The effect of body mass index and physical activity on recovery heart rate time post treadmill exercise

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Abstract. One important component of health-related physical fitness is cardiovascular-respiratory capacity. Cardiovascular-respiratory capacity can affect the recovery heart rate (RHR) time. RHR is the total pulse measured after a person has finished carrying out certain activities until return to resting heart rate (HRR). The aim of this study is to determine the effect of body mass index (BMI) and physical activity on RHR time post treadmill exercise. The research subjects were 39 healthy male students with an age range of 18-22 years who had been selected based on predetermined inclusion and exclusion criteria. Data was analyzed using descriptive statistics and multiple regression. The results of this study show that most students have high levels of physical activity (69.23%). The level of physical activity has a significant negative effect on the RHR time post treadmill exercise, but BMI has no effect on the RHR time post treadmill exercise. Thus, subjects who have a high level of physical activity require a faster RHR time.

1 Introduction

Physical fitness is a physiological state of well being to adapt with tasks or certain environmental state, which requires efficient and fatigue-free response, without the need to sacrifice readiness to perform upcoming tasks [1], [2]. Physical fitness is influenced by several factors, namely age, genetic, nutrition status, health status, sleep quality, healthy lifestyle, and physical activity [3], [4], [5], [6], [7]. There are several important components in physical fitness, one of which is cardiovascular endurance. Cardiovascular endurance reflects one's overall quality of cardiovascular health condition.

Cardiovascular endurance triggers physiological transformations of the body, one of which is reduced RHR. RHR is the total pulse measured after completing certain activities until it returns to the resting heart rate (HRR). RHR post-exercise reflects cardiovascular fitness and the existence of any disorder on someone's heart [8]. The reduction of RHR on someone performing lifestyle involving regular physical activity will be more accelerated than someone performing sedentary lifestyle [9], [10]. Other studies furthermore explain that people with normal BMI possess faster RHR reduction rate than obese [11], [12].

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Several previous studies have pointed out that both BMI and physical activity lifestyle are related to RHR reduction rate. Nevetheless, researchers have yet to explore the influence of energy expenditure rate exerted during daily physical activities towards RHR. Also, in previous studies, RHR data was usually taken for 3 - 5 minutes only; whereas in this study, RHR data is taken until the heart rate returned to the resting heart rate (HRR) before activity. Thus, the variable used in this research is the RHR time.

The physical activities in this study refer to activities performed while working, travelling to and from workplace, and on leisure activities [13]. In this research, physical activity is measured by Metabolic Equivalent (MET) supported by Global Physical Activity Questionnaire (GPAQ), which was developed by WHO, as the instrument. MET is a metric used to estimate exerted energy while performing physical activity [14].

This research is conducted to investigate the influence of BMI and physical activities towards RHR time post treadmill exercise, therefore explains whether both BMI and physical activity possess any impact on someone's heart health. The use of treadmill exercise is based on the previous researchs which similarly adopts treadmill. It also belongs to one of the popular methods in measuring cardiovascular endurance.

2 Methods

This research adopts experimental research methods to investigate the influence of both physical activity and BMI on RHR time. Therefore, physical activity, BMI, and RHR time are the variables investigated in this research.

RHR time serves as the dependent variable. RHR is the the total pulse rate measured after completing certain activities until it returns to the resting pulse. The measurement of RHR is started when the subject has just finished the treadmill exercise until his pulse returns to the resting pulse before treadmill exercise. Resting heart rate is measured for 3 minutes with 10 seconds intervals within, then the highest and the lowest value are recorded. When RHR data is on the range within the highest and the lowest resting heart rate (HRR), RHR measurement will be stopped and recorded as the RHR time of the subject.

The independent variable of this research will be both physical activity and BMI. Physical activity is a motion performed by the bodily muscles and their supports. Physical activity is performed by using Global Physical Activity Questionnaire (GPAQ) as the instrument. There are 16 questions involving three essentials: workplace activity, travel activity, and recreational or leisure activity performed in a week [15]. Sitting still is equivalent to 1 MET, medium activity with 4 MET, and high activity with 8 MET [16]. The result of GPAQ measurement is classified into three categories: high (performing high physical activities for 3 days minimum with minimum intensity of 1500 MET-minute/week or performing a combination of high, medium, and walking activities in 7 days with minimum intensity of 3000 MET- minute/week); medium (performing physical activity with minimum 20 minutes/day for 3 days or more, or performing medium physical activity for 5 days or more, or walking with minimum 30 minutes/day, or a combination of high, medium, and walking activities for 5 days or more with minimum intensity of 600 MET-minute/week); and low (any activity does not meet the criteria set for both high and medium activities). Body Mass Index (BMI) is a metric to measure one's nutritional status obtained from the comparison between bodyweight and height. Excessive BMI, where the comparison value lies above the preset benchmark, is categorized as an unfavorable condition.

