Jurnal SPORTIF: Jurnal Penelitian Pembelajaran
Vol. 9 No. 1, April 2023, pp. 92 - 109
https://doi.org/10.29407/js_unpgri.v9i1.19575

The acute effects of concurrent and breathing exercises on the pulmonary function in post-covid-19 syndrome women

Dian Listiarini[1abcdef], BM. Wara Kushartanti[1abe], Novita Intan Arovah[1abef].

[1]Department of Sports Science, Faculty of Sport Science, Universitas Negeri Yogyakarta, Indonesia.

Received: 31 January 2023; Revised: 12 March 2023; Accepted: 27 March 2023; Available online: 09 April 2023.

Abstract

The incidence of persistent respiratory symptoms after acute post-COVID-19 infections, referred to as post-COVID-19 syndrome, is high. This study aimed to determine the feasibility and the acute effects of the combination of aerobic, strength and breathing exercises on pulmonary function and oxygen saturation among women post-COVID-19. This study involved 36 women post-COVID-19, with a mean age of 34.4±9.1 years, in a 45-minute aerobic, strength, and breathing exercise with an intensity of 65-75% maximum heart rate. The pulmonary function was measured with spirometry, while oxygen saturation was measured with an oximeter. These measurements were taken pre and post-exercise. Feasibility was determined as participants' ability to complete the exercise and the incidence of adverse effects. A pair-t-test and effect size were assessed to estimate the acute effects of the exercise on Cohen's d estimation. All patients complied, and no adverse events were reported, thus, supporting the feasibility of the exercise protocol. There was an increase in most post-exercise pulmonary function and oxygen saturation compared to pre-exercise ($p < .001$ to 0.03), with effect sizes ranging from 0.5 to 0.8, indicating medium to large effects of the exercise program on pulmonary functions and oxygen saturation. In conclusion, the combination of aerobic, strength, and breathing exercises is feasible and safe for women post-COVID-19 and potentially improves most pulmonary functions. Further research is recommended to evaluate the longer adaptation of the exercise on the pulmonary function in post-COVID-19.

Keywords: Exercise, oximeter, spirometer, post-COVID-19.

How to Cite: Listiarini, D., Kushartanti, B. W., & Arovah, N. I. (2023). The acute effects of concurrent and breathing exercises on the pulmonary function in post-covid-19 syndrome women. Jurnal SPORTIF : Jurnal Penelitian Pembelajaran, 9(1), 92-109. https://doi.org/10.29407/js_unpgri.v9i1.19575

Authors contribution: a – Preparing concepts; b – Formulating methods; c – Conducting research; d – Processing results; e – Interpretation and conclusions; f - Editing the final version

INTRODUCTION

Post Corona Virus Disease (COVID-19) is described as a condition in which the COVID-19 symptoms persist for at least 12 weeks (Delbressine et al., 2021; Fernández-De-las-peñas et al., 2021; Lin et al., 2020), that may affect any systems in the body (National Insitute for Health and Care

Correspondence author: Novita Intan Arovah, Universitas Negeri Yogyakarta, Indonesia.
Email: novita@uny.ac.id

Excellence, 2020). The post-COVID-19 syndrome associated with the respiratory system is related to the decline of pulmonary function (Kokhan et al., 2022; Rawashdeh & Alnawaiseh, 2018; Sewa & Ong, 2014), that primarily manifested as dyspnoea and chronic coughing (Moreno-pérez et al., 2021).

Pulmonary function tests are important tools in the investigation and monitoring of patients with respiratory pathologies, including those with post-COVID-19 syndrome. Volume, time, and flow are the three fundamental measurements in this assessment (Moore, 2012). The test provides important information on the conditions of the large and small airways, the pulmonary parenchyma, and the size and integrity of the pulmonary capillary bed (Moore, 2012). Although the test does not provide a diagnosis, different patterns of abnormalities are seen in various respiratory diseases that could help establish the diagnosis (Ranu et al., 2010). Changes in pulmonary function in some patients who were previously diagnosed with COVID-19, in particular, have been confirmed (Huang et al., 2020; Torres-Castro et al., 2021). This pulmonary function test can differentiate mild, moderate, and severe post-COVID-19 (Lewis et al., 2021), thus, can assist the physician in managing post-COVID-19 syndromes (Lewis et al., 2021). The forced vital capacity (FVC) and forced expiratory volume (FEV) are the primary measurements in pulmonary function assessment using spirometry (Ponce & Sharma, 2021; Shokri et al., 2022). Post-COVID-19 patients with respiratory symptoms usually show FVC and FEV abnormalities, especially those who experience severe symptoms (Eksombatchai et al., 2021).

Oxygen level saturation is also affected by COVID-19 infection (Anastasio et al., 2021) due to the decline in both respiratory and cardiorespiratory function. Oxygen saturation measures the amount of haemoglobin bound to oxygen compared to those which were unbound (Hafen & Sharma, 2021). The oxygen saturation is assessed with an oximeter which measures the amount of oxygenated and oxygen-deficient blood (Lim, 2021). The decrease in oxygen saturation can result in fatigue

https://doi.org/10.29407/js_unpgri.v9i1.19575
9 (1) 2023 | 92-109

or shortness of breath, cyanosis, restlessness, chest pain, and an increased heart rate (Lim, 2021). Oxygen is tightly regulated in the body because hypoxemia can cause many acute side effects on individual organ systems and can be detrimental to vital organs such as the brain, heart, and kidneys. Oxygen saturation, therefore, needs to be monitored in COVID-19 and post-COVID-19 patient cares.

