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Original

IMPACTO DE UNA INTERVENCIÓN DE EJERCICIO ACUÁTICO SOBRE LA FATIGA Y LA CALIDAD DE VIDA EN PACIENTES POST-COVID-19

IMPACT OF A WATER-BASED EXERCISE INTERVENTION ON FATIGUE AND QUALITY OF LIFE IN POST-COVID-19 PATIENTS

Dorica Sajber[1]; Barbara Gilic[2]; Robert Marcun[3]

[1]*Faculty of Sport, University of Ljubljana, Slovenia*

[2]*Faculty of Kinesiology, University of Split, Split, Croatia*

[3] University Clinic of Respiratory and Allergic Diseases Golnik, Slovenia

Correspondence to:
Barbara Gilic
University of Split, Faculty of Kinesiology
Teslina 6, 21000 Split, Croatia
Email: Barbara.gilic@kifst.eu

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editor@journalshr.com

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RESUMEN

Objetivos; Material y métodos; Resultados; Discusión; Conclusiones.

Palabras clave: (3-10).

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ABSTRACT

Recovery from COVID-19 can involve long-lasting symptoms such as fatigue and reduced quality of life. Water-based exercise programs may be appropriate for improving these outcomes, but their effectiveness has not been explored in post-COVID-19 patients. Therefore, the objective of this study was to evaluate the effects of an 8-week water-based exercise program on fatigue levels and quality of life in post-COVID-19 patients. A total of 21 (15 females, 6 males) post-COVID-19 patients aged 58.15±17.71 years completed water-based exercises twice weekly for eight weeks. Fatigue was assessed via the Multidimensional Fatigue Inventory (MFI-20), and quality of life was measured via the EQ-5D-5L questionnaire. Changes were analyzed pre- and post-intervention using matched-pairs Wilcoxon test and factorial analysis of variance. Fatigue levels showed minimal changes overall, as they were low (MFI total score of 53.43±10.54 pre-intervention). Most participants had good quality of life scores, with no issues in self-care or daily activity. However, overall health status remained unchanged, possibly due to participants' good pre-intervention health (score of 77.06±17.59 pre-intervention). Water-based exercise programs can help maintain quality of life and fatigue levels in post-COVID-19 patients. These findings highlight their role as safe, inclusive, and supportive rehabilitation options, especially for individuals recovering from mild to moderate COVID-19. Future studies should explore longer interventions and more serious conditions to further explore the benefits of water-based exercises.

Keywords: therapeutic exercise, aquatic exercise, rehabilitation, physical capacity, recreation.

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INTRODUCTION

COVID-19 has been widespread since 2019, leading to a global pandemic and more than 768 million confirmed cases worldwide (Organization, 2022). The most common acute symptoms in COVID-19 patients include fever (81%), cough (58%), fatigue (38.5%), and dyspnea (26.1%) (Alimohamadi et al., 2020). The severity and duration of these symptoms vary widely, with some individuals recovering fully within a few months and others experiencing prolonged and debilitating effects. Indeed, several symptoms have been reported to last longer (more than two months after infection), leading to so-called long-term or post-COVID-19 (Descatha et al., 2023). The most common post-COVID-19 symptoms are fatigue; cognitive disorders; and emotional and psychological effects, such as anxiety, depression, or mood swings and pain, which last even two years after infection (Fernandez-de-las-Peñas et al., 2024). A concerning number of patients experience persistent symptoms after mild or moderate COVID-19, including fatigue, exertion intolerance, headaches, myalgia, neurological and cognitive deficits, and orthostatic disturbances, all of which can significantly affect their quality of life (Augustin et al., 2021; Della-Constanza et al., 2022). Studies estimate that 2%–10% of all COVID-19 patients continue to experience impairments even one year after infection (Tran et al., 2022). These symptoms can vary in intensity and duration, affecting daily life and productivity for some individuals long after the initial infection (Fernandez-de-las-Peñas et al., 2024).

Post-COVID-19 conditions often mirror myalgic encephalomyelitis and chronic fatigue syndrome, which can significantly impact quality of life and be profoundly debilitating (Deumer et al., 2021). Fatigue is defined by an intense sense of weakness, exhaustion, and a reduced ability to perform physical or mental tasks, which is disproportionate to recent activity (Rudroff et al., 2020). It is a complex condition influenced by both central regulatory processes (such as homeostasis) and psychological factors, including mood and motivation (Chaudhuri & Behan, 2004). Estimates indicate that approximately one-third of individuals experience fatigue persisting for three months or longer following their initial COVID-19 infection (Alkodaymi et al., 2022). In line with this, recent findings revealed that fatigue was more than twice as prevalent in individuals with COVID-19 than in matched non-COVID-19 controls (Hartung et al., 2022). Notably, fatigue was especially common among younger patients and those who experienced only mild or moderate acute COVID-19 (Bungenberg et al., 2022). Moreover, ongoing post-COVID-19 symptoms that affect both physical and mental well-being can significantly reduce quality of life. These symptoms frequently impair social connections, employment, and the capacity to carry out everyday tasks, which lowers quality of life. Indeed, one systematic review reported decreased health-related quality of life in 52% of post-COVID-19 individuals (Sanchez-Ramirez et al., 2021). Since fatigue leads to weakness, exhaustion, a reduced ability to perform physical or mental tasks and overall reduced quality of life, it is essential to find strategies to improve these conditions.