The population of this research are the male students at Petra Christian University with good health, and currently within 18-22 years old. Purposive sampling is adopted as the subject of the research and has already been predestined based on the criteria of inclusion and exclusion. Inclusion criteria is criteria to select respondent candidate. Inclusion criteria used in this study are male healthy students without any medical record (heart, lung, liver, diabetes, hypertension, infectious diseases, and muscle trauma), not consuming alcohol and smoking. Exclusion criteria is criteria set during treadmill exercise day and aimed to determine whether someone is eligible to perform the exercise on the day. If a subject is short of the criteria on the day, the exercise will be rescheduled. If the subject failure on the next appointment, the subject will not be taken as the respondent. Exclusion criteria set for this study are the subject should not be consuming any medication in the last 24 hours, not drinking coffee in the last 6-8 hours, sleeping for 7-9 hours, and possess <10 systole – diastole difference from right and left hands.

Pre-testing activity is performed to determine treadmill exercise intensity of each of the subjects. This is intended to establish homogeneous exercise dose on each of them, thus the result of the study will not be affected by exercise intensity differences received by each of them. For health exercise, exercise intensity is given between 60% - 80% from the maximum pulse (220 – age), continuously for minimum 10 minutes [17]. This is becoming the base in determining treadmill exercise speed. Based on the pre-testing result, treadmill speed is divided into 4 phases (including both warming up and cooling down phases). The first phase is performed for 3 minutes at 3 km/h speed, then continued by the second phase at 4.5 km/h speed for another 3 minutes. Third phase is performed on 6.5 km/h speed for 3 minutes, and the final phase on 3 km/speed on 1 minute. Collected data involve age (year), BMI (kg/m2), physical activity score on MET-minute /week, Metabolic Rate (MWR) in kcal/min is measured by regression equality from Kamalakannan et al. [18], HRR (pulse/min), Working Heart Rate (HRW), RHR (pulse/min), and RHR time (minute). HRR, HRW, and RHR are measured by using heart rate monitor. Before performing treadmill exercise, the subject is requested to rest and relax in a seated postur. HRR data is obtained when the respondents' pulse is in stable condition. The data is recorded in every 10 seconds, for a total of 3 minutes. Afterwards, the subject is asked to perform treadmill exercise for 10 minutes as arranged on the exercise dose previously explained, where the HRW data is recorded in every 10 seconds. After finished, the subject will be asked to sit, and this is when the RHR data is recorded. The RHR data is recorded in every 10 seconds and will be stopped if the RHR data is between the range of the highest and the lowest recorded HRR. The duration of pulse recovery time will be perceived as the subject's RHR time. MWR calculation is also performed post treadmill exercise.

3 Results and Discussion

3.1 Respondents' Profile

Based on both inclusion and exclusion criteria; 39 healthy males, within 18-22 years old have participated in this study. Among those, 21 (53.85%) have normal BMI and 18 (46.15%) have overweight and obese BMI. Most subjects (69.23%) perform relatively high physical activity (≥ 3000 MET-minute/week) and 30.77% perform medium physical activity. Based on the value of MWR, subjects performing low physical activity are in amount of 58.97%, medium to high physical activity in amount of 33.33%, and extremely low activity in amount of 7.7%. Table 1 displays descriptive characteristics of the subjects.

Table 1. Respondents' Profile

Characteristics	Mean ± SD	Range
Age (year)	20 ± 2	18 – 22
Weight (kg)	79 ± 33	46 – 112

Height (m)	1.76 ± .16	1.6 – 1.92
BMI (kg/m2)	25.02 ± 3.97	16.9 – 36.72
MWR (kcal/min)	4.29 ± 1.5	1.87 – 7.19
Physical Activity (MET-minute/week)	4037 ± 1493.46	1040 - 6720

As displayed in Table 1, subjects are on average 20 years old with BMI in amount of 25.02 kg/ m2 (normal category). Treadmill exercise is performed within the low category (4.29 kcal/min) and physical activity level lies within the high category.

3.2 Comparison Testing

The result of this study points out that subjects with RHR time varying within 3-18 minutes with the average of 9.33 ± 3.29 minutes, perform high physical activity with the average of 4037 ± 1493.45 MET-minute/week, and low workload with the average MWR in amount of 4.29 ± 1.5 kcal/min. In addition, the percentage of the subjects with normal and excessive BMI are relatively the same. Previous researchs has stated that people with normal BMI tend to possess a more accelerated RHR reduction rate than obese. Therefore, prior to the regression analysis, comparison testing was performed by using independent T-test samples to observe whether there is a difference in the RHR time, physical activity, and MWR between subjects with normal and excessive BMI.

Table 2. Comparison Testing

Characteristics	**Sig.**
RHR Time	.554
Physical Activity	.55
MWR	.001*

$^{*}p < .05$

Based on Table 2, significant BMI difference is only observed in the MWR (*p-value* < .05). The result of MWR - BMI comparison points out that subject with normal BMI has relatively low workload category. Thus, regression analysis is divided into three classifications: based on the normal BMI (model I), excessive BMI (model II), and BMI as a whole (model III).

