The Effect of Climbing Stairs Activity Toward Aerobic Fitness and Measurement of Its Energy Expenditure

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Abstract. Aerobic fitness is one of the factors that affect occupational health. The way to improve aerobic fitness is through exercise that trains the cardiovascular organs. Busyness is often the cause of someone being too lazy to exercise. Researchers from Cambridge University say being sedentary is far more dangerous than being overweight. WHO says about two million people worldwide die from diseases caused by a lazy lifestyle and lack of exercise. One of the simple sports activities that can be done together with daily activities is going up and down stairs. This activity does not require special equipment and does not take much time. This study aimed to determine the effect of climbing stairs on aerobic fitness and the energy expenditure rate when climbing stairs. The treatment of climbing stairs was given to 28 respondents. Respondents were divided into two groups: the group that did the treatment five times a week for one month and the group that did the treatment six times a week for one month. The respondent's initial aerobic fitness level was compared to aerobic fitness level after treatment. Fitness level measurement was carried out using sub-maximum exercise, namely the Harvard Step Test method. The comparison results show that all respondents experienced an increase in aerobic fitness level, and two respondents had a change in the aerobic fitness category from poor to below average. The treatment portion given did not differ between 5 times a week and six times a week. The Metabolic Work Rate (MWR) equation measured respondents' energy expenditure. The average MWR of respondents is 5.7 kilocalories per minute or is included in the rather heavy physiological load category, the same as walking at a speed of 3 kilometers per hour, cycling at a speed of 16 kilometers per hour, and jogging at a speed of 7.2 kilometers per hour.

1 Introduction

Health is an essential thing in a person's life. According to Indonesian Law No. 36 of 2009 [1], health is a healthy state, both physically, mentally, spiritually, and socially, which enables everyone to live productively, socially, and economically. A healthy person is usually protected from various diseases and can carry out their activities and obligations satisfactorily. Occupational health is important for workers. Occupational health needs to be

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considered so that workers can work more productively. Several factors, including food consumption, sleep patterns, fluid intake for the body, immune system level, and physical fitness training, influence occupational health.

Physical fitness is the body's ability to carry out routine tasks for a long period without experiencing significant fatigue and still having reserve energy to carry out sudden activities [2]. Physical fitness can provide many benefits for a person's body, including reducing weight and preventing obesity, preventing heart disease, and increasing intelligence in the brain [3]; provides a lot of energy so that the mind becomes clear, sleeps soundly, avoids stress; and protecting against osteoporosis. Physical fitness is divided into physical fitness related to health and physical fitness related to performance. Health-related components of physical fitness are cardiovascular endurance (aerobic fitness), muscular endurance, muscle strength, body composition, and flexibility. Each of these components has benefits in increasing body fitness, which indirectly helps humans carry out various activities.

Aerobic fitness or cardiorespiratory endurance is a part of physical fitness. Aerobic fitness is the ability of the circulatory and respiratory systems to regulate or adjust from strenuous exercise and to restore the effects of the exercise itself. Aerobic fitness involves the functioning of the heart and lungs, blood, and its capacity to carry oxygen, blood vessels, and capillaries in supplying blood to all body tissues and muscle cells, which use oxygen to provide energy for endurance training. The greater the aerobic capacity of a person, the higher the aerobic fitness. Several ways to maintain the health of the cardiovascular system are to regulate eating patterns regularly; to have adequate rest, including sufficient sleep time; not consuming illegal drugs, alcohol, and smoking; and to exercise regularly so that the cardiovascular system runs smoothly. Some examples of sports that train the cardiovascular organs are walking, jogging, swimming, and cycling. Aerobic fitness can also be obtained by other sports that use equipment or not. Aerobic exercise not only improves blood circulation to the muscles and joints but also the rhythmic nature of the activity can help lubricate the joints, thereby reducing pain.

