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THE EFFECT OF COVID-19 HISTORY ON CARDIORESPIRATORY FITNESS OF HAJJ PILGRIM CANDIDATES

Ikrar Abdillah Muryasani[1,2], Sri Wahyudati[1,2], Erna Setiawati[1,3]*
[1]Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia
[2]Kariadi Hospital, Semarang, Indonesia
[3]Diponegoro National Hospital, Semarang, Indonesia

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Corresponding Author:
E-mail: roswithaerna@fk.undip.ac.id

ABSTRACT

Background: Hajj pilgrims are expected to be able to walk a minimum of 12 kilometers. Therefore, good physical fitness is required. COVID-19 is a disease that can cause deconditioning of heart and lung function. **Objective:** The purpose of this study was to determine the effect of COVID-19 history on cardiorespiratory fitness of hajj pilgrim candidates. **Methods:** This cross-sectional study was conducted on prospective hajj pilgrim candidates in Salatiga City aged 50-70 years who fit the inclusion criteria. Subject characteristics such as age, comorbid history, and exercise history were collected from subject interviews. Body Mass Index (BMI) was measured by calculating height and weight. Physical activity history was assessed using Indonesian version of the International Physical Activity Questionnaire (IPAQ). Cardiorespiratory fitness was assessed using the six minutes walking test (6MWT). Data were analyzed using comparative test. **Results:** A total of 32 subjects with a history of COVID-19 with 31 mild symptoms and 1 moderate symptom, and 101 subjects without a history of COVID-19 were included as research subjects. There was significant difference in age (p=0.006) and education (p=0.003) between subject with COVID-19 history and without COVID-19 history (p=0.006). The VO2max result from 6MWT in subjects with history of COVID-19 were significantly lower than those in subjects without a history of COVID-19 (p=0.007, 14.54±3.54 mL/kg/min vs 16.36±3.19 mL/kg/min). **Conclusion:** COVID-19 history affects the cardiorespiratory fitness of hajj pilgrim candidates. Endurance training should be recommended for Hajj pilgrim candidates with a history of COVID-19 to improve cardiorespiratory fitness.

BACKGROUND

The Hajj pilgrimage is an act of worship that is mainly performed physically, so pilgrims are required to be physically, mentally, spiritually, and financially capable. The Hajj pilgrimage is obligatory for Muslims once in a lifetime for those who meet the requirements.[1] The health of Istithaah is defined as their physical and mental ability, which is measured through reliable medical examinations so that pilgrims can perform their pilgrimage optimally.[2] Pilgrims need to be able to walking properly to perform the rituals of tawaf, sai'i, throwing jumrah, and daily activities of moving to and returning from their accommodation. Pilgrims are estimated be able to walk a minimum distance of 12 kilometres to perform these religious activities, therefore good cardiopulmonary fitness is required.[3]

Severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), which causes COVID-19, is a highly contagious single-stranded RNA coronavirus. Transmission between humans is thought to be dominated by respiratory droplet spread.[4,5] Symptoms resemble those of the flu or respiratory tract infection. The severity of the disease varies from asymptomatic, mild upper respiratory tract infection, severe viral pneumonia with respiratory failure, to death. In cases of asymptomatic infection or mild symptoms, patients generally recover completely without residual

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symptoms. However, in severe cases, the infection can cause damage to other internal organs that have specific receptors for the COVID-19 virus, such as the lungs, heart, blood vessels, kidneys, and digestive tract.[6,7]

Asymptomatic COVID-19 patients are reported to recover completely within 2 weeks, while patients with severe manifestations of COVID-19 will require a longer recovery time, estimated at 3-6 weeks, and often experience organ damage, leading to long-term sequelae. It is reported that patients with severe infections will experience long-term lung damage and decreased lung function.[8] Another study reported that in post-COVID-19 patients who still have residual respiratory symptoms, rehabilitation actions play a role in increasing lung capacity, so that optimal respiratory function can be achieved again.[9]

Systematic review by Schwendinger reported that Cardiopulmonary Exercise Testing (CPET) results in post-COVID-19 subjects showed a decrease in VO_2 peak from normal levels. This decrease in VO2 peak involves various factors such as deconditioning of the cardiopulmonary system, muscle mass, muscle strength, blood perfusion, mitochondrial function, and psychological factors.[10]

The effect of Covid-19 history on the cardiorespiratory fitness of prospective Hajj pilgrims has not been studied before. Researchers want to know the effect of Covid-19 history on the cardiorespiratory fitness of prospective Hajj pilgrims.