3.3 Regression Analysis

A model is seen as fit if it has low prediction failure. Therefore, prior to being used, regression model needs to pass identical result, independence, and normality testings performed towards the residual of existing data. In addition, multicollinearity testing needs to be performed as well in order to investigate whether correlation exists between independent variables (BMI and physical activity) within the regression model.

Based on the statistical testing, the regression model displaying physical activity and BMI on RHR time has fulfilled the requirements. In order to find out whether the model can be used to predict the dependent variable, namely RHR time, ANOVA or F-Test is used. The result of ANOVA testing on model I, II, and III can be seen on Table 3-5. Based on the tables, *p-value* (.000) is lower than α-value (.05), therefore it can be concluded that the model can be utilized to predict RHR time post treadmill exercise.

Table 3. ANOVA Testing Result for Model I

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	183.379	2	91.689	17.173	.000*
Residual	96.102	18	5.339		
Total	279.481	20			

$^{*}p < .05$

Table 4. ANOVA Testing Result for Model II

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	95.019	2	47.509	21.167	.000*
Residual	33.667	15	2.224		
Total	128.686	17			

$^{*}p < .05$

Table 5. ANOVA Testing Result for Model III

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	275.720	2	137.860	36.392	.000*
Residual	136.375	36	3.788		
Total	412.095	38			

$^{*}p < .05$

T-testing is performed to reveal the significance of both constant and independent variables, respectively in this research, physical activity, and BMI. Table 6-8 points out physical activity variable as the mere significant variable (p-value < .05) for all regression models. Thus, it can be concluded that physical activity variable possesses a negative significant impact on RHR time for normal, excessive, and all BMI categories. The higher the level of physical activity, the less time is required for the RHR.

Table 6. Output Result for Regression Model I

Model	Coefficients	Sig.	R-Square	Adjusted R-Square
(Constant)	21.835	.006*		
BMI	.210	.479	.656	.618
MET	-.002	.000*		

$^{*}p < .05$

Table 7. Output Result for Regression Model II

Model	Coefficients	Sig.	R-Square	Adjusted R-Square
(Constant)	12.284	.002*		
BMI	.146	.232	.738	.703
MET	-.002	.000*		

*$p < .05$

Table 8. Output Result for Regression Model III

Model	Coefficients	Sig.	R-Square	Adjusted R-Square
(Constant)	15.707	.000*		
BMI	.035	.667	.669	.651
MET	-.002	.000*		

*$p < .05$

In order to determine how well a dependent variable can be explained by its independent variable, the value of adjusted r-square on each of the regression model needs to be performed. On Table 6-8, the value of adjusted R-square varies between 61.8 – 70.3%. This shows that the variance of RHR time can be predicted more accurately by the variance of physical activity and BMI.

3.4 Analysis

Cardiovascular-respiratory capacity refers to heart ability in pumping blood, lung's ability to perform respiratory process (inhale and exhale), and muscle contraction continuously for a period of time without severe exhaustion and lengthy recovery time. This endurance capacity is essential to support the muscular system in obtaining oxygen and distributing it to all active muscle tissue, thus producing better metabolism. The result of this study reveals that RHR time, as one of the indicators of cardiovascular-respiratory capacity, is influenced by the level of physical activity exerted, not BMI.

MWR comparative test has revealed energy expenditure difference between normal and excessive BMI; however, the result of the regression analysis points out that BMI possesses no influence towards RHR time. This can be observed from low BMI coefficient score (.035 - .21) as seen in Table 6-8. This result is a reverse from the previous study pointing out that BMI influences RHR reduction rate [11], [12]. This study, however, confirms the result of other studies pointing out the absence of BMI influence on physical fitness level [19]. Theoretically, good nutritional status has an impact on better physical fitness level, as someone would have sufficient energy to perform daily activities without severe exhaustion. Nevertheless, the result of this study points out that BMI does not possess any influence on physical fitness.

Sport is a physical activity which is performed regularly and systematically, will influence all components of health-related physical fitness [2]. Despite someone having a normal BMI, if no physical activity is performed regularly and systematically, physical fitness (especially cardiovascular-respiratory capacity) is a no guarantee. Therefore, both nutritional quality and high physical activity (achieved by doing sport) must all be performed in order to improve cardiovascular-respiratory capacity. This is supported by the result of this study, as it points to that higher physical activity level may influence cardiovascular-respiratory capacity as shown in the RHR time.

4 Conclusion

The result of this study points out that physical activity possesses an impact towards HRR time post exercise. This study has also pointed out that BMI possesses no impact on HRR time post exercise. Someone having a high level of physical activity will be having better cardiovascular-respiratory capacity, one of the essential components of health-related physical fitness. Therefore, it can be concluded that people with a higher level of physical activity will also have better physical fitness.

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