Various studies have been conducted to overcome prolonged COVID-19 symptoms, including using exercise modalities (Humphreys et al., 2021). In clinical settings, physical activity levels and cardiovascular fitness are helpful health indicators for diagnosis and prognosis (Arovah & Heesch, 2022). While there is no specific exercise recommendation that has been published for COVID-19 and post-COVID-19 patients, similar to the recommendation for the general population, the primary exercises recommended for these patients are aerobic exercise and strength training (Saeki et al., 2021). Multicomponent exercise programs that include aerobic, resistance, balance, coordination, and mobility exercises are also recommended (Woods et al., 2020). The overall guideline recommends aerobic exercise in moderate to vigorous physical activity intensity (Suhaimi et al., 2022). Moderate intensity is defined as physical activity that exerts an increase in heart rate to 40-60% of reserve heart rate or 65-75% of maximal heart rate (Jiménez-Pavón et al., 2020; Listiarini et al., 2022). It can be in the form of walking (Liu et al., 2020), stairs climbing, chair squats, push-ups, sit-ups, jumping ropes, yoga (Jann, 2021; Roldan, 2021; Thompson, 2020), Pilates, and tai chi (Yang et al., 2021). Among patients recovering from COVID-19, it is recommended to start the exercise at low intensity and for shorter periods, then progress slowly to more intense physical activity in a longer duration (Woods et al., 2020). Combining aerobics with strength and breathing exercises may also provide additional benefits in improving cardiorespiratory (Angulo et al., 2020; Liu et al., 2020; Naralia et al., 2021).

Athletes also experience post-COVID-19, including reporting fatigue, dyspnea, intolerance to physical activity, and impaired functional function that interferes with daily activities (Cavigli et al., 2023). Some athletes have

https://doi.org/10.29407/js_unpgri.v9i1.19575
9 (1) 2023 | 92-109

confirmed prolonged symptoms, with shortness of breath, coughing, and chest tightness affecting their return to training and competition (Williams & Hull, 2022). Other studies indicate that women tend to have persistent symptoms (>28 days), which include dyspnea, exercise intolerance, and chest pain (Çelik et al., 2022; Moulson et al., 2022).

To date, the feasibility and acute effect of the combination of aerobic, strengthening, and breathing among post-COVID-19 syndrome patients have not been adequately explored. To be noted that the capacity of the pulmonary function differs between sexes as women typically have smaller lungs, airways, and different lung geometries than men, controlled for height and weight (Dominelli et al., 2022). These morphological differences influence respiratory efficiency and susceptibility to arterial hypoxemia, thus limiting full-body workouts for women compared to men (Dominelli et al., 2022). These differences thus need to be considered while studying the feasibility and effectiveness of exercise in post-COVID-19 syndrome. The combination of concurrent and breathing exercises is expected to improve pulmonary function among women with post-COVID-19 syndrome. The concurrent exercise includes low-impact aerobic exercises and strengthening exercises. This study, therefore, aimed to assess the feasibility and the acute effect of the exercise combination on pulmonary function and oxygen saturation in women experiencing post-COVID-19 syndrome. It is expected that the exercise will contribute to alleviating respiratory symptoms among women with Post COVID-19 syndromes.

METHOD

Study design, participants, and ethical consideration.

The study was a one-group pre and post-test design study on 36 women experiencing post-COVID-19 syndrome recruited with purposive sampling. The inclusion criteria were those who were previously diagnosed with COVID-19, who were developed symptoms during the period of infection, who had tested negative for COVID-19, who reported symptoms after 12 weeks of the COVID-19 diagnosis, and who had not previously

https://doi.org/10.29407/js_unpgri.v9i1.19575
9 (1) 2023 | 92-109

been trained in sports. The exclusion criteria included those who did not agree to participate in the scheduled exercise session. Prior to the study recruitment, we gave all participants informed consent in a written form regarding the objectives of the study, the research procedures, the risk and benefits of the study and all the safety measures that were in place. They were asked to sign the written form when they agreed to participate in this study. The research protocol has been approved by the Semarang State University Research Ethics Commission No. 008/KEPK/EC/2022.

The exercise protocol

The 45-minute exercise session started with a warming-up session which included static and dynamic stretching using low-impact aerobic exercise movements. The core exercise consisted of mixed impact aerobics, followed by going up and down benches, isometric plank strength training, squats, punches, lying ankle touches, mountain climbers, push-ups, sit-ups, and quick feet exercises. The cooling-down was conducted with stretching, relaxation, and breathing along with low-intensity yoga sun salutation. Throughout the exercise, pulses were monitored to achieve an intensity of 65-75% of the maximum heart rate.

Outcome measures and instrument

The main outcomes were pulmonary functions which were assessed an hour prior to the exercise program (pretest) and immediately after the exercise session (post-test).