METHODS

This research used a cross-sectional design to compare the effects of COVID-19 history on cardiorespiratory fitness in Hajj pilgrims. The study population was Hajj pilgrims departing from the city of Salatiga, Indonesia.

The inclusion criteria were age 50–70 years old, able to walk without assistive devices, fulfil the Hajj health and istithaah requirements, no cognitive impairment (based on a score of ≥26 points on the Indonesian Version of Montreal Cognitive Assessment), and able to understand instructions. The subjects were excluded if they experienced pain in the lower extremities, based on a visual analogue scale (VAS) score ≥5; musculoskeletal diseases (hypotonus and laxity on the lower extremities; an manual muscle testing score <5 for upper and lower extremities; leg fractures; spinal fractures); uncontrolled metabolic diseases (diabetes mellitus with Random Blood Glucose <70 mg/dl or >250 mg/dl; excessive blood pressure without control (≥160/100 mmHg); stage IV chronic kidney failure with peritoneal dialysis/regular haemodialysis); cardiac diseases (underwent a cardiac surgical procedure or percutaneous coronary intervention during the research period; stage III–IV heart failure); pulmonary diseases (severe chronic obstructive pulmonary disease, tuberculosis total drug resistance (TDR); other diseases (stage IV acquired immunodeficiency syndrome with opportunistic infections, extensive haemorrhagic stroke, end-stage malignancy, cirrhosis or decompensated hepatoma, severe schizophrenia, severe dementia, severe mental retardation); and refused to take part or participating in other research.

Subject characteristics such as age, comorbid history, and exercise history were collected from subject interviews. Body Mass Index (BMI) was measured by calculating height and weight. Physical activity history was assessed using Indonesian version of the International Physical Activity Questionnaire (IPAQ).

Cardiorespiratory fitness was assessed using the six minutes walking test. The six-minute walk test is a submaximal cardiovascular exercise test. It is performed on a 15-meter flat surface track indoors (temperature 25ºC) that was performed by walking as fast as possible in 6 minutes. The test is monitored by a trained operator who is blind to the subject. If the subject was fatigued, the subject was allowed to stop and rest during the test, but the time was kept running. Cardiorespiratory fitness values (VO_2max) were obtained by converting the distance of the 6-minute walk test using the Nury Formula in ml/kg/min.[11]

$$VO_2max = [(0{,}053 \times \text{total distance}_{meter}) + (0{,}22 \times \text{age}_{years}) + (0{,}032 \times \text{height}_{centimeter}) - (0{,}164 \times \text{weight}_{kilogram}) - (2{,}228 \times \text{gender}_{male=0,\ female=1}) - 2{,}287]$$

Figure 1. Nury formula to predict VO_2max

Confounding factors such as age were controlled according to the inclusion criteria. No adjustments were made for the other confounding factors. Data were analyzed using comparative test. We used Stata version 13.1 to process the data. We analysed normality subject with Shapiro-Wilk test and

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difference of the variable with Chi-Square, Mann-Whitney, and independent T-test. We considered a p-value <0.05 was considered to be statistically significant.

RESULTS

From 214 Hajj Pilgrim Candidates on Salatiga, total of 32 subjects with a history of COVID-19 with 31 mild symptoms and 1 moderate symptom, and 101 subjects without a history of COVID-19 were included as research subjects (figure 1). Both groups were assessed for subject characteristics and underwent a six-minute walking test.

Table 1 presents the comparison result according to history of COVID-19. There was significant difference in age (p=0.006) and education (p=0.003) between subject with COVID-19 history and without COVID-19 history. The VO_2max predicted values was calculated via Nury Formula. Table 2 showed independent-t test result for VO_2max in subjects with history of COVID-19 (14.54±3.54 mL/kg/min) were lower compared with subjects without history of COVID-19 (16.36±3.19 mL/kg/min), and the difference was significant (p=0.007, 95% CI -3.14 – (-0.51)). From the results of the Cohen's d test, the effect size value = 0.5415 (0.5 - ≤0.8) so it can be concluded that the difference in VO_2max based on Covid 19 history has a large effect size. There were no significant differences were found in other variable.

