical exercise prescription that generates the greatest benefits with the minimum risk and the greatest adherence in patients, due to the multi-clinical sequels that post-COVID-19 patients may experience. Finally, it is important to consider physical activity as a non-pharmacological treatment in the treatment of depression, anxiety and stress symptomatology mainly.

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Conflicts of interest

The authors declare they have no conflicts of interest.

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References

- Ahmadi-Hekmatikar, A. H., Ferreira-Júnior, J. B., Shahrbanian, S., & Suzuki, K. (2022). Functional and psychological changes after exercise training in post-COVID-19 patients discharged from the hospital: A PRISMA-compliant systematic review. *International Journal of Environmental Research and Public Health*, 19(4), 2290. <https://doi.org/10.3390/ijerph19042290>.
- Ahmed, I., Inam, A. B., Belli, S., Ahmad, J., Khalil, W., & Jafar, M. M. (2022). Effectiveness of aerobic exercise training program on cardio-respiratory fitness and quality of life in patients recovered from COVID-19. *European Journal of Physiotherapy*, 24(6), 358-363. <https://doi.org/10.1080/21679169.2021.1909649>.
- Araújo, B. T., Barros, A. E. V., Nunes, D. T., Remígio de Aguiar, M. I., Mastroianni, V. W., de Souza, J. A., et al. (2023). Effects of continuous aerobic training associated with resistance training on maximal and submaximal exercise tolerance, fatigue, and quality of life of patients post-COVID-19. *Physiotherapy Research International*, 28(1), e1972.