Pulmonary function

Pulmonary function was assessed using the Pony FX the with turbine flowmeter C09062-01-99, a desktop spirometer made by the COSMED company. Table 1 summarizes the pulmonary function parameters, their definition, and the protocol for measuring the parameters.

Table 1. Pulmonary function measurement with spirometry

Measurement	Definition	Procedures
Forced Vital Capacity (FVC)- liter	FVC is the greatest total amount of air that can be forcefully breathed out after breathing in as deeply as possible	Participants were seated, and their nose was clamped with a clip just above the nose. They then were asked to take a deep breath and hold it for a few seconds before exhaling quickly into the mouthpiece on the spirometer
Forced expiratory volume ratio in 1 second (FEV1)- liter	FEV1 is the amount of air that can be forced out of the lungs in 1 second.	
FEV1/FVC%- %	FEV1/FVC ratio is the percentage of lung capacity that can be exhaled in one second	
Peak Expiratory Flow (PEF)- liter/sec	PEF is a person's maximum speed of expiration	
Slow Vital Capacity (SVC)- liter	SVC is the maximum volume of air that can be exhaled slowly after slow maximum inhalation, measurements taken at a leisurely pace from a position of maximal inspiration to maximal expiration.	Participants in a sitting position used a mouthpiece and a nasal clip while doing the VC technique. Except at the end of inspiration and expiration, the manoeuvre was not forced and was carried out in a comfortable manner. The patient fully exhaled while maintaining a generally consistent flow. To avoid underestimating SVC, however, the exhalation shouldn't be very slow.
Maximum Voluntary Ventilation (MVV)- liter/min	A measure of the maximum amount of air that can be inhaled and exhaled in one minute. For the comfort of the patient, this is done over a 12-second time period, which is then extrapolated to a value for a minute (expressed as liters/minute).	Participants were in a seating position wearing a nose clip and conducting at least three resting tidal breaths. The patient breathed as deeply and rapidly as possible for at least 12 seconds and then waited for automatic interruption (5 seconds without flow) in order to visualize the V/t graph together with the main parameters compared to the predicted values.
Maximum Respiratory Frequency (MRf) – l/min	MRf is the number of maximum breaths taken per minute.	
Tidal Volume (during MVt) - liter	Tidal Volume (during MVV is the amount of air that moves in or out of the lungs with each respiratory cycle.	
MVV duration time (MVVt)- second	MVVt is the measurement time in seconds that can be inhaled and exhaled at the highest possible.	

Oxygen saturation

Oxygen saturation was measured using the RS232/SpO2 port embedded in the COSMED Pony spirometer unit. The SpO2 measurement was measured by placing the SpO2 port on the subject's finger while ensuring that the rubber guard was intact on the pulse oximeter. At the time of measurement, participants refrained from using nail polish (Hafen & Sharma, 2021). The instrument has been validated and registered by the Ministry of Health of the Republic of Indonesia.

Additional measures

The additional measures included social demographic data, anthropometric data, strengths, post-COVID-19 symptoms and immune

ISSN : 2477-3379 (Online)
ISSN : 2548-7833 (Print)

status. These were only assessed at baseline during the pretest assessment. The social demographic data was age. Anthropometric data included weight and height, which were measured using a standardized protocol. Hand, back, and leg strengths were assessed using a hand grip test and a back and leg dynamometer to illustrate participants' fitness levels. COVID-19 symptoms and impact were also measured using the symptom and impact tools questionnaire for assessing post-COVID symptoms, that were developed and validated by Tran et al. (2022), and the immune status questionnaire that has been validated by Maulana & Arovah (2022).

Feasibility study

At the end of the exercise program, the feasibility of the exercise and data collection protocol was assessed using a 4-item paper-based questionnaire developed by the researcher that asked whether the exercise protocol was comfortable, safe, easy, and enjoyable. For each question, participants were provided with three response options (i.e., Yes, No, Neutral).

Statistical analysis

Participants' demographics, feasibility data, and outcomes were summarized using descriptive statistics. The feasibility aspect was assessed by observing the participants' ability and adherence to the exercise and data collection protocol and their responses to the questionnaires, which were descriptively analysed by calculating the proportion of participants who answered 'Yes'. Changes in the outcomes pre and post-exercise were examined using the Wilcoxon signed-rank test differences between pre and post-data were not normally distributed. The analyses were completed using IBM Corp, Released in 2017, IBM SPSS Statistics for Macintosh, Version 25.0. Armonk, NY: IBM Corp. Next, the effect size is calculated to see the size of the standardized difference between the scores of the pre-test and post-test groups by calculating the formula from Cohen's d formula for repeated measures.

https://doi.org/10.29407/js_unpgri.v9i1.19575
9 (1) 2023 | 92-109

RESULT

Participants Characteristics

Table 2 summarizes the participants' characteristics in this study. The participant's ages ranged from 20 years to 49 years, with an average age of 34.3 years (SD= 9.08). The mean of body mass index and participants' strength measurements were within the normal range. On average, participants also experienced mild post-COVID-19 symptoms. Their physical functions were also within the normal range.