Sport is important, but workers often need to remember to exercise because of their busy schedules. Busy activities make people sometimes ignore exercise. Sport is a need for every human being in life so that his physical condition and health are well maintained [4]. The greatest risk of early death occurs in those who rarely move. Researchers from the University of Cambridge also say lack of movement is far more dangerous than being overweight. As many as 676 thousand deaths yearly occur due to lack of movement and deaths due to obesity 337 thousand cases. The World Health Organization (WHO) says that around two million people worldwide die from diseases caused by a lazy lifestyle and lack of exercise [5]. Research also proves that a sedentary lifestyle can lead to obesity, more than 30 chronic diseases and conditions, and high healthcare costs [6]. The estimated gains in life expectancy in the US population were two years for reducing excessive sitting to less than 3 hours per day [7]. These things prove how important exercise is for one's body. Sports activities can be done together with daily activities, one of which is going up and down stairs [4].

Going up and down stairs is an exercise that can be an alternative sport during busy activities because it can be done while carrying out daily activities. Going up and down stairs is easy because it requires little equipment or time [8]. Going up and down stairs effectively burns fat, strengthens the heart, and increases endurance. This sport can be done indirectly over a short period. The activity of going up and down stairs, which will routinely accumulate every day without realizing it, can contribute to physical activity. According to previous research, climbing up and down stairs exercise affects the VO2 max [9]. Daily stair climbing may be protective against metabolic syndrome [10]. Accumulating short bouts of stair climbing activity throughout the day can favorably alter important cardiovascular risk factors in previously sedentary young women [11]. Stairs as a facility for doing sports are easy to find in daily activities because currently, almost all buildings have multi-story floors, so they

require stairs as access for moving places. In addition, going up and down stairs can also reduce the use of elevators in a building, so energy use can also be minimized because it is undeniable that the use of elevators uses the most energy.

This research continues previous research in which respondents who were given the treatment of going up and down stairs experienced an increase in their aerobic fitness levels before and after the treatment. However, the category of aerobic fitness level in previous studies remained the same or in a poor position, presumably due to the lack of adaptation time for going up and down stairs. In addition, in previous research, the energy consumption expended when a person climbs stairs has not been measured. Energy calculation needs to be done to determine the amount of energy expended when climbing stairs.

2 Methods

This research began with the selection of respondents. Prospective respondents are male Petra Christian University students aged 20-22, who do not smoke, have not exercised in the last six months, and have an 18.5-29.9 Body Mass Index (BMI), categorized as normal/pre-obesity [12]. Initial aerobic fitness levels were measured on potential respondents. One method for measuring aerobic fitness is the Harvard Step Test. The tools used in HST include a 45 cm high bench, stopwatch, and metronome. The metronome regulates the respondent's tempo during the Harvard Step Test. The following equation can measure fitness level with the Harvard Step Test[2]:

$$Body\ fitness\ level = \frac{(HST\ time \times 100)}{2x(pulse\ 1 + pulse\ 2 + pulse\ 3)} \qquad (1)$$

HST : respondent HST time (in seconds)
Pulse 1 : Pulse rate in the first one minute when resting for 3 minutes (bpm)
Pulse 2 : Pulse rate in the second one minute when resting for 3 minutes (bpm)
Pulse 3 : Pulse rate in the third minute when resting for 3 minutes (bpm)
The results are analyzed by referring to the fitness test categories contained in Table 1.

Table 1. Body Fitness Categories.

Excellent	Above Average	Average	Below Average	Poor
≥90	80-89	65-79	50-64	≤55

The initial aerobic fitness level will be used to compare with the respondents' aerobic fitness after climbing stairs treatment to determine the effect of climbing stairs exercise on cardiovascular endurance. After the initial aerobic fitness level of potential respondents is measured, the next stage is selecting respondents, considering the respondent's aerobic fitness level results. Respondents with aerobic fitness levels outside the poor range will not be selected for treatment.

The pre-treatment stage took a sample of 5 respondents. Pre-treatment was carried out by going up seven floors of stairs in the P Building at Petra Christian University. Pre-treatment was conducted to determine the respondent's adequacy limit for climbing stairs during treatment. The training zone limit used is 70% (aerobic zone). The training zone is a limit for carrying out exercises that must be achieved by paying attention to the maximum heart rate. The maximum heart rate is calculated as a function of age, which is 220 – age [13].