Physical exercise is one of the most promising ways to improve physical and psychological conditions impaired by COVID-19 (Jimeno-Almazán et al., 2021). Indeed, physical exercise enhances cardiorespiratory fitness, rebuilds muscle strength, and improves overall functional capacity, all of which are reduced following COVID-19 infection (Franklin et al., 2022). Specifically, post-COVID-19 patients who engaged in respiratory training and exercise-based rehabilitation programs presented increased exercise capacity, reduced shortness of breath, and improved quality of life compared with those receiving standard care (Harris, 2023). Additionally, a recent study that applied a 6-week intervention consisting of strength and endurance exercises reported improvements in quality of life, reduced fatigue levels, improved lung capacity and improved functional status and muscle strength in post-COVID-19 patients (Kogel et al., 2023). Studies involving 8-week programs of concurrent training, which combine resistance and aerobic exercises, have demonstrated significant improvements in cardiovascular fitness and muscle strength in post-COVID-19 patients (Jimeno-Almazán et al., 2023; Jimeno-Almazán et al., 2022). Overall, a recent comment regarding exercise and post-COVID-19 patients concluded that carefully integrating exercise into rehabilitation plans, tailoring the intensity to match the patient's symptoms and capabilities, and gradually increasing as they progress are recommended (Ladlow et al., 2024).

Although several studies have investigated the effects of various exercise programs, there are limited studies which have incorporated water exercise as a therapeutic form of exercise for post-COVID-19 recovery in adults. Several studies have examined how a water-based exercise program affected lung function in kids with COVID-19 who were 10 to 12 years old. Following a water-exercise intervention, the authors of previously mentioned research observed a considerable improvement in tiredness, quality of life, and lung function (Ogonowska-Slodownik et al., 2023; Ogonowska-Slodownik et al., 2025). There are numerous benefits of water-based exercises. Owing to its properties such as buoyancy, which minimizes joint stress, water enhances muscle strength and endurance through natural resistance (Bergamin et al., 2012). Water activities improve cardiovascular fitness and flexibility and promote better balance, especially in older adults or those with mobility issues (Nascimento et al., 2020). Moreover, exercise in water reduces stress and improves mood by stimulating relaxation and lowering anxiety (Yoo, 2020). Exercises in water have been shown to be effective therapeutic strategies for decreasing fatigue and improving quality of life for several conditions, such as multiple sclerosis, COPD and various kinds of cancer (Cantarero-Villanueva et al., 2013; Kargarfard et al., 2012). Specifically, one study reported that patients with multiple sclerosis in the aquatic exercise group showed notable improvements in fatigue and health-related quality of life subscores after 8 weeks compared with those in the control group with no exercise (Kargarfard et al., 2012).

Few studies have investigated how water-based exercise interventions might help reduce fatigue levels and enhance quality of life in post-COVID-19 patients. This study explored whether structured water-based exercise interventions might help reduce fatigue levels and enhance quality of life in post-COVID-19 patients. The hypothesis was that post-COVID-19 patients would have reduced fatigue levels and improved quality of life following the water-based intervention.

METHODS

Participants and study design

Adults who had recovered from COVID-19 and were ready to join an 8-week exercise program were invited to participate in this study. The participants could join the swimming program at no cost, provided that they met the eligibility criteria and did not have any acute injury or illness preventing them from taking part. The study included post-COVID-19 patients from Slovenia, Serbia, and Croatia as part of the EU-funded collaborative post-COVID-19 Swim project (Project number 101050089, ERASMUS-SPORT-2021-SSCP Small Scale Partnerships). This partnership involved the Slovenian Swimming Association, Hospital Golnik, Serbia's Faculty of Sport and Physical Education, and a Croatian swimming club. Each participant provided informed consent, and the study was approved by the University of Split's Faculty of Kinesiology Ethics Board on February 6, 2023 (document number 2181-205-02-05-23-004). Being older than 18, having contracted COVID-19 more than six months prior, and exhibiting ongoing symptoms were the requirements for admission. The study excluded participants with acute injuries, acute illnesses, or physical and mental disabilities that prevented them from participating in the examinations. It is important to note that included participants had light to moderate COVID-19 condition and none of them was hospitalized. The characteristics of the participants are presented in Table 1.

Variable	Mean	Min	Max	SD
Age (years)	58.15	22.74	83.50	17.71
Body height (cm)	167.79	152.50	191.00	10.53
Body mass (kg)	76.09	50.20	109.70	16.34
Times infected	1.21	1.00	4.00	0.71

The study included an initial test (pre-intervention), an 8-week intervention, and a final test (post-intervention), with identical assessments conducted at the start and end. Out of the 72 participants who were initially enrolled,21 (15 female, 6 male) participants aged 58±17 years completed the program and were assessed at both testing points for investigated variables in this study. The participant flow diagram is presented in Figure 1.