Table 2. Participant's characteristics (n=36)

Parameters	Mean	*SD*
Age (years)	34.4	9.1
Height (meters)	1.5	0.05
Weight (kilogram)	61.1	9.5
BMI (body mass index)	24.9	0.6
Symptom Score	5.5	2.4
Impact Score	16.6	10.3
Immune System Score	5.0	1.8
Back Strength (kilogram)	54.5	26.2
Leg Strength (kilogram)	59.2	24.7
Handgrip right (kilogram)	23.7	5.5
Handgrip left (kilogram)	21.7	4.4

Feasibility data

All participants had completed and adhered to the exercise protocols and data collection procedures. Participants were able to maintain exercise intensity at a moderate level based on the specified intensity, which is 65-75% of the maximum heart rate. No incidents and injuries were reported by participants and observed by the researchers. No missing data were found for all result measures. Figure 1 illustrates the results from the feasibility study.

https://doi.org/10.29407/js_unpgri.v9i1.19575
9 (1) 2023 | 92-109

ISSN : 2477-3379 (Online)
ISSN : 2548-7833 (Print)

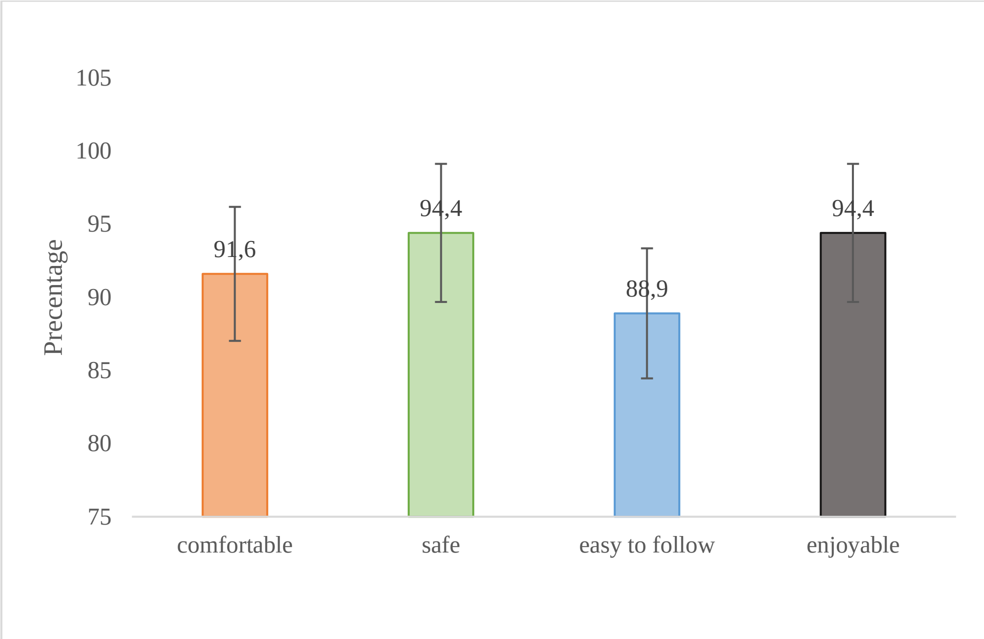

Figure. 1 Feasibility Data (n=36)

As seen in Figure 1, From 36 participants, 91.6% of participants reported that they were comfortable with the exercise protocol, 94.4% felt this exercise was safe, 88.9% considered that the exercise program was easy to follow, and 94.4% stated that the exercise was enjoyable.

The acute effect of the exercise on the cardiorespiratory parameters

The changes in the outcome measures pre and post-exercise are summarized in Table 2.

Table 3. Analytical data and effect sizes of the exercise on pulmonary function

Tools	Time	Mean	*SD*	*P**	*r*	*ES*
FVC	Pre-test	3.2	0.5	0.694	0.202	0.25
	Post-test	3.3	0.1			
FEV1	Pre-test	2.5	0.5	**<0.001**	0.290	0.69
	Post-test	2.8	0.3			
FEV1/FEV%	Pre-test	79.1	12.7	**0.004**	-.0007	0.69
	Post-test	86.5	7.3			
PEF	Pre-test	3.9	1.3	**0.001**	0.279	0.81
	Post-test	5.03	1.4			
SVC	Pre-test	3.03	0.5	**0.030**	0.059	-0.58
	Post-test	2.7	0.6			
MVV	Pre-test	51.3	11.7	**0.004**	0.163	0.69
	Post-test	62.1	17.7			
MRf	Pre-test	83.3	27.4	0.987	0.253	0.06
	Post-test	85.3	29.7			
MVt	Pre-test	0.7	0.3	0.195	0.390	0.37
	Post-test	0.8	0.2			
MVVt	Pre-test	10.6	1.4	**0.018**	-0.047	0.73
	Post-test	11.4	0.6			
spO2	Pre-test	97.8	0.9	**0.005**	0.381	0.52
	Post-test	98.2	0.4			

*=All tests were conducted using Wilcoxon Signed Ranks Test

FVC=Forced Vital Capacity), FEV1=Forced Expiratory Volume 1; FEV1/FVC=Forced expiratory volume ratio in 1 second/forced vital capacity); SVC= Slow Vital Capacity); PEF =Peak Expiratory Flow; MVV =Maximum Voluntary Ventilation); MVVt =MVV duration time; MRf=Maximum Respiratory Frequency; MVt =Tidal Volume (during MVV)), spO2 (Oxigen saturation, SD=standard deviation, P= p value, r= correlation ES=effect size.