The treatment stage was conducted on 28 respondents. The treatment carried out was climbing the stairs in Building P at Petra Christian University for five floors. Treatment was carried out for a month for each respondent. Respondents were divided into two different groups. In the first group, respondents underwent treatment five times a week with one

treatment per day. The second group did it six times a week with two treatments per day. The experiment aimed to observe the effect of climbing stairs on aerobic fitness levels and compare the aerobic fitness levels between two groups of respondents. The post-treatment aerobic fitness level is also measured by using HST. This post-treatment measurement result will be compared with the initial one. Data was analyzed using a paired-T test and 2-Sample T with Minitab software.

Humans need energy as a power source to carry out daily activities—energy results from the metabolism of food (carbohydrates, proteins, and fats). Energy intake must be the same as energy expenditure. When the energy intake is greater than the energy expenditure, then it will be accumulated as fat. On the contrary, when the energy intake is lower than the energy expenditure, fat will burn. Energy expenditure when doing physical activity can be calculated using the following regression equation [14]:

$$MWR = -1967 + 8.58\ HR + 25.1\ HT + 4.5\ A - 7.47\ RHR + 67.8\ G \quad (2)$$

MWR : Metabolic Work Rate (W)
HR : working heart rate (bpm)
HT : height (inches)
A : age (years)
RHR : resting heart rate (bpm)
G : 1 = female, 0 = male

The amount of energy expenditure calculated will be categorized based on workload categories. Table 2 shows energy expenditure categorization based on workload categories [15].

Table 2. Energy Expenditure Categorization.

Physiological Load	Oxygen Consumption (l/min)	Calorie Quantity (Kkal/min)	Rectal Temperature (°C)	Heart Rate (bpm)
Very Low	<0.5	<2.5		<75
Low	0.5-1	2.5-5		75-100
Moderate	1-1.5	5-7.5	37,5-38	100-125
High	1.5-2	7.5-10	38-38,5	125-150
Very High	2-2.5	10-12.5	38,5-39.5	150-175
Extremely High	>2.5	>12.5	>39.5	>175

3 Result and Discussion

3.1 Respondent

Potential respondents were 31 male students at Petra Christian University aged 20-22, who did not smoke and had not exercised in the last six months. Respondent selection was based on Body Mass Index (BMI) values and aerobic fitness levels. Of the 31 potential respondents, there were three respondents whose BMI values were not in the same category as the other respondents. The Body Mass Index (BMI) determined for each respondent is in the range 18.5-29.9, where this range falls into the normal and overweight categories. Therefore, the respondents in this study were 28 people with poor aerobic fitness level. The respondents' BMI and initial aerobic fitness levels can be seen in Table 3.

Table 3. Respondent' BMI and Initial Aerobic Fitness Level.

Respondent	BMI	BMI Category	Initial Aerobic Fitness Level	Initial Aerobic Fitness Category
1	24.22	Normal	17.27	Poor
2	25.95	Pre-obesity	18.74	Poor
3	19.84	Normal	41.34	Poor
4	24.24	Normal	26.52	Poor
5	21.30	Normal	25.76	Poor
6	22.46	Normal	20.53	Poor
7	28.41	Pre-obesity	22.78	Poor
8	18.69	Normal	27.57	Poor
9	27.76	Pre-obesity	21.19	Poor
10	26.14	Pre-obesity	21.22	Poor
11	21.22	Normal	32.34	Poor
12	24.98	Pre-obesity	30.06	Poor
13	25.26	Pre-obesity	24.93	Poor
14	25.95	Pre-obesity	22.80	Poor
15	28.01	Pre-obesity	21.88	Poor
16	23.23	Normal	21.14	Poor
17	26.72	Pre-obesity	22.11	Poor
18	21.01	Normal	21.04	Poor
19	22.84	Normal	27.92	Poor
20	23.03	Normal	25.13	Poor
21	22.53	Normal	26.89	Poor
22	26.89	Pre-obesity	32.25	Poor
23	26.37	Pre-obesity	30.27	Poor
24	24.77	Normal	29.38	Poor
25	20.07	Normal	26.52	Poor
26	23.18	Normal	30.41	Poor
27	22.18	Normal	20.63	Poor
28	26.71	Normal	22.68	Poor

3.2 Pre-Treatment

The training zone is the limit for respondents to carry out an exercise. The aerobic training zone in this study ranged from approximately 140 bpm. The training zone results will be a limitation in determining the number of floors to complete treatment. Five respondents were selected to carry out pre-treatment. Table 4 is the result of measuring the heart rate of 5 respondents when climbing stairs.