Based on the findings from the difference test, we conducted a Spearman's correlation test on age and education level to further determine whether these were confounding factors in this study. There was no significant relationship between age (p=0.575) and education (p=0.538) toward VO2max. Because there was no significant relationship between age and education toward VO2 max, the data analysis could not proceed to multivariate analysis.

Table 1. The Comparison Result According to History of Covid-19

Variable	Covid-19 History		p
	Yes	No	
Age (years old)	58 (50–70)	62 (51–70)	0.006‡*
Gender			
Male	14 (23.7%)	45 (76.3%)	1.000¥
Female	18 (24.3%)	56 (75.7%)	
Education			
Elementary School	1 (4.8%)	20 (95.2%)	0.003¶*
High School	8 (17%)	39 (83%)	
Diploma and Bachelor	18 (35.3%)	33 (64.7%)	
Master and above	5 (35.7%)	9 (64.3%)	
Work			
Working	21 (27.6%)	55 (72.4%)	0.364¥
Unemployed	11 (19.3%)	46 (80.7%)	
Comorbid			
Yes	18 (25.4%)	53 (74.6%)	0.865¥
No	14 (22.6%)	48 (77.4%)	
Exercise regularly			
Yes	24 (22.4%)	83 (77.6%)	0.524¥
No	8 (30.8%)	18 (69.2%)	
Smoking			
Yes	2 (13.3%)	13 (86.7%)	0.521¥
No	30 (25.4%)	88 (74.6%)	
Weight (Kg)	65.19±10.20	63.52±11.02	0.449§
Height (cm)	159.06±6.64	158.77±7.74	0.849§
BMI (Kg/m^2)	25.70±3.19	25.09±3.28	0.358§
IPAQ			
Low	23 (26.4%)	64 (73.6%)	0.416¶
Moderate	8 (18.6%)	35 (81.4%)	
High	1 (33.3%)	2 (66.7%)	
METs	4.28±1.00	4.64±0.93	0.067§

The symbols indicate the statistical test used for analysis: *Significant (p <0,05); ¥Chi-Square; ¶Mann-Whitney (alternative χ^2); ‡Mann-Whitney; §Independent-t

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Table 2. The Comparison Result in VO_2max According to History of Covid-19

Covid 19 History	N	VO_2max (ml/kg/min)			
		Mean ± SD	p	Mean difference	95% CI
Yes	32	14.54±3.54	0.007*	-1.82	-3.14 – (-0.51)
No	101	16.36±3.19			

Notes: *Significant (p <0.05)