As shown in Table3, there were increases in post-exercise FEV1, FEV1/FEV, PEF, SVC, MVV, MVVt, and spO2 (p values ranged from <0.001 to 0.03), with effect sizes ranging from 0.5 to 0.8 indicating medium to large effect of the exercise on the pulmonary and oxygen saturation. The results suggest that the aerobic, strength, and breathing exercises improve inhalation and exhalation of pulmonary function and oxygen saturation in post-COVID-19 women.

DISCUSSION

This study is the first study to assess the feasibility and the acute effects of the combination of aerobic, strength, and breathing exercises in women with post-COVID-19 syndromes. The study resulted in participants' full adherence to the program, with no reports of side effects, highlighting the feasibility and safety of the protocol. Most participants reported that they were comfortable with the exercise protocol, stated that the exercise protocol was safe, considered that the exercise program was easy to follow, and stated that the exercise was enjoyable. There were also increases in FEV1, FEV1/FEV, PEF, SVC, MVV, MVVt, and spO2 p value < 0.05, with

https://doi.org/10.29407/js_unpgri.v9i1.19575
9 (1) 2023 | 92-109

effect sizes ranging from 0.5 to 0.8. The findings of this study, thus, indicate that a combination of moderate-intensity aerobic exercise, strength training, and breathing improves pulmonary function and oxygen saturation among women with post-COVID-19 symptoms, suggesting the positive effect of the exercise program on pulmonary functions and oxygen saturation.

The increases of FEV1, FEV1/FVC%, PEF, SVC, MVV, and MVVt after performing a single session of a combination of aerobic, strength, and breathing exercises in this study is in line with a study that reported increases in pulmonary function capacity after 60 minutes per day of stretching, strengthening, and other types of aerobic exercise conducted for two weeks in patients with the post-COVID-19 syndrome (Choi et al., 2021). Long-term endurance and strength training, high-intensity inspiratory muscle training, and respiratory physiotherapy have also been reported to improve dyspnoea and optimize pulmonary and cardiorespiratory function in COPD patients (Greulich et al., 2014). Exercise has also been reported to improve aerobic ability and help optimize the respiratory (Campoi et al., 2019), metabolic parameters (Arovah & Heesch, 2021), and immune systems (Huntula et al., 2022; Mohamed & Alawna, 2020). The findings of this present study, thus, extend the literature by supporting the acute effect of concurrent exercise combined with breathing exercise in improving pulmonary function among women with post-COVID-19 syndrome.

A significant improvement in oxygen saturation in this study is in agreement with findings from a study suggesting that moderate-intensity aerobic exercise increases the respiratory system, cardiovascular system, and physical capacity in post-COVID-19 (Woods et al., 2020). Another study also suggests that low to moderate-intensity exercise and breathing exercises such as Liuzijue exercise that involves inhalation and exhalation through different mouth patterns to regulate and control the rise and fall of the breath in the body could improve pulmonary function, exercise capacity, and quality of life in post-COVID-19 patients (Tang et al., 2021), that may contribute in the improvement of oxygen saturation. This study has suggested the acute effects of combining concurrent exercise with a breathing exercise have resulted in an improvement in pulmonary function. Breathing exercises and physical exercise for patients have also been reported to generate a positive impact on reducing the perceived symptoms of post-COVID-19 (Naralia et al., 2021).

Our study has indicated that the combination of aerobic, strength, and breathing exercises is feasible and safe for COVID-19 survivors and can potentially improve several pulmonary function parameters and oxygen saturation. Some limitations in this study, however, need to be acknowledged. First, our study was conducted with limited sample size, constrained by our limited resources. Second, we did not control our analysis with confounding variables such as fitness level and nutrient intake, mainly due to the fact that no differences in these characteristics were found in the baseline data. Third, this study did not assign a control group, so we cannot distinguish whether the increase was largely due to the natural course of the disease or treatment. Further research is recommended to determine the long-term adaptation of exercise to the respiratory response in a randomized control trial design on the pulmonary function, physical and psychic capacities, and immune status in post-COVID-19.

CONCLUSION

The feasibility and safety of the 45-minute aerobic, strength, and breathing exercise session in women with post-COVID-19 syndrome were demonstrated. The positive acute effect was also indicated with improved pulmonary function and oxygen saturation in women with post-COVID-19 syndrome. Future research should focus on chronic exercise adaptation to pulmonary function and oxygen saturation using randomized control trial design not only to the pulmonary function but also to other physical functions as well as psychological and immune status in individuals with post-COVID-19 syndrome.

https://doi.org/10.29407/js_unpgri.v9i1.19575
9 (1) 2023 | 92-109

ACKNOWLEDGMENT

The authors would like to thank the research participants for their participation contributions and thank the State University of Yogyakarta, which supported the author's research.