Table 4. Respondent Heart Rate During Pre-Treatment.

Respondent	Floor							
	P0	P1	P2	P3	P4	P5	P6	P7
A	-	-	-	136 bpm	146 bpm	147 bpm	147 bpm	149 bpm
B	-	-	-	133 bpm	141 bpm	145 bpm	148 bpm	154 bpm
C	-	-	-	127 bpm	134 bpm	140 bpm	144 bpm	147 bpm
D	-	-	-	136 bpm	137 bpm	143 bpm	146 bpm	151 bpm
E	-	-	-	129 bpm	133 bpm	140 bpm	143 bpm	150 bpm

From Table 4, respondent's aerobic training zone was reached after the respondent reached the 5th floor. Therefore, during treatment, the respondent would only carry out the activity of climbing the stairs to the 5th floor.

3.3 Climbing Stairs Treatment

Respondents who have passed the selection will undergo climbing stairs treatment. Respondents will be divided into two groups to carry out treatment. The first group of respondents will climb the stairs five times in a row for a week. The second group of respondents will climb the stairs six times a week, but the respondents must carry out the activity of climbing stairs two times in 1 day. They will be given a break of 1 day so that respondents do not do it thrice in a row for each week. All groups of respondents will have one month of treatment. The purpose of dividing respondents based on the number of treatments is to determine the number of more significant treatments for improving aerobic fitness. The number of respondents who did the climbing stairs five times a week was 14 people, and the number of respondents who did the climbing stairs six times was 14. Treatment is done by climbing the stairs from the basement to the 5th floor of building P, Petra Christian University. The condition for the treatment is that the respondent must climb the stairs relaxed and unhurriedly. Respondents are also not allowed to bring anything that could burden them during treatment. The respondent's heart rate and recovery heart rate will be measured and used to calculate the metabolic work rate (MWR).

Table 5. Aerobic Fitness Level Comparison.

Respondent	Treatment (in a Week)	Initial Aerobic Fitness Level	Post Treatment Aerobic Fitness Level
1	5 times	17.27	24.33
2	5 times	18.74	20.18
3	5 times	41.34	**56.11**
4	5 times	26.52	29.61
5	5 times	25.76	32.22
6	5 times	20.53	28.04
7	5 times	22.78	28.14
8	5 times	27.57	44.35
9	5 times	21.19	26.39
10	5 times	21.22	27.27
11	5 times	32.34	33.98
12	5 times	30.06	46.14
13	5 times	24.93	22.15
14	5 times	22.80	23.96
15	6 times	21.88	24.79
16	6 times	21.14	22.49
17	6 times	22.11	26.42
18	6 times	21.04	39.20
19	6 times	27.92	**59.21**
20	6 times	25.13	48.80
21	6 times	26.89	39.43
22	6 times	32.25	36.47
23	6 times	30.27	32.29
24	6 times	29.38	24.38
25	6 times	26.52	37.05
26	6 times	30.41	49.40
27	6 times	20.63	19.25
28	6 times	22.68	29.58

After treatment, all respondents will complete a post-treatment HST to determine their aerobic fitness level. Table 5 compares the results of the initial aerobic fitness and the post-treatment aerobic fitness of the respondents.

Each treatment intensity will be analyzed using the paired t-test in Minitab software. This study's initial hypothesis (H0) is that aerobic fitness levels have no significant difference. The final hypothesis (H1) is that there is a significant difference in aerobic fitness levels. Figure 1 is the result of the paired t-test for the respondents who had treatment five times a week.