- <https://doi.org/10.1002/pri.1972>.
- Asociación Médica Mundial (AMM). (2014). Declaración de Helsinki. Principios éticos para la investigación en seres humanos. *Boletín del Consejo Académico de Ética Médica*, 1(2), 239-243.
- Benítez-Borrego, S., Mancho-Fora, N., Farràs-Permanyer, L., Urzúa-Morales, A., & Guàrdia-Olmos, J. (2016). Differential Item Functioning of WHOQOL-BREF in nine Iberoamerican countries. *Revista Iberoamericana de Psicología y Salud*, 7(2), 51-59. <https://doi.org/10.1016/j.riips.2016.04.001>.
- Cattadori, G., Di Marco, S., Baravelli, M., Picozzi, A., & Ambrosio, G. (2022). Exercise training in post-COVID-19 patients: The need for a multifactorial protocol for a multifactorial pathophysiology. *Journal of Clinical Medicine*, 11(8), 2228. <https://doi.org/10.3390/jcm11082228>.
- Chang, S. H., Chiang, C. C., & Chien, N. H. (2023). Efficacy of a multicomponent exercise training program intervention in community-dwelling older adults during the COVID-19 pandemic: A cluster randomized controlled trial. *Geriatric Nursing*, 49, 148-156. <https://doi.org/10.1016/j.gernurse.2022.11.019>.
- Chapela, I. B., & de Snyder, N. S. (2009). Características psicométricas de la Escala Center for Epidemiological Studies-depression (CES-D), versiones de 20 y 10 reactivos, en mujeres de una zona rural mexicana. *Salud mental*, 32(4), 299-307.
- Colmenero, B. R. (2023). Efecto de un programa de actividad física basado en el uso de aplicaciones móviles sobre la composición corporal de jóvenes universitarios durante el confinamiento por COVID-19. *Retos: nuevas tendencias en educación física, deporte y recreación*, (50), 717-723. <https://doi.org/10.47197/retos.v50.98385>.
- Denay, K. L., Breslow, R. G., Turner, M. N., Nieman, D. C., Roberts, W. O., & Best, T. M. (2020). ACSM call to action statement: COVID-19 considerations for sports and physical activity. *Current Sports Medicine Reports*, 19(8), 326-328. <https://doi.org/10.1249/JSR.0000000000000739>.
- Esparza-Ros, F., Vaquero-Cristóbal, R., & Marfell-Jones, M. (2019). International standards for anthropometric assessment. *International Society for the Advancement of Kinanthropometry (ISAK)*.
- Fossati, C., Torre, G., Vasta, S., Giombini, A., Quaranta, F., Papalia, R., et al. (2021). Physical exercise and mental health: The routes of a reciprocal relation. *International Journal of Environmental Research and Public Health*, 18(23), 12364. <https://doi.org/10.3390/ijerph182312364>.
- García-Suárez, P. C., Aburto-Corona, J. A., Rentería, I., Gómez-Miranda, L. M., Moncada-Jiménez, J., Lira, F. S., et al. (2022). Short-Term High-Intensity Circuit Training Does Not Modify Resting Heart Rate Variability in Adults during the COVID-19 Confinement. *International Journal of Environmental Research and Public Health*, 19(12), 7367. <https://doi.org/10.3390/ijerph19127367>.
- Ghahramani, S., Kasraei, H., Hayati, R., Tabrizi, R., & Marzaleh, M. A. (2022). Health care workers' mental health in the face of COVID-19: A systematic review and meta-analysis. *International Journal of Psychiatry in Clinical Practice*, 1-10. <https://doi.org/10.1080/13651501.2022.2101927>.
- Hamilton, M. (1959). The assessment of anxiety states by rating. *British Journal of Medical Psychology*, 32, 50-55. <https://doi.org/10.1111/j.2044-8341.1959.tb00467.x>.
- Hernández, P. Z., Mata, K. J. M., & Jurado, F. V. (2023). Autoeficacia para el ejercicio físico antes y durante la Pandemia Covid-19. *Retos: nuevas tendencias en educación física, deporte y recreación*, (47), 1041-1045. <https://doi.org/10.47197/retos.v47.90792>.
- Herrero, M. J., Blanch, J., Peri, J. M., De Pablo, J., Pintor, L., & Bulbena, A. (2003). A validation study of the hospital anxiety and depression scale (HADS) in a Spanish population. *General hospital psychiatry*, 25(4), 277-283.
- Hidalgo, J. L. T., & Sotos, J. R. (2021). Effectiveness of physical exercise in older adults with mild to moderate depression. *Annals of Family Medicine*, 19(4), 302-309. <https://doi.org/10.1370/afm.2670>.
- Hogg, L., Grant, A., Garrod, R., & Fiddler, H. (2012). People with COPD perceive ongoing, structured and socially supportive exercise opportunities to be important for maintaining an active lifestyle following pulmonary rehabilitation: a qualitative study. *Journal of Physiotherapy*, 58(3), 189-195. [https://doi.org/10.1016/S1836-9553\(12\)70110-8](https://doi.org/10.1016/S1836-9553(12)70110-8).
- Kaur, H., Singh, T., Arya, Y. K., & Mittal, S. (2020). Physical fitness and exercise during the COVID-19 pandemic: A qualitative enquiry. *Frontiers in psychology*, 2943. <https://doi.org/10.3389/fpsyg.2020.590172>.
- Kaye, A. D., Okeagu, C. N., Pham, A. D., Silva, R. A., Hurley, J. J., Arron, B. L., et al. (2021). Economic impact of COVID-19 pandemic on healthcare facilities and systems: International perspectives. *Best Practice & Research Clinical Anaesthesiology*, 35(3), 293-306. <https://doi.org/10.1016/j.bpa.2020.11.009>.
- Li, Y., Hou, T., Cheng, M., Miao, Y., Yeerjang, Y., Sheng, C. S., et al. (2023). Anxiety prevalence and its association with physical activity in patients with non-communicable diseases during COVID-19 lockdown: A cross-sectional study in Shanghai, China. *BMC Public Health*, 23(1), 1-10. <https://doi.org/10.1186/s12889-022-14369-1>.
- Lovibond, S., & Lovibond, P. (1995). *Manual for the depression anxiety stress scales*. Psychology Foundation of Australia.
- Machaczek, K. K., Allmark, P., Goyder, E., Grant, G., Ricketts, T., Pollard, N., et al. (2018). A scoping study of interventions to increase the uptake of physical activity (PA) amongst individuals with mild-to-moderate depression (MMD). *BMC Public Health*, 18(1), 1-22. <https://doi.org/10.1186/s12889-018-5270-7>.
- Maggu, G., Verma, V., Chaudhury, S., & Indla, V. (2023). Epidemic of Depression and Anxiety in child and adolescent population during COVID-19 pandemic: A systematic review and meta-analysis of the prevalence of depression and anxiety. *Indian Journal of Psychiatry*, 65(3), 299-309. https://doi.org/10.4103/indianjpsychiatry.indianjpsychiatry_700_21.
- Mak, I. W., Chu, C. M., Pan, P. C., Yiu, M. G., & Chan, V. L. (2009). Long-term psychiatric morbidities among SARS survivors. *General Hospital Psychiatry*, 31(4), 318-326. <https://doi.org/10.1016/j.genhosppsych.2009.03.001>.
- Mikkelsen, K., Stojanovska, L., Polenakovic, M., Bosevski, M., & Apostolopoulos, V. (2017). Exercise and mental health. *Maturitas*, 106, 48-56. <https://doi.org/10.1016/j.maturitas.2017.09.003>.
- Morales-Beltrán, A. R., Hernández-Cruz, G., González-Fimbres, R., Rangel-Colmenero, B., Zazueta-Beltrán, D., & Reynoso-Sánchez, L. (2022). La actividad física como moderador en la ansiedad asociada al COVID-19 en estudiantes universitarios. *Retos: Nuevas Perspectivas de Educación Física, Deporte y Recreación*, 45. <https://doi.org/10.47197/retos.v45i0.92974>.
- Ochani, R., Asad, A., Yasmin, F., Shaikh, S., Khalid, H., Batra,