Abbreviation:

FVC (Forced Vital Capacity), FEV1 (Forced Expiratory Volume 1); FEV1/FVC (Forced expiratory volume ratio in 1 second/forced vital capacity); SVC (Slow Vital Capacity); PEF (Peak Expiratory Flow); MVV (Maximum Voluntary Ventilation); MVVt (MVV duration time); MRf (Maximum Respiratory Frequency); MVt (Tidal Volume (during MVV)), HR (Heart Rate).

REFERENCES

Anastasio, F., Barbuto, S., Scarnecchia, E., Cosma, P., Fugagnoli, A., Rossi, G., Parravicini, M., & Parravicini, P. (2021). Medium-term impact of COVID-19 on pulmonary function, functional capacity and quality of life. *Eur Respir J*, *58*. https://doi.org/10.1183/13993003.04015-2020

Angulo, J., Assar, M., Álvarez-Bustos, A., & Rodríguez-Mañas, L. (2020). Physical activity and exercise: Strategies to manage frailty. *Redox Biology*, *35*(January), 1–21. https://doi.org/10.1016/j.redox.2020.101513

Arovah, N. I., & Heesch, K. C. (2021). The association between cardiorespiratory fitness and metabolic syndrome diagnosis: A cross-sectional study in Indonesian middle-aged and older adults. *Physical Activity Review*, *9*(2), 101–110. https://doi.org/10.16926/par.2021.09.26

Arovah, N. I., & Heesch, K. C. (2022). Social cognitive measures related to exercise behaviour: Validation in Indonesian middle-aged and older adults. *Clinical Epidemiology and Global Health*, *14*, 100975. https://doi.org/10.1016/J.CEGH.2022.100975

Campoi, H. G., Campoi, E. G., Lopes, R. F. T., Alves, S. A., Regueiro, E. M. G., Regalo, S. C. H., Taube, O. L. S., da SILVA, G. P., Verri, E. D., & Fabrin, S. C. V. (2019). Effects of physical activity on aerobic capacity, pulmonary function and respiratory muscle strength of football athletes and sedentary individuals. Is there a correlation between these variables? *Journal of Physical Education and Sport*, *19*(4), 2466–2471. https://doi.org/10.7752/jpes.2019.04374

Cavigli, L., Fusi, C., Focardi, M., Mandoli, G. E., Pastore, M. C., Cameli, M., Valente, S., Zorzi, A., Bonifazi, M., D'Andrea, A., & D'Ascenzi, F.

(2023). Post-Acute Sequelae of COVID-19: The Potential Role of Exercise Therapy in Treating Patients and Athletes Returning to Play. In *Journal of Clinical Medicine* (Vol. 12, Issue 1). MDPI. https://doi.org/10.3390/jcm12010288

Çelik, Z., Güzel, N. A., Kafa, N., & Köktürk, N. (2022). Respiratory muscle strength in volleyball players suffered from COVID-19. *Irish Journal of Medical Science*, *191*(5), 1959–1965. https://doi.org/10.1007/s11845-021-02849-z

Choi, K., Kim, M., Lee, S. M., & Kim, J. (2021). *Exercise-based pulmonary rehabilitation for a post-COVID-19 pulmonary fibrosis patient A case report*. https://doi.org/10.1097/MD.0000000000027980

Delbressine, J. M., Machado, F. V. C., Goërtz, Y. M. J., van Herck, M., Meys, R., Houben-Wilke, S., Burtin, C., Franssen, F. M. E., Spies, Y., Vijlbrief, H., van 't Hul, A. J., Janssen, D. J. A., Spruit, M. A., & Vaes, A. W. (2021). The impact of post-covid-19 syndrome on self-reported physical activity. *International Journal of Environmental Research and Public Health*, *18*(11), 1–11. https://doi.org/10.3390/ijerph18116017

Dominelli, P. B., Molgat-Seon, Y., Weatherald, J., Humbert, M., & Riha, R. (2022). Sex, gender and the pulmonary physiology of exercise Number 5 in the Series "Sex and gender in lung disease" Edited by. *Europian Respiratory Review*, *31*, 1–14. https://doi.org/10.1183/16000617.0074-2021

Eksombatchai, D., Wongsinin, T., Phongnarudech, T., Thammavaranucupt, K., Amornputtisathaporn, N., & Sungkanuparph, S. (2021). Pulmonary function and six-minute-walk test in patients after recovery from COVID-19: A prospective cohort study. *PLoS ONE*, *16*(9), 1–10. https://doi.org/10.1371/journal.pone.0257040

Fernández-De-las-peñas, C., Palacios-Ceña, D., Gómez-Mayordomo, V., Cuadrado, M. L., & Florencio, L. L. (2021). Defining post-covid symptoms (Post-acute covid, long covid, persistent post-covid): An integrative classification. *International Journal of Environmental Research and Public Health*, *18*(5), 1–9. https://doi.org/10.3390/ijerph18052621

Greulich, T., Kehr, K., Nell, C., Koepke, J., Haid, D., Koehler, U., Koehler, K., Filipovic, S., Kenn, K., Vogelmeier, C., & Koczulla, A. R. (2014). A randomized clinical trial to assess the influence of a three months training program (Gym-based individualized vs. Calisthenics-based non-invidualized) in COPD-patients. *Respiratory Research*, *15*(1), 1–8. https://doi.org/10.1186/1465-9921-15-36