Paired T-Test and CI: Initial Aerobic Fitness; Post Treatment Aerobic Fitness

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
Initial Aerobic Fitness	14	25,22	6,28	1,68
Post Treatment Aerobic Fitness	14	31,63	10,33	2,76

Estimation for Paired Difference

Mean	StDev	SE Mean	95% CI for μ_difference
-6,42	5,85	1,56	(-9,80; -3,04)

μ_difference: mean of (Initial Aerobic Fitness - Post Treatment Aerobic Fitness)

Test

Null hypothesis H_0: μ_difference = 0
Alternative hypothesis H_1: μ_difference ≠ 0

T-Value	P-Value
-4,10	0,001

Fig. 1. Paired t-Test for Five Treatments a Week

The paired t-test results showed that the average initial aerobic fitness level was 25.22, and the average post-treatment aerobic fitness level was 31.63. There was an increase of 6.41. The p-value from the paired t-test results is 0.001, and by using a degree of accuracy (α) of 5%, it can be said that there is a significant difference between the level of aerobic fitness before and after the climbing stairs treatment in the group of respondents who had treatment five times in a week (H0 is rejected).

The paired t-test results for the group of respondents who had treatment six times a week, can be seen in Figure 2. The paired t-test results show that the average initial aerobic fitness level was 25.59, and the average post-treatment aerobic fitness level was 34.91. There was an increase of 9.32. The p-value from the paired t-test results is 0.005, and α equal to 5%, it can be said that there is also a significant difference between the level of aerobic fitness before and after climbing stairs in the group of respondents who did the treatment six times a week.

Paired T-Test and CI: Initial Aerobic Fitness_1; Post Treatment Aerobic Fitnes_1

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
Initial Aerobic Fitness_1	14	25,59	4,03	1,08
Post Treatment Aerobic Fitnes_1	14	34,91	11,63	3,11

Estimation for Paired Difference

Mean	StDev	SE Mean	95% CI for μ_difference
-9,32	10,40	2,78	(-15,33; -3,32)

μ_difference: mean of (Initial Aerobic Fitness_1 - Post Treatment Aerobic Fitnes_1)

Test

Null hypothesis	H_0: μ_difference = 0
Alternative hypothesis	H_1: μ_difference ≠ 0

T-Value	P-Value
-3,35	0,005

Fig. 2. Paired t-Test for Six Treatments a Week

The next analysis is to determine whether the treatment carried out by respondents five times a week and six times a week has a significant difference. This analysis was carried out using the 2-sample t-test in Minitab software. Tests using 2 sample t-tests were carried out using data on the post-treatment aerobic fitness level of each group of respondents. The initial hypothesis (H0) for this test is that there is no difference between the respondents who underwent treatment five times a week and those who underwent treatment six times a week. The final hypothesis (H1) for this test is that there is a difference between the group of respondents who underwent treatment five times a week and those who underwent treatment six times a week. Figure 3 is the test result using 2-sample t-test. The test results show that the p-value is 0.438, which means there is no difference between the group of respondents who underwent treatment five times a week and those who underwent treatment six times a week.

Two-Sample T-Test and CI: five times; six times

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
five times	14	31,6	10,3	2,8
six times	14	34,9	11,6	3,1

Estimation for Difference

Difference	95% CI for Difference
-3,28	(-11,84; 5,29)

Test

Null hypothesis	H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis	H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0,79	25	0,438

Fig. 3. Two Sample t-Test for Five Treatment vs Six Treatments a Week

Comparing respondents' initial and post-treatment aerobic fitness aims to determine the number of respondents who experienced an increase in their aerobic fitness category. The initial aerobic fitness category for all respondents was in the poor category. Table 5 compares respondents' initial and post-treatment aerobic fitness along with the aerobic fitness category of each respondent. Two respondents experienced an increase in the aerobic fitness category after undergoing treatment. The small number of respondents who experienced a rise in aerobic fitness was due to a lack of exercise. There needs to be more than 20 times to improve aerobic fitness for some people. This research is a continuation of previous research, which showed that the respondents did not experience an increase in aerobic fitness with 13 training adaptation times. The results of previous research also showed that there were no respondents who experienced an increase in their aerobic fitness category, in contrast to this study, where there were two respondents who experienced an increase in their aerobic fitness category with the number of exercises 20 times. It shows that increasing the amount of exercise will affect a person's aerobic fitness level.