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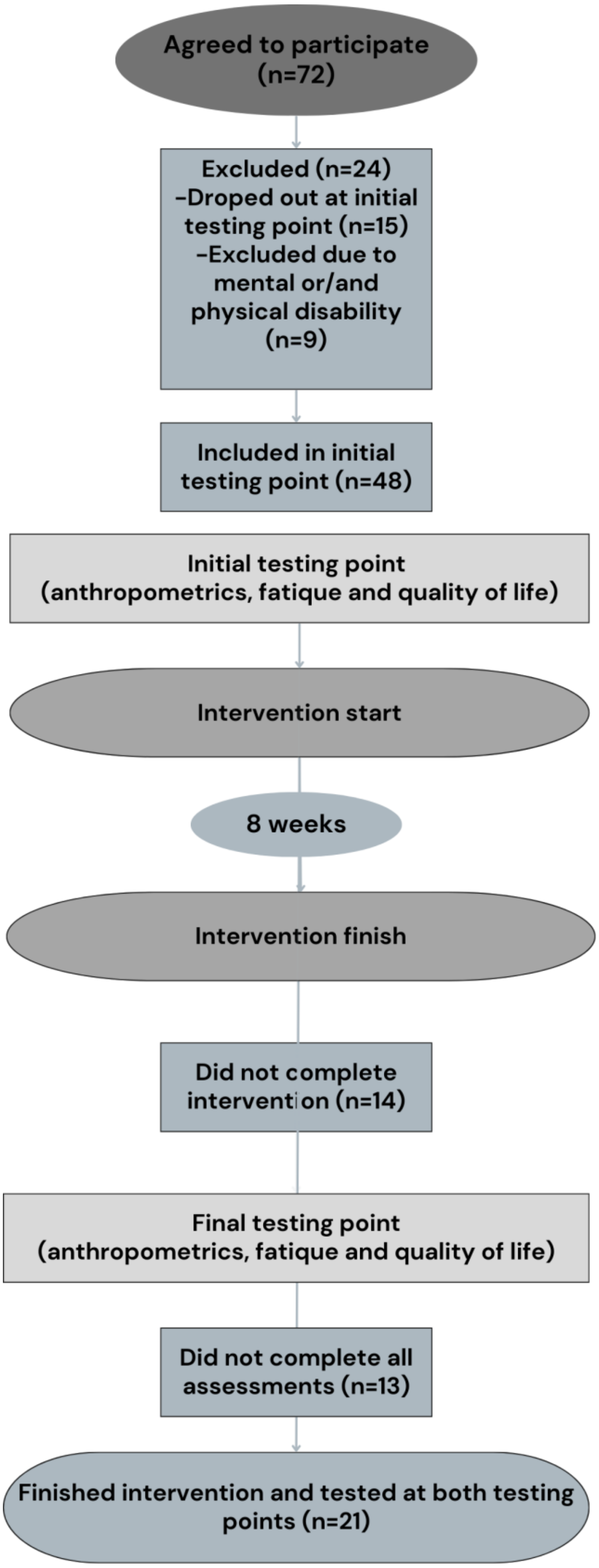

Figure 1. Participant flow diagram.

Intervention protocol

The 8-week intervention included two weekly, hour-long swimming and water exercise sessions in an indoor pool, totaling 16 sessions. Exercises in both deep and shallow water were part of the eight-week intervention, which began in March 2023. The program consisted of 16 sessions for the subjects, which were held twice a week in an indoor pool and lasted an hour each. It was carried out in deep water in Zagreb (Croatia) and Velenje (Slovenia) with a pool length of 25m, 180cm deep, water temperature 26.5 degrees, and humidity 60%. The program was carried out in both shallow and deep water in Ljubljana and Kranj (25m pool length, half pool 130cm deep and half pool 3m deep, water temperature 27 degrees, humidity 60%). Crucially, two intervention plans were provided based on the participants' medical and physical circumstances. In particular, the shallow-water program comprised people with certain medical issues and restricted physical capacity, while the deep-water program included people in better physical condition and free of chronic ailments. Following the initial testing phase, when skilled investigators assessed participants' functional capacity and under the guidance of a medical professional, the participants were divided into groups. Both programs featured warm-up, cardio, mobility, strength, and flexibility exercises; even for the deep-water participants, some of them were done in shallow water. There were four components to the shallow water program. Easy warm-up activities were included in the first ten minutes and strengthening exercises using a variety of equipment were included in the second twenty minutes. The third phase, which lasted fifteen minutes, had cardiovascular activities including leaping, hopping, and skipping; the fourth section, which lasted fifteen minutes, contained cool-down and flexibility exercises. The deep-water program started with basic warm-up activities in shallow water (5 minutes), which were followed by a 15-minute warm-up in the deep pool that included slow swimming and observation skills. An emphasis on breathing technique and swimming skill (15–20 minutes), a range of shallow-water activities mostly centered on strength training, and interval swimming (10–15 minutes) came next. The class concluded with ten to fifteen minutes of low-intensity swimming and water-based flexibility exercises. An expert coach

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and swimming instructor meticulously developed the intervention program, and the doctor made adjustments to make it the most effective program for the altered lung function brought on by the COVID-19 condition. For a detailed outline of the program, see https://www.canva.com/design/DAFtfJ7tLkE/znmzfhG0Wiism_lavpGfOw/edit.

Variables

The variables in this study consisted of anthropometric indices (body mass, body height), demographic characteristics (gender, age), fatigue inventory scores, and quality of life questionnaire scores.