Hafen, B. B., & Sharma, S. (2021). Oxygen Saturation. In *StatPearls*. https://www.ncbi.nlm.nih.gov/books/NBK525974/

Huang, Y., Tan, C., Wu, J., Chen, M., Wang, Z., Luo, L., Zhou, X., Liu, X., Huang, X., Yuan, S., Chen, C., Gao, F., Huang, J., Shan, H., & Liu, J. (2020). Impact of coronavirus disease 2019 on pulmonary function in early convalescence phase. *Respiratory Research*, *21*(163), 1–10. https://doi.org/10.1186/s12931-020-01429-6

Humphreys, H., Kilby, L., Kudiersky, N., & Copeland, R. (2021). Long COVID and the role of physical activity: a qualitative study. *BMJ Open*, *11*(3), 1–8. https://doi.org/10.1136/bmjopen-2020-047632

Huntula, S., Punsawad, C., & Lalert, L. (2022). Alteration in salivary cortisol and interleukin-6 levels during two different intensities of acute aerobic exercise. *Journal of Physical Education and Sport ® (JPES)*, *22*(6), 1363–1371. https://doi.org/10.7752/jpes.2022.06171

Jann, B. (2021). 20 Home Strength Training Best Exercise to Burn Fats, Build Muscles, Boosts Strength and Stamina. In *Morgan*. Morgan.

Jiménez-Pavón, D., Carbonell-Baeza, A., & Lavie, C. J. (2020). Physical exercise as therapy to fight against the mental and physical consequences of COVID-19 quarantine: Special focus in older people. *Progress in Cardiovascular Diseases*, *63*(3), 386–388. https://doi.org/10.1016/j.pcad.2020.03.009

Kokhan, S., Kolokoltsev, M., Vorozheikin, A., Gryaznykh, A., Romanova, E., Guryanov, M., Faleeva, E., Tarasov, A., & Aganov, S. (2022). Physical rehabilitation of patients with post-COVID syndrome. *Journal of Physical Education and Sport ® (JPES)*, *22*(9), 2005–2011. https://doi.org/10.7752/jpes.2022.09255

Lewis, K. L., Helgeson, S. A., Tatari, M. M., Mallea, J. M., Baig, H. Z., & Patel, N. M. (2021). COVID-19 and the effects on pulmonary function following infection: A retrospective analysis. *EClinicalMedicine*, *39*. https://doi.org/10.1016/j.eclinm.2021.101079

Lim, J. (2021). *Oximeters and COVID-19 | Health Plus*. Health Plus. https://www.mountelizabeth.com.sg/healthplus/article/oximeter

Lin, L., Luo, S., Qin, R., Yang, M., Wang, X., Yang, Q., Zhang, Y., Wang, Q., Zhu, R., Fan, H., Wang, H., Hu, Y., Wang, L., & Hu, D. (2020). Long-term infection of SARS-CoV-2 changed the body's immune status. *Clinical Immunology*, *218*(July). https://doi.org/10.1016/j.clim.2020.108524

Listiarini, D., Kushartanti, W., & Arovah, N. I. (2022). The Caffeine Supplementation in a Moderate-Intensity Aerobic Exercise in Obese Asian Women. *Women in Sport and Physical Activity Journal*, 1–7. https://doi.org/10.1123/wspaj.2022-0035

Liu, K., Zhang, W., Yang, Y., Zhang, J., Li, Y., & Chen, Y. (2020). Respiratory rehabilitation in elderly patients with COVID-19: A randomized controlled study. *Complementary Therapies in Clinical Practice*, *39*(101166), 1–4. https://doi.org/10.1016/J.CTCP.2020.101166

Maulana, G. F., & Arovah, N. I. (2022). The Psychometric Evaluation of the Immune Status Questionnaire in Indonesia. *East J Med*, *27*(3), 380–388. https://doi.org/10.5505/ejm.2022.93764

Mohamed, A. A., & Alawna, M. (2020). Role of increasing the aerobic capacity on improving the function of immune and respiratory systems in patients with coronavirus (COVID-19): A review. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, *14*(4), 489–496. https://doi.org/10.1016/j.dsx.2020.04.038

Moore, V. C. (2012). Spirometry: step by step. *Breathe*, *8*(3), 232–240. https://doi.org/10.1183/20734735.0021711

Moreno-pérez, O., Merino, E., Leon-ramirez, J., Andres, M., Manuel, J., Arenas-jiménez, J., & Asensio, S. (2021). Post-acute COVID-19 syndrome. Incidence and risk factors: A Mediterranean cohort study. *Journal of Infection*, *82*(January), 373–378.

Moulson, N., Gustus, S. K., Scirica, C., Petek, B. J., Vanatta, C., Churchill, T. W., Guseh, J. S., Baggish, A., & Wasfy, M. M. (2022). Diagnostic evaluation and cardiopulmonary exercise test findings in young athletes with persistent symptoms following COVID-19. *British Journal of Sports Medicine*, *56*(16), 927–932. https://doi.org/10.1136/bjsports-2021-105157

Naralia, T., Kesehatan, H. P.-S. J. I., & 2021, undefined. (2021). The Effectiveness of Breathing Exercises for Post Covid-19 Patients during Rehabilitation: A Literature Review. *Sjik.Org*, *10*(1), 844–850. https://doi.org/10.30994/sjik.v10i1.717

National Insitute for Health and Care Excellence. (2020). *COVID-19 guideline scope: management of the long-term effects of COVID-19*. *October 2020*, 1–7.