- S., et al. (2021). COVID-19 pandemic: From origins to outcomes. A comprehensive review of viral pathogenesis, clinical manifestations, diagnostic evaluation, and management. *Infezioni Mediche*, 29(1), 20-36.
- Pan-American Health Organization (PAHO). (s.f.). Brote de enfermedad por el Coronavirus (COVID-19). [En línea]. Disponible en: https://www.paho.org/es/temas/coronavirus/brote-enfermedad-por-coronavirus-covid-19?Gclid=Cj0KCQjwqNqkBhDIARIsA-FaxvwzNYGDp905TjhKli8bNu5aUduXsCZIE-TOknyJiHvz6ynS_xvfisqrqaalulealw_wcb. Accedido el [October 2023].
- Panchal, U., Salazar de Pablo, G., Franco, M., Moreno, C., Parellada, M., Arango, C., et al. (2021). The impact of COVID-19 lockdown on child and adolescent mental health: systematic review. *European Child & Adolescent Psychiatry*, 1-27. <https://doi.org/10.1007/s00787-021-01856-w>.
- Pearce, M., Garcia, L., Abbas, A., Strain, T., Schuch, F. B., Golubic, R., et al. (2022). Association between physical activity and risk of depression: A systematic review and meta-analysis. *JAMA Psychiatry*, 79(6), 550-559. <https://doi.org/10.1001/jamapsychiatry.2022.0609>.
- Philippot, A., Dubois, V., Lambrechts, K., Grogna, D., Robert, A., Jonckheer, U., et al. (2022). Impact of physical exercise on depression and anxiety in adolescent inpatients: A randomized controlled trial. *Journal of Affective Disorders*, 301, 145-153. <https://doi.org/10.1016/j.jad.2022.01.011>.
- Picorelli, A. M. A., Pereira, L. S. M., Pereira, D. S., Felício, D., & Sherrington, C. (2014). Adherence to exercise programs for older people is influenced by program characteristics and personal factors: a systematic review. *Journal of Physiotherapy*, 60(3), 151-156. <https://doi.org/10.1016/j.jphys.2014.06.012>.
- Piva, T., Masotti, S., Raisi, A., Zerbini, V., Grazi, G., Mazzoni, G., et al. (2023). Exercise program for the management of anxiety and depression in adults and elderly subjects: Is it applicable to patients with post-covid-19 condition? A systematic review and meta-analysis. *Journal of Affective Disorders*. <https://doi.org/10.1016/j.jad.2022.12.155>.
- Quist, J. S., Winther, J., Friis, A. L., Gram, A. S., Blond, M. B., Rosenkilde, M., ... & Stallknecht, B. M. (2022). Maintenance of cardiorespiratory fitness, body composition, and a physically active lifestyle after structured exercise interventions in individuals with overweight and obesity: A mixed-method follow-up study. *Public Health in Practice*, 4, 100293. <https://doi.org/10.1016/j.pubhip.2022.100293>.
- Radloff, L. (1977). The CES-D Scale: a self-report depression scale for research in the general population. *Applied Psychological Measurement*, 1, 385-401. <https://doi.org/10.1177/0146621677001003>.
- Salinas-Rodríguez, A., Argumedo, G., Hernández-Alcaraz, C., Contreras-Manzano, A., & Jáuregui, A. (2023). Depression, Anxiety, and Stress Scale: Factor validation during the first COVID-19 lockdown in Mexico. *Revista Latinoamericana de Psicología*, 55, 83-90. <https://doi.org/10.14349/rlp.2023.v55.10>.
- Singh, B., Olds, T., Curtis, R., Dumuid, D., Virgara, R., Watson, A., ... & Maher, C. (2023). Effectiveness of physical activity interventions for improving depression, anxiety and distress: an overview of systematic reviews. *British Journal of Sports Medicine*.
- Siri, W. E. (1961). Body composition from fluid spaces and density: analyses of methods; in: *Techniques for measuring body composition*. National Academy of Sciences, National Research Council, 223-244.
- The WHOQOL Group. (1998). Development of the World Health Organization WHOQOL-BREF quality of life assessment. *Psychological Medicine*, 28, 551-8.
- World Health Organization (WHO). (2017). Global Health Estimates (No. WHO/MSD/MER/2017.2). World Health Organization. Depression and other common mental disorders.
- World Health Organization (WHO). (2022). Brote de enfermedad por Coronavirus (COVID-19). [En línea]. Disponible en: <https://www.who.int/es/emergencias/diseases/novel-coronavirus-2019>. Accedido el [July 2023].
- World Health Organization (WHO). (2020). Physical activity and adults: Recommended levels of physical activity for adults aged 18 - 64 years. [En línea]. Disponible en: https://www.who.int/dietphysicalactivity/factsheet_adults/en/. Accedido el [August 2023].
- Zeng, N., Zhao, Y. M., Yan, W., Li, C., Lu, Q. D., Liu, L., et al. (2023). A systematic review and meta-analysis of long term physical and mental sequelae of COVID-19 pandemic: call for research priority and action. *Molecular Psychiatry*, 28(1), 423-433. <https://doi.org/10.1038/s41380-022-01614-7>