The Multidimensional Fatigue Inventory (MFI-20) was used to assess fatigue levels. There are five subscales in the MFI: 1. (items 1, 5, 12, 16) general fatigue; 2. (items 2, 8, 14, and 20) Physical fatigue; 3. (items 3, 6, 10, 17) decreased activity; 4. (items 4, 9, 15, 18) decreased motivation; and 5. (items 7, 11, 13, and 19) mental fatigue. Four items make up each subscale, and responses can be given on a 5-point Likert scale (1 being true and 5 being false). Higher fatigue levels are indicated by higher scores. The MFI consists of 5 subscales, each ranging from 4-20 points, in addition to a total score derived from the sum of results across these subscales. The maximum total score of 100 points represents the highest fatigue level, whereas a score of 20 points represents the highest fatigue level for each subscale (Smets et al., 1995).

Quality of life was assessed via the European Quality of Life-5 Dimensions-5 Levels (EQ-5D-5L), which is a standardized instrument used to measure health-related quality of life across five key dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is evaluated on a 5-level scale—ranging from no problems to extreme problems—to capture the respondent's perceived health state more precisely. In addition to the five dimensions, the EQ-5D-5L includes a visual analog scale (VAS), where participants rate their overall health on a scale from 0 (worst imaginable health) to 100 (best imaginable health).

All questionnaires were completed online (via Google sheets) with supervision and instructions from experienced researchers.

Statistical analysis

All variables were checked for normality using the Kolmogorov-Smirnov test. Descriptive statistics included means, standard deviations, frequencies and percentages. The Wilcoxon matched pairs test was used to determine the differences in fatigue levels between two testing points (pre-intervention vs. post-intervention) for the total sample and stratified by sex. Differences between pre- and post-intervention across genders in health status were calculated using 2x2 (time × sex) analysis of variance. The percentages of individuals with and without identified health-related quality of life issues were calculated. All analyses were conducted via Statistica v15, and a p value of 0.05 was applied.

RESULTS

Table 2 displays descriptive statistics and differences in fatigue levels between the pre- and post-intervention testing points in fatigue levels. In the total sample, the only significant change was noted in the reduced motivation score, with higher scores at the post-intervention testing point. In females, the MFI total score significantly increased at the post-intervention testing point. There were no significant changes from pre- to post-intervention testing in males.

The percentages of individuals with and without identified health-related quality of life issues are shown in Table 2. The majority of the subscales were dominated by no observed issues, whereas there was a change (reduction) in anxiety/depression frequency in the postintervention period. The majority of participants reported no issues in self-care or usual activities.

Differences between pre-intervention and post-intervention in health status according to sex are presented in Figure 2. There were no significant changes from pre-to post-intervention; result at pre-intervention was 77.06±17.59, while at post-intervention it was 78.76±13.89 ($F= 0.04$, $p=0.84$), and there was no significant difference between genders or in the interaction (time × sex).

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Table 2. Descriptive statistics and differences in fatigue levels between pre- and post-intervention testing points in fatigue levels

	Pre-intervention		Post-intervention		Wilcoxon test	
	Mean	**SD**	**Mean**	**SD**	**Z**	**p**
	Total (n=21)					
General fatigue	10.19	2.23	10.52	1.89	0.28	0.78
Physical fatigue	11.67	2.52	11.95	2.25	0.65	0.51
Reduced activity	11.81	2.40	12.10	1.51	0.45	0.65
Reduced motivation	10.05	2.64	11.14	1.59	2.10	0.04
Mental fatigue	9.71	2.51	10.52	1.29	1.56	0.12
MFI total	53.43	10.54	56.24	6.06	1.62	0.10
	Female (N=15)					
General fatigue	9.93	2.58	10.47	1.88	0.27	0.79
Physical fatigue	11.47	2.67	11.93	2.46	0.94	0.35
Reduced activity	11.40	2.69	12.20	1.52	1.38	0.17
Reduced motivation	9.80	2.68	11.13	1.19	1.99	0.05
Mental fatigue	9.60	2.75	10.67	1.18	1.64	0.10
MFI total	52.20	11.66	56.40	5.78	2.07	0.04
	Male (N=6)					
General fatigue	10.83	0.75	10.67	2.07	0.01	1.01
Physical fatigue	12.17	2.23	12.00	1.79	0.42	0.67
Reduced activity	12.83	0.98	11.83	1.60	1.60	0.11
Reduced motivation	10.67	2.66	11.17	2.48	0.73	0.47
Mental fatigue	10.00	2.00	10.17	1.60	0.18	0.86
MFI total	56.50	6.95	55.83	7.28	0.63	0.53

Legend: MFI - Multidimensional Fatigue Inventory, SD – standard deviation

Table 3. Frequencies and percentages of individuals with and without identified issues in health-related quality of life.