3.4 Energy Expenditure

The Metabolic Work Rate (MWR) equation measures a person's energy consumption. Table 6 shows MWR calculation results for each respondent. The average MWR result is 5.7 kilocalories per minute.

Table 6. Respondents' Energy Expenditure.

Respondent	MWR (Watt)	Energy expenditure (Kkal/Minute)	Physiological Load
1	241,03	3,62	Low
2	490,75	7,36	Moderate
3	327,07	4,91	Low
4	169,75	2,55	Low
5	245,29	3,68	Low
6	404,73	6,07	Moderate
7	446,06	6,69	Moderate
8	460,64	6,91	Moderate
9	413,74	6,21	Moderate
10	527,57	7,91	High
11	243,38	3,65	Low
12	336,38	5,05	Moderate
13	410,91	6,16	Moderate
14	348,13	5,22	Moderate
15	369,04	5,54	Moderate
16	549,06	8,24	High
17	386,83	5,80	Moderate
18	435,72	6,54	Moderate
19	394,46	5,92	Moderate
20	442,99	6,64	Moderate
21	372,41	5,59	Moderate
22	396,43	5,95	Moderate
23	314,21	4,71	Low
24	365,94	5,49	Moderate
25	381,26	5,72	Moderate
26	372,02	5,58	Moderate
27	396,71	5,95	Moderate
28	487,34	7,31	Moderate

Based on physiological load category in Table 2, the average MWR value of respondents was in the moderate category, and six respondents were in the low category. The remaining respondents were in the moderate and heavy categories. This classification aims to find out what activities and sports are equivalent to the MWR value calculated when carrying out the stair climbing treatment.

A list of activities and sports and the energy required is in Table 7 [16]. The climbing stairs activity in this study releases 5.7-kilo calories of energy per minute. The energy is equivalent to walking at 3 kilometers per hour and cycling at 16 kilometers per hour. A sport that can be done besides walking and cycling is jogging at a speed of 7.2 kilometers per hour. The energy expenditure of jogging has the same moderate category.

Table 7. Energy Expenditure for Various Activities.

Physical Activities Other Than Manual Labor	**Energy Expenditure (Kcal/min)**
Resting (seated)	1.5
Standing (not walking)	2.2
Walking at 3 Km/hr (1.9 mi/hr)	2.8
Walking at 3 Km/hr (1.9 mi/hr)	4.0
Walking at 3 Km/hr (1.9 mi/hr)	5.2
Climbing stairs at 100 step/min	13.7
Jogging at 7.2 Km/hr (4.5 mi/hr)	7.5
Running at 12 Km/hr (7.5 mi/hr)	12.7
Cycling at 16 Km/hr (10 mi/hr)	5.2

4 Conclusion

Occupational health is essential for workers. Occupational health needs to be considered so that workers can work more productively. Several factors, including aerobic fitness, influence occupational health. The way to increase aerobic fitness is with exercise that trains the cardiovascular organs. Climbing stairs is an exercise that can be done while carrying out daily activities.

Climbing stairs treatment was given to 28 respondents. Respondents were divided into two groups: the group that underwent treatment five times a week and six times a week for one month. Before the respondent underwent the climbing stairs treatment, the respondent's initial aerobic fitness level was measured first. After the respondent received the climbing stairs treatment, the respondent's final aerobic fitness level was also measured. Aerobic fitness levels were measured using sub-maximum exercise, namely the Harvard Step Test method. When respondents carry out treatment, the amount of energy released by each respondent will also be measured.

All respondents experienced an increase in aerobic fitness, and two experienced a change in the aerobic fitness category from poor to below average. The results of this study are better than previous research, where in the previous study, there were no respondents who experienced a change in the aerobic fitness category. The portion of treatment given is similar between 5 times a week and six times a week. The average MWR result is 5.7 kilo calories.

Based on energy expenditure, daily climbing stairs until a person reaches 70% aerobic training zone is equivalent to walking at 3 kilometers per hour, cycling at 16 kilometers per hour, and jogging at a pace of 7.2 kilometers per hour.

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