Ponce, M. C., & Sharma, S. (2021). Pulmonary Function Tests. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK482339/

Ranu, H., Wilde, M., & Madden, B. (2010). Pulmonary function tests. *Ulster Med J*, *80*(2), 84–90. www.ums.ac.uk

Rawashdeh, A., & Alnawaiseh, N. (2018). The effect of high-intensity aerobic exercise on the pulmonary function among inactive male individuals. *Biomedical and Pharmacology Journal*, *11*(2), 735–741. https://doi.org/10.13005/bpj/1427

Roldan, C. (2021). Moves Try the 10-Minute Home Workout and Boost Your Activity Level. In *https://us.macmillan.com/piracy*. macmillan.

Saeki, T., Ogawa, F., Matsumiya, M., Yamamura, M., Oritsu, H., Nonogaki, M., Uesugi, J., Takeuchi, I., & Nakamura, T. (2021). Long-Term Decreased Exercise Capacity of COVID-19 Patients Who Received Mechanical Ventilation in Japan: A Case Series. *American Journal of*

Physical Medicine and Rehabilitation, *100*(8), 737–741. https://doi.org/10.1097/PHM.0000000000001803

Sewa, D. W., & Ong, T. H. (2014). Pulmonary function test: Spirometry. *Proceedings of Singapore Healthcare*, *23*(1), 57–64. https://doi.org/10.1177/201010581402300110

Shokri, I. S. M., Suhaimi, N. S., Illias, N. F., Adnan, R., & Ismail, H. (2022). The effect of cardiovascular responses on aerobic exercise and relationship between pulmonary function and body composition among sedentary students. *Journal of Physical Education and Sport ® (JPES)*, *22*(9), 2012–2017. https://doi.org/10.7752/jpes.2022.09256

Suhaimi, N. S. M., Shokri, I. S. M., Illias, N. F., Adnan, R., & Ismail, H. (2022). The cardiovascular responses on difference exercise intensity and the relationship with body composition among sedentary college students. *Journal of Physical Education and Sport ® (JPES)*, *22*(10), 2340–2345. https://doi.org/10.7752/jpes.2022.10298

Tang, Y., Jiang, J., Shen, P., Li, M., You, H., Liu, C., Chen, L., Wang, Z., Zhou, C., & Feng, Z. (2021). Liuzijue is a promising exercise option for rehabilitating discharged COVID-19 patients. *Medicine*, *100*(6), e24564. https://doi.org/10.1097/MD.0000000000024564

Thompson, B. (2020). *Strength Training After 40: A Practical Guide to Building and Maintaining a Healthier, Leaner, and Stronger Body*.

Torres-Castro, R., Vasconcello-Castillo, L., Alsina-Restoy, X., Solis-Navarro, L., Burgos, F., Puppo, H., & Vilaró, J. (2021). Respiratory function in patients post-infection by COVID-19: a systematic review and meta-analysis. *Pulmonology*, *27*(4), 328–337. https://doi.org/10.1016/J.PULMOE.2020.10.013

Tran, V.-T., Riveros, C., Clepier, B., Desvarieux, M., Collet, C., Yordanov, Y., & Ravaud, P. (2022). Development and validation of the long coronavirus disease (COVID) symptom and impact tools: A set of patient-reported instruments constructed from patients' lived experience. *Clinical Infectious Diseases Clinical Infectious Diseases*, *74*(2), 278–287. https://doi.org/10.1093/cid/ciab352

Williams, Z., & Hull, J. H. (2022). Respiratory complications following COVID-19 in athletic populations: A narrative review. *Scandinavian Journal of Medicine and Science in Sports*. https://doi.org/10.1111/sms.14275

Woods, J. A., Hutchinson, N. T., Powers, S. K., Roberts, W. O., Gomez-Cabrera, M. C., Radak, Z., Berkes, I., Boros, A., Boldogh, I., Leeuwenburgh, C., Coelho-Júnior, H. J., Marzetti, E., Cheng, Y., Liu, J., Durstine, J. L., Sun, J., & Ji, L. L. (2020). The COVID-19 pandemic and physical activity. *Sports Medicine and Health Science*, *2*(2), 55–64. https://doi.org/10.1016/j.smhs.2020.05.006

World Health Organization. (2023, January). *WHO coronavirus (COVID-19) dashboard*. https://covid19.who.int/

Yang, S., Liu, T., Xiong, J., Teng, Y., Guo, Y., Yu, S., & Zeng, F. (2021). Traditional Chinese exercise potential role as prevention and adjuvant therapy in patients with COVID-19. *Complementary Therapies in Clinical Practice*, *43*, 1–4. https://doi.org/10.1016/j.ctcp.2021.101379

https://doi.org/10.29407/js_unpgri.v9i1.19575
9 (1) 2023 | 92-109