Variable	Pre-intervention	Post-intervention
Mobility	n (%)	n (%)
No issue	14 (70)	11 (55)
Issue	6 (30)	9 (45)
Selfcare		
No issue	18 (90)	19 (95)
Issue	2 (10)	1 (5)
Usual activities		
No issue	17 (85)	18 (90)
Issue	3 (15)	2 (10)
Pain/discomfort		
No issue	11 (55)	9 (45)
Issue	9 (45)	11 (55)
Anxiety/depression		
No issue	9 (45)	11 (55)
Issue	11 (55)	9 (45)

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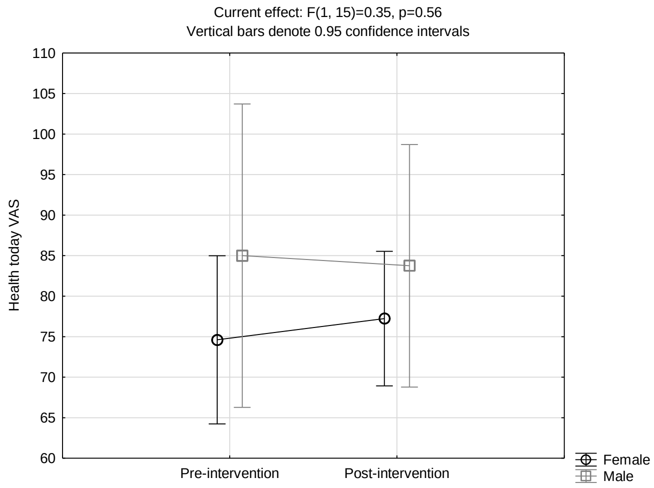

Figure 2. Differences between pre-intervention and post-intervention in health status according to sex. *VAS – visual analog scale.*

DISCUSSION

There are several main findings in this study. First, there was generally no significant change in fatigue levels from pre- to post-intervention. Second, participants mainly did not report issues in the majority of quality-of-life subscales, with the least reported issues in self-care and usual activities. There were no significant changes from pre-to post-intervention in health status.

The potential reason why there were no changes in fatigue levels after the application of the water-based exercise intervention is that our participants generally had low fatigue levels. Indeed, our participants reported low levels of fatigue compared with other studies assessing post-COVID-19 patients via the same fatigue questionnaire (MFI). For example, a German study that applied 6 weeks of strength and endurance training to post-COVID-19 patients reported a reduction in MFI scores after the intervention; however, the pre-intervention scores of their participants were higher than those of our patients (pre-intervention MFI total score of 71.3±12.7 in German participants and a score of 53.43±10.54 in our study) (Kogel et al., 2023). Moreover, a study of French post-COVID-19 patients revealed high levels of reduced motivation and mental fatigue (Morin et al., 2021). Additionally, compared with the general healthy German population, our participants' results were greater, with a total MFI score of 41.69±17.54 in the German population (Westenberger et al., 2022). This suggests that, despite being infected with COVID-19, our participants experienced low levels of fatigue; therefore, the space for significant change/improvement was reduced.

Notably, none of our participants were hospitalized, which means that we included only individuals with mild to moderate cases of COVID-19. However, one cohort study revealed that SARS-CoV-2 infections were linked to an increased risk of chronic fatigue and post exertional malaise symptoms within 2 to 18 months post infection, although the overall change in fatigue scores was minimal (O'Regan et al., 2024). Among the potential predisposing factors examined, acute hospitalization due to SARS-CoV-2 had the most significant influence on fatigue scores. These findings align with existing research highlighting that severe COVID-19 infections are associated with more severe post-COVID-19 condition outcomes, which confirms our finding of impaired fatigue (O'Regan et al., 2024). Moreover, the exercise program's usefulness for populations with chronic fatigue or conditions that limit energy reserves is further supported by the lack of substantial changes in fatigue levels from pre- to post-intervention, which shows that it was not unduly taxing. This stable fatigue level could mean that the intervention successfully kept participants' energy levels stable without worsening their preexisting symptoms, which is important for long-term physical exercise in vulnerable populations.

The second significant finding of our study is that participants did not report issues in most quality-of-life subscales and that they had good self-reported health status, both in pre-intervention and in post-intervention testing points. In contrast, according to pooled prevalence data from the EQ-5D-5L questionnaire, 42% of post-COVID-19 patients reported experiencing pain or discomfort, 38% struggled with anxiety or depression, 36% faced mobility issues, 28% had difficulties with usual daily activities, and 8% reported challenges with personal care (Malik et al., 2022). However, our participants reported no issues in self-care or usual activities, which means that their quality of life was not significantly reduced. Although not significant, the decrease in the incidence of anxiety and depressive

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symptoms following the intervention supports the body of research showing the psychological advantages of aquatic exercise, which are probably caused by the release of endorphins, the meditative rhythm of movement, and the relaxing qualities of the water (Jackson et al., 2022; Tang et al., 2022). These gains in mental health demonstrate how water-based exercise may be used as a therapeutic technique to manage emotional well-being, especially in populations that are more likely to experience stress or mental health issues.

Additionally, the absence of significant changes in overall health status from pre- to post-intervention might be explained by good pre-intervention health status, which reduces the space for any significant improvement. The "ceiling effect" in health interventions refers to the fact that there is naturally less space for quantifiable improvement when people begin with greater baseline health levels (Frost et al., 2005). This implies that although the exercise regimen preserved their health, it might not have been intended to encourage those who were already in good condition to achieve notable improvements in their physiology or functionality. Research backs up this theory, demonstrating that individuals who begin exercise treatments with lower baseline health measures tend to benefit more than those who begin with greater levels of fitness or health (Frost et al., 2005; Goedendorp & Steverink, 2017).

