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Affect of Different Intensities of Queens College Step Tests on Cardiopulmonary Function and Body Composition in Students

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ABSTRACT

Objective: The purpose of this study is to evaluate the effects of Queens's college step test on cardiorespiratory endurance and body composition during aerobic exercise, and to find out the difference when the interval is modified.

Method: Amongst thirty apparently healthy college students, fifteen were randomly assigned to a group (QCST) performing a normal Queens College step test and another fifteen were randomly assigned to a group (mQCST) performing a Queens college test with modified interval. The experiment was conducted three times a week for four weeks.Findings: Both groups showed positive enhancement in overall cardiorespiratory function and body composition after the experiment. In the QCST group compared to mQCST, there was an increment of 3.90% in FEV_1 . In the mQCST group compared to QCST group, there was a superior improvement of 1.01% in skeletal muscle mass and 2.41% in body fat percentage.

Improvements: A short-term experiment was conducted in randomly assigned groups that did not achieve uniform matching where confounding bias cannot be excluded. Future findings for long-term experiments may include further positive outcomes of cardiorespiratory endurance and body composition changes in the mQCST group.

Keywords: *Queen's college step test, Cardiorespiratory function, Body composition, aerobic capacity, interval training*

Introduction

The essential life supporting organs of the human being are the heart and lung that are closely related anatomically and connected throughout multiple vessels. Therefore, the failure of the lung can lead to drastic physiological impacts on the heart, which in turn may result in additional end organ failures. Hypoxia is the key mechanism of in which the imbalance of physiological homeostasis throughout the cells lead to apoptosis or necrosis and eventually organ failure. Cor pulmonale is where chronic lung diseases can cause heart failure as the chronic state of hypoxia causes the pulmonary vascularity to constrict and lead to persistent pulmonary hypertension. Pulmonary hypertension exerts pressure on the right ventricle causing right ventricular hypertrophy and dilatation. The pressure overload on the right ventricle deviates the ventricular septum to the left ventricle which eventually decreases the cardiac output. Overall cardiac function decreases as a consequence of the chronic state of lung diseases. Therefore, the relationships between cardiac and pulmonary functions cannot be overestimated and plays an essential role in maintaining the physiological homeostasis and life support.

Monitoring the cardiorespiratory endurance by evaluating the medical status of the patient and determining the factors for the continuous monitoring is the most important step prior to treating the patients with cardiorespiratory diseases. The measurement of cardiorespiratory endurance generally includes exercise stress test with additional radiological evaluations such as computed tomography, X-ray, and ultrasonography. In patients who can endure the strain from the test, maximal exercise test is used to measure the maximal

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functional capacity while submaximal exercise test can be implicated on patients having limits to execute maximal functional capacity. Compared to maximal exercise testing, submaximal exercise testing maybe less accurate due to the indirect calculations of the physical capacity and the oxygen consumption through the peak VO2. However, due to safety concerns, efficiency over equipment, cost, management, and time are the reasons the submaximal exercise testing is favored.

The submaximal exercise testing utilizes treadmills, bicycles, and step box or walking to measure the physical capacity. Although the Bruce treadmill protocol exploits the running machine to measure the maximal VO2 of athletes or healthy subjects, it can also be modified for patients with chronic diseases and the old [1,2,3]. Balke treadmill protocol, Noughton protocol, McHenry protocol, Kattus protocol are the modified versions of Bruce treadmill protocol which produces a sufficient level of exercising stress without physiological or biomechanical strain and can be implicated to people with various functional limitations and disabilities and older adults. The strain is leveled out based on the functional capacity of the individual [4]. Submaximal bicycle ergometer tests include Astrand-Ryhming nomogram and YMCA submaximal bicycle test although treadmill tests are preferred [5,6].

The prior exercise stress tests require specific equipment in contrast to walk tests and step tests which has less constriction and holds convenience. Especially, step tests take less space and the short duration makes it convenient compared to other exercise stress tests. Harvard Step Test requires the individual to step up onto, and back down from the 50.8 cm high step at a rate of 30 completed steps per minute (one second up, one second down) for 5 minutes or until exhaustion. Similar tests include YMCA 3-minute Step Test, The Canadian Home Fitness Step Test, Chester Step Test, Sharkey (Forestry) Step Test, and Queens college step test [7, 8]. Queens college step test is the modified version of Harvard step test where the individual steps up and down on the 41.3 cm platform at a rate of 22 steps per minute for females and at 24 steps per minute for males [8]. The individuals are to step using a four-step cadence, 'up-up-down-down' for 3 minutes duration. The athlete stops immediately on completion of the test, and the heart beats are counted for 15 seconds from 5-20 seconds of recovery. This short duration and less strain make the Queens college step test the preferable exercise stress test.