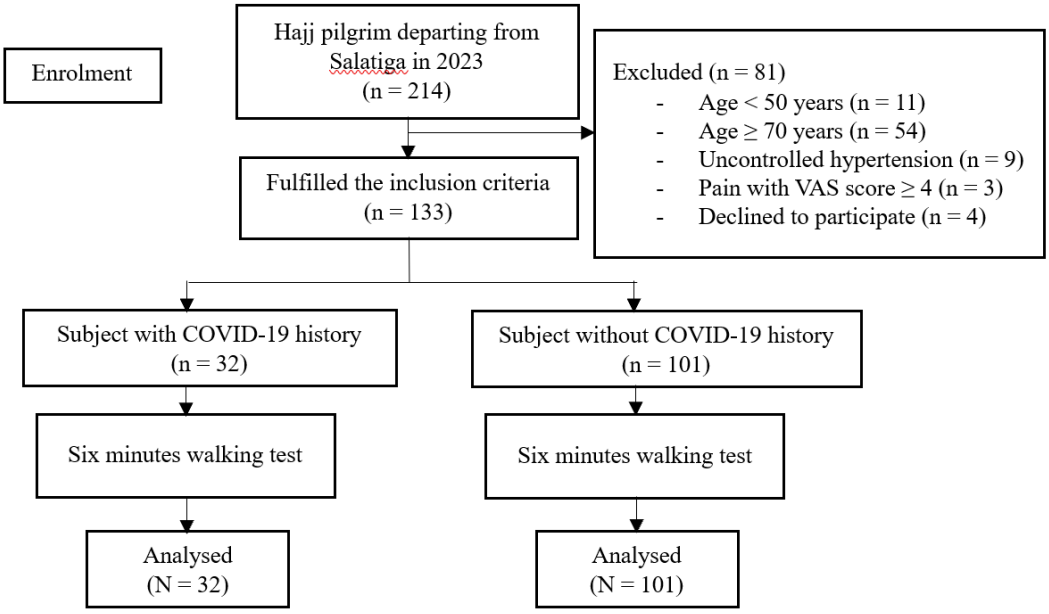

Figure 2. The CONSORT Flowchart

DISCUSSION

In this study, the VO_2max result from six minutes walking test in subjects with a history of COVID-19 were significantly lower than those in subjects without a history of COVID-19. These results are consistent with a previous systematic review by Schwendinger, in which Cardiopulmonary Exercise Testing (CPET) results in post-COVID-19 subjects showed a decrease in VO_2 peak from normal levels.[10] Durstenfeld's study also showed lower CPET results in individuals with Long Covid symptoms compared to those without Long Covid symptoms.[12] The contribution of respiratory function to low peak VO2 was shown in the decreased diffusion capacity of the lungs. The cardiovascular system might contribute to low VO_2 peak via subnormal cardiac output due to chronotropic incompetence and reduced stroke volume, especially in the first month's post-infection. Chronotropic incompetence was similarly present in the moderate- and long-term follow-up. Peripheral factors such as muscle mass, strength and perfusion, mitochondrial function, or arteriovenous oxygen difference may also contribute to low VO_2 peak. The mechanisms underlying the decrease in exercise intolerance, aside from deconditioning, include changes in autonomic function (chronotropic incompetence, respiratory dysfunction), endothelial dysfunction, and muscle or mitochondrial abnormalities.[10,12]

Asymptomatic COVID-19 patients are reported to recover completely within 2 weeks, while patients with severe COVID-19 manifestations will require a longer recovery time, estimated at 3-6 weeks, and often experience organ damage, leading to long-term sequelae. It is reported that patients with severe infections will experience long-term lung damage and decreased lung function.[8] According to a study on post-COVID-19 patients who still have residual respiratory symptoms, cardiorespiratory rehabilitation plays a role in increasing lung capacity so that optimal respiratory function can be achieved again.[9]

The purpose of aerobic exercise on post COVID-19 patients is to maintain and improve cardiorespiratory fitness. The principle of aerobic

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exercise is focused on large muscles such as arms and legs by performing repetitive movements.[13] Walking aerobic exercise is effective in improving cardiorespiratory fitness by increasing maximum heart rate capacity, stimulating muscle contraction, breaking down glycogen and improving tissue oxygenation. It can also reduce plaque formation through increased fat and glucose metabolism. In addition, walking exercise will have an impact on reducing the risk of mortality and morbidity through the mechanism of burning calories, maintaining body weight, helping the body relax and increasing beta endorphins which can reduce stress levels.[14] Walking exercise starts at a low intensity and can be gradually increased to moderate intensity according to patient tolerance.

Muscle strengthening exercises are also effective for improving cardiorespiratory fitness on post COVID-19 patients. These exercises are dynamic exercises that can increase intramuscular pressure and cause increased blood flow. Increased blood flow can improve tissue strength and flexibility. This condition will increase strength, endurance, improve posture, increase joint range of motion, improve fitness, improve function and reduce pain.[15,16] The exercise starts from an intensity of 30-40% of 1 RM (repetition maximal) or can use heavy weights of 1-5 kg, 3 times a week. The intensity increases gradually according to the patient's tolerance.[13]

Respiratory muscle training in post COVID-19 patients can be done using the Inspiratory Muscle Trainer. Respiratory muscle strengthening exercises are performed with an initial load of 30% of the individual's maximum inspiratory pressure and the increase in load is determined according to the purpose of the exercise (endurance or strengthening). Exercises were given at a frequency of 1-2 times per day, with repetitions of 15-30 times for endurance and 8-12 times for strengthening. Respiratory muscle training can be followed by effective coughing exercises of 3 sets with 10 repetitions for each set.[13] Diaphragmatic breathing exercises and breath stacking exercises will help improve lung capacity. Airway dilatation during deep breathing exercise can also help with sputum discharge. The frequency of exercise is 2-3 x per day performed daily, 10-15 minutes duration.[17]