Limitations and strengths

The fact that we included only an experimental group and not a control group is one of the greatest limitations of this study. However, the study's selection procedure and the inequity of giving some people the opportunity to exercise while denying others that opportunity made it impossible to include the control group. It should be mentioned that under normal circumstances, a control group could be created by either delaying the start of the intervention or offering the intervention to participants at the end of the study. However, the main reason this was not the case in this research was because the project was short-lived, which meant we lacked the funding to do so. The second drawback is the comparatively small sample size, which ought to be raised for subsequent research. However, this study's primary strength is that it is one of the first studies to explore the possible advantages of a water exercise program for enhancing quality of life and reducing fatigue in adult patients recovering from COVID-19. Furthermore, the findings of this study may be helpful for other respiratory disorders that are comparable to COVID-19, which broadens its applicability.

CONCLUSIONS

This study investigated the effects of an 8-week water-based exercise program on quality of life and fatigue in post-COVID-19 participants. The benefits of water-based exercise for mental health were highlighted by the participants' decrease in anxiety and depression symptoms, even while their fatigue levels remained mostly unchanged. Furthermore, most participants reported no problems with self-care or their regular daily routines, indicating that the water-based exercise program supported their continued independence and general wellbeing. Moreover, the participants' high baseline health may have contributed to the lack of notable improvements in their general health status, as there was minimal opportunity for significant improvement. As a safe and inclusive type of rehabilitation, water-based activities are valuable, as evidenced by the stability of their physical condition and improvements in their emotional well-being. These results suggest that water exercise may be especially helpful for promoting psychological healing, reducing fatigue and preserving functioning in people recovering from mild to moderate COVID-19. However, to confirm these results, a study with both intervention and control group is warranted to make a precise conclusion on this issue.

Future studies should concentrate on including and adjusting water-based programs for various demographics, investigating longer interventions, and incorporating those with more serious preexisting medical conditions. This would enhance the results and solidify water-based exercise as a useful strategy for recovering from COVID-19.

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REFERENCES

1. Alimohamadi, Y., Sepandi, M., Taghdir, M., & Hosamirudsari, H. (2020). Determine the most common clinical symptoms in COVID-19 patients: a systematic review and meta-analysis. *Journal of Preventive Medicine and Hygiene, 61*(3), E304-e312. https://doi.org/10.15167/2421-4248/jpmh2020.61.3.1530

2. Alkodaymi, M. S., Omrani, O. A., Fawzy, N. A., Shaar, B. A., Almamlouk, R., Riaz, M., Obeidat, M., Obeidat, Y., Gerberi, D., Taha, R. M., Kashour, Z., Kashour, T., Berbari, E. F., Alkattan, K., & Tleyjeh, I. M. (2022). Prevalence of post-acute COVID-19 syndrome symptoms at different follow-up periods: a systematic review and meta-analysis. *Clinical Microbiology and Infection*, *28*(5), 657-666. https://doi.org/10.1016/j.cmi.2022.01.014

3. Augustin, M., Schommers, P., Stecher, M., Dewald, F., Gieselmann, L., Gruell, H., Horn, C., Vanshylla, K., Cristanziano, V. D., Osebold, L., Roventa, M., Riaz, T., Tschernoster, N., Altmueller, J., Rose, L., Salomon, S., Priesner, V., Luers, J. C., Albus, C., Rosenkranz, S., Gathof, B., Fätkenheuer, G., Hallek, M., Klein, F., Suárez, I., & Lehmann, C. (2021). Post-COVID syndrome in non-hospitalised patients with COVID-19: a longitudinal prospective cohort study. *Lancet Regional Health Europe*, *6*, 100122. https://doi.org/10.1016/j.lanepe.2021.100122

4. Bergamin, M., Zanuso, S., Alvar, B. A., Ermolao, A., & Zaccaria, M. (2012). Is water-based exercise training sufficient to improve physical fitness in the elderly? A systematic review of the evidence. *European Review of Aging and Physical Activity*, *9*, 129-141.

5. Bungenberg, J., Humkamp, K., Hohenfeld, C., Rust, M. I., Ermis, U., Dreher, M., Hartmann, N. K., Marx, G., Binkofski, F., Finke, C., Schulz, J. B., Costa, A. S., & Reetz, K. (2022). Long COVID-19: Objectifying most self-reported neurological symptoms. *Annals of Clinical and Translational Neurology*, *9*(2), 141-154. https://doi.org/10.1002/acn3.51496

6. Cantarero-Villanueva, I., Fernández-Lao, C., Cuesta-Vargas, A. I., Del Moral-Avila, R., Fernández-de-Las-Peñas, C., & Arroyo-Morales, M. (2013). The effectiveness of a deep water aquatic exercise program in cancer-related fatigue in breast cancer survivors: a randomized controlled trial. *Archives of physical medicine and rehabilitation*, *94*(2), 221-230.

7. Chaudhuri, A., & Behan, P. O. (2004). Fatigue in neurological disorders. *Lancet, 363*(9413), 978-988. https://doi.org/10.1016/s0140-6736(04)15794-2

8. Della-Constanza, P.; Ferrari, G.; Espoz-Lazo, S.; Álvarez-Arangua, S.; Espinoza-Salinas, A.; Cofre-Bolados, C.; Cofre-León, F.; Poblete-Aro, C.; Ríos-Riquelme, M.; Farías-Valenzuela, C. (2022). Lifestyles and self-esteem in adults practicing calisthenics and other disciplines and/or urban sports during the COVID 19 pandemic in Chile. *Journal of Sport and Health Research. 14*(Suppl 1): 91-104.