Exercises used in step tests can be converted into an efficient aerobic exercise and this type of regular aerobic exercise can improve cardiorespiratory endurance and metabolism of an individual which can be beneficial to rehabilitating chronic cardiovascular patients [9,10]. According to several meta-analysis and case studies, aerobic exercise has been proved to benefit stroke, Parkinson's disease, dementia, chronic cardiac failure, and chronic obstructive pulmonary disease [11-16]. Therefore, aerobic exercise proves to be an essential tool to physical therapists. However, when conducting exercise stress tests upon patients, additional management and assistance maybe required as well as standardized criteria for the evaluation of functional capacity. Submaximal exercise test is what meets those requirements to evaluate functionally limited patients without physiologic or biomechanical strain in a safe and efficient manner.

Recently, interval training methods such as altering the intensity and frequency of the exercise in aerobic exercising has become popular. Studies suggest applying interval training can improve insulin sensitivity, decrease systolic blood pressure, and increase maximal oxygen consumption in obese patients or over-weighted men [17]. There was also an increase in maximal oxygen consumption in patients with myocardial infarction and improvement of physical capacity and peripheral vascular function in patients with acute coronary disease [18]. There was also an enhancement in myocardial function with effects of decreasing blood pressure in patients with hypertension [19]. Therefore, interval training can be considered as to have an overall health benefit in cardiovascular function as well as lowering body fat.

Our study is aimed to clarify the impact of Queens college step test on cardiorespiratory endurance and body composition when conducted as means of aerobic exercise and in addition to evaluate the differences when applying interval training into Queens college step test.

Table 1: Initial Set of features used for the experimentation

	Value		
	mQCST(n=15)	**QCST(n=15)**	**t**
Gender	Male n = 7	Male n = 6	0.71
	Female n = 8	Female n = 9	
Smoking	Male n = 2	Male n = 1	0.28
	Female n = 1	Female n = 0	

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Age (year)	20.8 ± 3.57	20.87 ± 3.87	0.049
Height (cm)	167.4 ± 7.3	165.2 ± 7.23	-0.829
Weight (kg)	64.36 ± 10.8	63.24 ± 15.9	-0.226

Values indicate mean ± standard deviation, *p<0.05, mQCST : Group performing Queens college test with modified interval, QCST : Group performing Queens college step test

Figure 1: Queens college step test exercise A-E

Method

Total of thirty healthy college students who do not have or were treated for cardiovascular diseases, do not have orthopedic related diseases or were not undergo surgery from the same socioeconomic background, having age range from nineteen to thirty one were recruited for the study on basis of random sampling from Asan, Republic of Korea. The experimental protocol was fully explained to participants and the research was based on agreement of every single participant. Table 1 shows the physical features of the subjects.

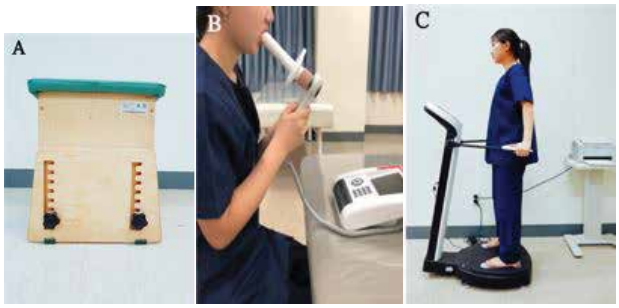

Figure 2: Measurement A) Step box B) Spirometry C) Bio Impedance assessment compare

Research Method: Amongst thirty subjects, fifteen were randomly assigned to a group (QCST) performing a normal Queens college step test and another fifteen were randomly assigned to a group (mQCST) performing a Queens college test with modified interval. In both groups, individuals stepped up and down on a 41.3 cm platform. The subjects were to step using a four-step cadence, 'up-up-down-down' for 3 minutes per repetition which was conducted three times a week for four weeks Figure 1 A-E. Subjects were put to rest for 5 minutes after each repetition.