In this study, there was a statistically significant difference in age among subjects with a history of COVID-19 (p=0.006). Different ages are significant in subjects with a history of COVID-19 and could potentially be a confounding variable. Although this study limited the age of subjects to between 50 and 70 years, which is the most common age range for Indonesian Hajj pilgrims, significant differences in age could affect cardiorespiratory fitness results. VO2max values decrease with age. In men, VO2max decreases from approximately 45 mL/kg/minute at age 25 to approximately 25 mL/kg/minute at age 70. In comparison, women have approximately 20% lower VO2max due to their lower muscle mass and hemoglobin levels. Healthy women aged 80 typically have a peak VO2 value of 15-20 mL/kg/min, which is characteristic of mild heart failure.[18]

In this study, there was a statistically significant difference in education among subjects with a history of COVID-19 (p=0.003). Previews study show that higher education levels are associated with higher cardiorespiratory fitness (VO2max) in adults. Education correlates with VO2max primarily because it influences physical activity habits, health awareness, and socioeconomic conditions that support better cardiorespiratory fitness, rather than education directly increasing VO2max. This relationship is seen across different age groups, from adolescents to adults, with education level being a marker of lifestyle and health-related choices that affect maximal aerobic capacity.[19,20]

The mean BMI of the study subjects both in the group with a history of COVID-19 and the group without a history of COVID-19 showed that the subjects were in obesity I according to Asia-Pacific criteria.[21] Lavie et al found that subjects with obesity had a lower VO2max when compared to subjects who had a normal body mass index.[22]

Obesity is associated with altered production and secretion of lipids as well as lipoproteins and adipokines. These changes can negatively impact vascular endothelial function through increased proinflammatory pathways including increased endothelin-1, monocyte chemoattractant protein-1, pentraxin, tumour necrosis factor α, and interleukins 6 and 12 as well as through direct actions on endothelial cells and vascular smooth muscle. Previous research states that an increase in these conditions will be associated with a decrease in arterial compliance which is associated with a decrease in cardiorespiratory fitness.[23] Individuals with obesity

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will have low levels of physical activity that will cause muscle deconditioning. Obesity will result in metabolic imbalance due to neuromuscular dysfunction. This will lead to decreased cardiorespiratory fitness.[24]

Hajj activities can be categorized into light (activities that require energy expenditure of less than 3 METs), moderate (3-6 METs) and heavy (more than 6 METs).[25] In this study, both groups with a history of COVID-19 and without a history of COVID-19 obtained moderate METs results. Based on ACSM guidelines, VO_2max result among subject with and without a history of COVID-19 were classified as very poor.[26] It is hoped that the rehabilitation interventions consist of aerobic, strengthening, and respiratory muscle exercises can increase VO_2max and METs close to the numbers needed in Hajj activities that classified as heavy activities (such as sa'i and throwing Jumroh) so that prospective pilgrims can be optimal in carrying out the hajj pilgrimage.

CONCLUSION

COVID-19 history does affect the cardiorespiratory fitness of hajj pilgrim candidates. Endurance training should be recommended for Hajj pilgrim candidates with a history of COVID-19 to improve cardiorespiratory fitness.

This study has limitation, study method was cross sectional, we only evaluated the measurements once, no follow up after first evaluation. This study also did not explore the causal relationship. Future research can be carried out to prospective study to explore more about cardiorespiratory fitness of hajj pilgrim candidates with history of COVID-19 after rehabilitation intervention.

ETHICAL APPROVAL

The Research Ethics Committee at the Health and Medical Research Ethics Commission of Diponegoro University, Semarang, Indonesia granted ethical approval with the ethical clearance number 97/EC/KEPK/FK-UNDIP/IV/2023.

CONFLICTS OF INTEREST

The authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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AUTHOR CONTRIBUTIONS

The authors confirm contribution to the article areas as follows: Conceptualization, Sri Wahyudati, Erna Setiawati, and Ikrar Abdillah Muryasani; methodology, Ikrar Abdillah Muryasani; software, Ikrar Abdillah Muryasani; validation, Ikrar Abdillah Muryasani; formal analysis, Ikrar Abdillah Muryasani; investigation, Ikrar Abdillah Muryasani; resources, Ikrar Abdillah Muryasani; data curation, Ikrar Abdillah Muryasani; writing—original draft preparation, Ikrar Abdillah Muryasani; writing—review and editing, Ikrar Abdillah Muryasani; visualization, Ikrar Abdillah Muryasani; supervision, Sri Wahyudati and Erna Setiawati; project administration, Ikrar Abdillah Muryasani; funding acquisition, Ikrar Abdillah Muryasani.

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