9. Descatha, A., Evanoff, B. A., & Fadel, M. (2023). Post-COVID condition or “long COVID”, return-to work, and occupational health research. *Scandinavian Journal of Work, Environment & Health, 49*(3), 165.

10. Deumer, U. S., Varesi, A., Floris, V., Savioli, G., Mantovani, E., López-Carrasco, P., Rosati, G. M., Prasad, S., & Ricevuti, G.

(2021). Myalgic Encephalomyelitis/Chronic Fatigue Syndrome (ME/CFS): An Overview. *Journal of Clinial Medicine, 10*(20). https://doi.org/10.3390/jcm10204786

11. Fernandez-de-las-Peñas, C., Notarte, K. I., Macasaet, R., Velasco, J. V., Catahay, J. A., Ver, A. T., Chung, W., Valera-Calero, J. A., & Navarro-Santana, M. (2024). Persistence of post-COVID symptoms in the general population two years after SARS-CoV-2 infection: A systematic review and meta-analysis. *Journal of Infection, 88*(2), 77-88. https://doi.org/https://doi.org/10.1016/j.jinf.2023.12.004

12. Franklin, B. A., Eijsvogels, T. M. H., Pandey, A., Quindry, J., & Toth, P. P. (2022). Physical activity, cardiorespiratory fitness, and cardiovascular health: A clinical practice statement of the ASPC Part I: Bioenergetics, contemporary physical activity recommendations, benefits, risks, extreme exercise regimens, potential maladaptations. *American Journal of Preventive Cardiology*, *12*, 100424. https://doi.org/10.1016/j.ajpc.2022.100424

13. Frost, A. E., Langleben, D., Oudiz, R., Hill, N., Horn, E., McLaughlin, V., Robbins, I., Shapiro, S., Tapson, V., & Zwicke, D. (2005). The 6-min walk test (6MW) as an efficacy endpoint in pulmonary arterial hypertension clinical trials: demonstration of a ceiling effect. *Vascular pharmacology*, *43*(1), 36-39.

14. Goedendorp, M., & Steverink, N. (2017). Interventions based on self-management of well-being theory: pooling data to demonstrate mediation and ceiling effects, and to compare formats. *Aging & Mental Health*, *21*(9), 947-953.

15. Harris, E. (2023). Exercise Programs Might Improve Long COVID. *JAMA*, *330*(15), 1421-1421. https://doi.org/10.1001/jama.2023.18739

16. Hartung, T. J., Neumann, C., Bahmer, T., Chaplinskaya-Sobol, I., Endres, M., Geritz, J., Haeusler, K. G., Heuschmann, P. U., Hildesheim, H., Hinz, A., Hopff, S., Horn, A., Krawczak, M., Krist, L., Kudelka, J., Lieb, W., Maetzler, C., Mehnert-Theuerkauf, A., Montellano, F. A., Morbach, C., … Finke, C. (2022). Fatigue and cognitive impairment after COVID-19: A prospective multicentre study. *EClinicalMedicine, 53*, 101651. https://doi.org/10.1016/j.eclinm.2022.101651

17. Jackson, M., Kang, M., Furness, J., & Kemp-Smith, K. (2022). Aquatic exercise and mental health: A scoping review. *Complementary Therapies in Medicine*, *66*, 102820. https://doi.org/https://doi.org/10.1016/j.ctim.2022.102820

18. Jimeno-Almazán, A., Buendía-Romero, Á., Martínez-Cava, A., Franco-López, F., Sánchez-Alcaraz, B. J., Courel-Ibáñez, J., & Pallarés, J. G. (2023). Effects of a concurrent training, respiratory muscle exercise, and self-management recommendations on recovery from post-COVID-19 conditions: the RECOVE trial. *Journal of Applied Physiology (1985), 134*(1), 95-104. https://doi.org/10.1152/japplphysiol.00489.2022

19. Jimeno-Almazán, A., Franco-López, F., Buendía-Romero, Á., Martínez-Cava, A., Sánchez-Agar, J. A., Sánchez-Alcaraz Martínez, B. J., Courel-Ibáñez, J., & Pallarés, J. G. (2022). Rehabilitation for post-COVID-19 condition through a supervised exercise intervention: A randomized controlled trial. *Scandinavian Journal of Medicine and*

Science in Sports, 32(12), 1791-1801. https://doi.org/10.1111/sms.14240

20. Jimeno-Almazán, A., Pallarés, J. G., Buendía-Romero, Á., Martínez-Cava, A., Franco-López, F., Sánchez-Alcaraz Martínez, B. J., Bernal-Morel, E., & Courel-Ibáñez, J. (2021). Post-COVID-19 syndrome and the potential benefits of exercise. *International Journal of Environmental Research and Public Health, 18*(10), 5329.