In the QCST group the subjects stepped at a rate of 88 beats per minute for females and at 96 beats per minute for males. In the mQCST group the subjects stepped in three different stages of intensities for three minutes, one minute for each phase. For females, moderate intensity at a rate of 88 beats per minute for one minute, high intensity at a rate of 108 beats per minute for one minute, and mild intensity at a rate 68 beats per minute for one minute. For males, moderate intensity at a rate of 96 beats per minute for one minute, high intensity at a rate of 116 beats per minute for one minute, and mild intensity at a rate 76 beats per minute for one minute. This research was performed under the approval of Institutional Review Board (IRB) at Sunmoon University (SM-201804-024-1)

Data Analysis: In this research, descriptive statistics were used in order to analyze the mean and standard deviation (SD) of each variable. Statistical analysis was conducted through SPSS/PC ver.22.0 for windows program (SPSS INC. Chicago.IL). Reliability and validity were measured using independent samples t-test and paired samples t-test. Independent samples t-test was used to compare measurements between group performing Queens college test with modified interval and group performing Queens college step test. Paired samples t-test was used for the post hoc analysis and the statistical valid level was set to p<0.05. The overall research process is shown in Figure 3.

Result and Discussion

In the QCST group compared to mQCST, FEV_1 was improved by 3.90 %. In the mQCST group compared to QCST group, there was a greater improvement of 1.01% in skeletal muscle mass and 2.41% in body fat percentage, indicating a significant change in body composition when performing mQCST and respiratory function improvement when performing QCST. In the QCST group, body fat percentage improved from 24.64% to 23.51%, FEV_1 increased from 2.85% to 2.96% (p<0.05). But skeletal muscle mass, body fat mass, BMI, waist-hip Ratio, visceral fat percentage, obesity degree, FVC (L), FEV_1 /FVC (%), FEV_1 / FVCp (%), PEF (L/sec), PEF (%) were not significant

differences before and after($p>0.05$). In the mQCST group, skeletal muscle mass increased from 26.9% to 27.53%, body fat percentage decreased from 28.07% to 27.46% ($p<0.05$). But body fat mass, BMI, waist-hip Ratio, visceral fat percentage, obesity degree, FVC (L), FEV_1 (L), FEV_1 (%), FEV_1 /FVC (%), FEV_1 / FVCp (%), PEF (L/sec), PEF (%) showed no reliable differences before and after($p>0.05$) in Table 2, Table 3.

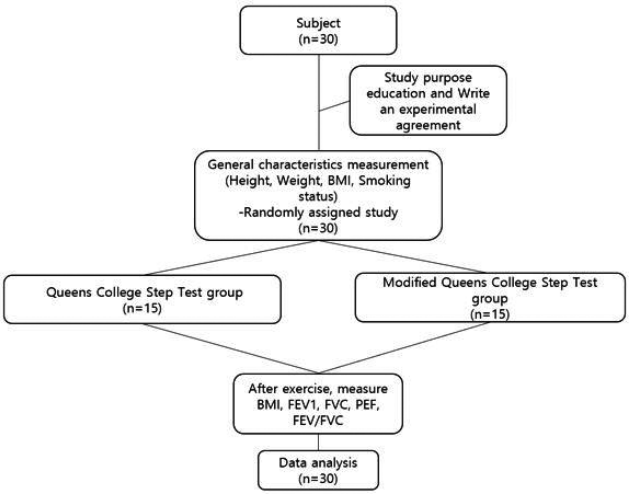

Figure 3: Flow diagram of subject experimental protocol

This study was to evaluate the comparison of cardiorespiratory endurance and body composition based on the implication of interval training in mQCST group and the QCST group. Current studies propose the functionality of submaximal exercise tests to predict the heartrate, blood pressure and maximal oxygen capacity, however, there are few studies that propose these tests as means of aerobic exercise [9]. Submaximal exercise tests include Rockport 1mile walk test or 1mile jogging test, modified Bruce treadmill test, single stage submaximal treadmill walk test, YMCA submaximal bicycle test, Queens college step test, and 6 minute walk test. Amongst numerous submaximal exercise tests, Queens college step test is the most standardized test widely used and provides advantages in terms of safety, cost, efficiency, convenience, and time [20]. Therefore, this study selected Queens college step test as a method of exercising and contrasts it with the modified interval training in various aspects.