21. Kargarfard, M., Etemadifar, M., Baker, P., Mehrabi, M., & Hayatbakhsh, R. (2012). Effect of Aquatic Exercise Training on Fatigue and Health-Related Quality of Life in Patients With Multiple Sclerosis. *Archives of physical medicine and rehabilitation, 93*(10), 1701-1708. https://doi.org/https://doi.org/10.1016/j.apmr.2012.05.006

22. Kogel, A., Machatschek, M., Scharschmidt, R., Wollny, C., Lordick, F., Ghanem, M., Laufs, U., & Fikenzer, S. (2023). Physical exercise as a treatment for persisting symptoms post-COVID infection: review of ongoing studies and prospective randomized controlled training study. *Clinical Research in Cardiology, 112*(11), 1699-1709. https://doi.org/10.1007/s00392-023-02300-6

23. Ladlow, P., Bennett, A. N., & O'Sullivan, O. (2024). Exercise Therapy for Post–COVID-19 Condition—Does No Harm. *JAMA Network Open, 7*(4), e246959-e246959. https://doi.org/10.1001/jamanetworkopen.2024.6959

24. Malik, P., Patel, K., Pinto, C., Jaiswal, R., Tirupathi, R., Pillai, S., & Patel, U. (2022). Post-acute COVID-19 syndrome (PCS) and health-related quality of life (HRQoL)-A systematic review and meta-analysis. *Journal of Medical Virology, 94*(1), 253-262. https://doi.org/10.1002/jmv.27309

25. Morin, L., Savale, L., Pham, T., Colle, R., Figueiredo, S., Harrois, A., Gasnier, M., Lecoq, A. L., Meyrignac, O., Noel, N., Baudry, E., Bellin, M. F., Beurnier, A., Choucha, W., Corruble, E., Dortet, L., Hardy-Leger, I., Radiguer, F., Sportouch, S., … Monnet, X. (2021). Four-Month Clinical Status of a Cohort of Patients After Hospitalization for COVID-19. *JAMA, 325*(15), 1525–1534. https://doi.org/10.1001/jama.2021.3331

26. Nascimento, L. R., Flores, L. C., de Menezes, K. K., & Teixeira-Salmela, L. F. (2020). Water-based exercises for improving walking speed, balance, and strength after stroke: a systematic review with meta-analyses of randomized trials. *Physiotherapy*, *107*, 100-110.

27. O'Regan, E., Spiliopoulos, L., Bech Svalgaard, I., Nielsen, N. M., Vedel Sørensen, A. I., Bager, P., Videbech, P., Ethelberg, S., Koch, A., & Hviid, A. (2024). Post–COVID-19 Condition Fatigue Outcomes Among Danish Residents. *JAMA Network Open*, *7*(10), e2434863-e2434863. https://doi.org/10.1001/jamanetworkopen.2024.34863

28. Ogonowska-Slodownik, A., Labecka, M. K., Maciejewska-Skrendo, A., McNamara, R. J., Kaczmarczyk, K., Starczewski, M., Gajewski, J., & Morgulec-Adamowicz, N. (2023). Effect of Water-Based vs. Land-Based Exercise Intervention (postCOVIDkids) on Exercise Capacity, Fatigue, and Quality of Life in Children with Post COVID-19 Condition: A Randomized Controlled Trial. *Journal of Clinical Medicine*, *12*(19). https://doi.org/10.3390/jcm12196244

29. Ogonowska-Slodownik, A., Labecka, M. K., Maciejewska-Skrendo, A., Morgulec-

Adamowicz, N., Starczewski, M., Gajewski, J., McNamara, R. J., & Kaczmarczyk, K. (2025). Effect of water-and land-based exercise on lung function in children with post COVID-19 condition: secondary results from a randomized controlled trial. *ERJ Open Research*.

30. Organization, W. H. (2022). World health organization coronavirus (covid-19) dashboard. *World Health Organization, Geneva, Switzerland.* https://data.who.int/dashboards/covid19/cases Assessed on 23rd March 2024.

31. Rudroff, T., Fietsam, A. C., Deters, J. R., Bryant, A. D., & Kamholz, J. (2020). Post-COVID-19 Fatigue: Potential Contributing Factors. *Brain Sciences, 10*(12). https://doi.org/10.3390/brainsci10121012

32. Sanchez-Ramirez, D. C., Normand, K., Zhaoyun, Y., & Torres-Castro, R. (2021). Long-term impact of COVID-19: a systematic review of the literature and meta-analysis. *Biomedicines*, *9*(8), 900.

33. Smets, E. M., Garssen, B., Bonke, B., & De Haes, J. C. (1995, Apr). The Multidimensional Fatigue Inventory (MFI) psychometric qualities of an instrument to assess fatigue. *Journal of Psychosomatic Research, 39*(3), 315-325. https://doi.org/10.1016/0022-3999(94)00125-o

34. Tang, Z., Wang, Y., Liu, J., & Liu, Y. (2022). Effects of aquatic exercise on mood and anxiety symptoms: A systematic review and meta-analysis. *Frontiers in Psychiatry, 13*, 1051551.

35. Tran, V. T., Porcher, R., Pane, I., & Ravaud, P. (2022). Course of post COVID-19 disease symptoms over time in the ComPaRe long COVID prospective e-cohort. *Nature communications*, *13*(1), 1812. https://doi.org/10.1038/s41467-022-29513-z