Table 2: Bio Impedance assessment compare

		mQCST (n = 15)	QCST (n = 15)	t
Skeletal Muscle Mass (kg)	Pre	26.9 ± 6.6	24.8 ± 6.7	-0.86
	Post	27.53 ± 6.7	25.13 ± 6.68	-0.98
	t	-3.12*	-2.12	
Body Fat Mass(kg)	Pre	15.81 ± 7.58	18.21 ± 9.38	0.77
	Post	15.13 ± 7.36	17.77 ± 9.15	0.87
	t	1.83	1.48	
BMI (kg/ m^2)	Pre	22.91 ± 3.21	22.97 ± 4.6	0.04
	Post	23.01 ± 3.34	22.98 ± 4.45	-0.02
	t	-1.07	-0.15	
Body Fat Percentage (%)	Pre	28.07 ± 9.64	24.64 ± 10.08	0.95
	Post	27.46 ± 9.4	23.51 ± 9.65	1.13
	t	2.47*	1.40*	
Waist-hip Ratio (%)	Pre	0.83 ± 0.03	0.86 ± 0.06	1.49
	Post	0.82 ± 0.03	0.85 ± .0.06	1.59
	t	1.13	1.00	
Visceral Fat Percentage	Pre	6.27 ± 4.1	7.60 ± 4.90	0.81
	Post	5.73 ± 3.71	7.20 ± 4.91	0.92
	t	2.09	2.10	
Obesity degree (%)	Pre	106.67 ± 14.90	107.4 ± 20.96	0.11
	Post	107.07 ± 15.41	107.47 ± 20.21	0.06
	t	-1.0	-0.15	

Conted…

Table 3: Comparison of respiratory function between mQCST and QCST

		mQCST (n = 15)	QCST (n = 15)	t
FVC (L)	Pre	3.74 ± 0.73	3.21 ± 0.76	-1.94
	Post	3.72 ± 0.71	3.38 ± 0.81	-1.22
	t	0.24	-1.90	
FEV_1 (L)	Pre	3.15 ± 0.66	2.85 ± 0.61	-1.29
	Post	3.15 ± 0.64	2.96 ± 0.64	-0.82
	t	0.08	-2.20*	
FEV_1 (%)	Pre	87.47 ± 13.02	81.47 ± 13.23	-1.25
	Post	91.0 ± 12.95	85.60 ± 13.05	-1.14
	t	-0.80	-2.84*	
FEV_1/ FVC (%)	Pre	83.87 ± 7.34	88.80 ± 5.81	2.04
	Post	84.07 ± 6.90	87.6 ± 6.45	1.45
	t	-0.08	0.98	
FEV_1/ FVCp (%)	Pre	99.47 ± 8.57	105 ± 7.87	1.84
	Post	100.73 ± 7.22	103.87 ± 7.69	1.51
	t	-0.43	0.83	
PEF (L/ sec)	Pre	6.99 ± 1.62	6.62 ± 2.33	-0.51
	Post	6.98 ± 1.48	7.01 ± 2.15	0.04
	t	0.04	-1.48	
PEF (%)	Pre	83.13 ± 15.25	81.07 ± 19.68	-0.32
	Post	84.87 ± 15.89	85.20 ± 15.72	0.06
	t	-0.48	-1.33	

Results showed significant change in body composition when performing mQCST and respiratory function improvement when performing QCST as well as improvement of cardiorespiratory endurance and body composition after the experiment within each group. Olson et al suggest step tests facilitate loss of body fat and promote cardiovascular and metabolic responses [9]. Our study also lies with the results from prior studies in terms of improvement of metabolism and cardiopulmonary functionality.

Prior studies that implicated High Intensity Interval Training (HIIT) suggested improvements in pulmonary functional capacities. Wormgoor et al suggested the effects on reducing body fat and subcutaneous fat [21]. Our studies also comply to the previous studies in reducing body fat, increasing skeletal muscle mass, and reducing visceral fat level.

Limitations to this study are that control variables related to daily activity that may have an impact on the results were not controlled. The height of participants varied greatly compared to the standardized height of platform which produced measurement bias. Also, a short duration of four weeks of the study cannot be generalized into long term outcomes. Future studies require better control of control variables by either matching or through crossover studies to reduce confounding bias.

Conclusion

The purpose of this study was to evaluate the effects of Queens college step test on cardiorespiratory endurance and body composition during aerobic exercise, and to find out the difference when the interval was modified. Results implied improvement in body composition when performing mQCST and respiratory function when performing QCST in addition to improvement of cardiorespiratory endurance and body composition after the experiment within each group. This suggests that altering Queens college step test into various exercise programs by modifying intervals with HIIT can provide significant improvements in cardiorespiratory endurance and body composition.

Ethical Clearance: This research was performed under the approval of Institutional Review Board (IRB) at Sunmoon University (SM-201804-024-1)

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Conflict of Interest: Nil

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