Metabolic Equivalent of Exercise Stress Test Explained by Six-Minute Walk Test in Post Coronary Artery Bypass Graft and Post Percutaneous Coronary Intervention Patients

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Objective: *To investigate the relationship among metabolic equivalents of an exercise stress test (METs of EST), demographic parameters (age, body weight, height, BMI), peak oxygen consumption (VO_2 peak), and six-minute walk distances (6MWD) determined from a six-minute walk test (6MWT).*
Material and Method: *Exercise capacity was estimated by a 6MWT and EST at the sixth week post operation in post coronary artery bypass graft (post CABG, n = 17) and post percutaneous coronary intervention (post PCI, n = 13) patients.*
Results: *METs of EST showed: high correlation ($p<0.01$) with VO_2 peak of 6MWT ($r = 0.94$), 6MWD ($r = 0.92$); muscle strength ($r = 0.78$), moderate correlation ($p<0.01$) with height ($r = 0.53$); negative correlation with age ($r = -0.50$). Low correlation was found ($p<0.05$) with step length ($r = 0.43$), and weight ($r = 0.38$). No correlation was found among METs of EST and rating perceived exertion (RPE) of EST and 6MWT. The multiple linear regression equation for explaining METs of EST is as follows: METs of EST = -2.94+0.02 (6MWD), ($r = 0.923$, $R^2 = 0.85$, $p<0.001$).*
Conclusion: *The 6MWT may possibly be used as an alternative choice for estimating energy expenditure to design exercise programs for these post operation groups.*

Keywords: *Metabolic equivalents, Peak oxygen consumption, Post coronary artery bypass graft, Post percutaneous coronary intervention, Six-minute walk test*

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Thai patients with heart disease try to avoid exercising. They perceived that exercise might provoke angina, dyspnea, and dizziness; therefore, they prefer to stay in bed with minimal activities[1]. For this reason, physical abilities will be restricted. Even though some patients' angina subsides after medical treatment, their cardiac function may not be in stable condition and some physical activities are inappropriate for them[2-4]. The outcomes of physical activity tests in terms of metabolic equivalent are required in clinical aspects. Myers in 2006[5] and Pollentier in 2010[6] studied the relationship of 6MWT and VO_2 peak in chronic heart failure patients. Whereas, no study has been conducted of the relationship between METs of EST, VO_2 peak, and 6MWD by 6MWT and the use of the 6MWT in prediction METs of EST has not been established in post-revascularization of CAD patients. Therefore, the purposes of the present study were to determine the relationship between METs of EST and VO_2 peak, and 6MWD of a 6MWT and construct the regression

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equation of these parameters in post coronary artery bypass graft (postCABG) and post percutaneous coronary intervention (postPCI) patients.

Material and Method

Subjects were postCABG and postPCI with ages above 50 years, physical activity level in the New York Heart Association Functional Classification (NYHAFc) I-II. Exclusion criteria were those who had contraindication to exercise testing[7], neurological deficits and any musculoskeletal problems affecting walking ability. The subjects understood and signed the consent form approved by the Siriraj Hospital, Mahidol University Institutional Review Board (SiIRB) COA No. Si 342/2011.

Exercise capacity was estimated with 6MWT and EST at the sixth week post operation. VO_2 peak during 6MWT was measured using Vmax Encore portable metabolic testing (Oxycon mobile, VIASYS Respiratory Care Inc, USA), and EST was performed with modified Bruce protocol using treadmill Q-Stress exercise test monitor (Quinton Inc., USA). Quadriceps muscle strength of the dominant side was measured by the Nicholas Handheld Force Dynamometer (Lafayette Inc., USA). The dynamometer was placed at the anterior surface of the lower leg one to two inches above the ankle. The subjects extended their leg against the dynamometer with a maximum effort at 60° of knee extension.

Pearson's correlation and multiple regression were used to determine the relationship between demographics (age, weight, height, BMI) and functional capacity [VO_2 peak of 6MWT, 6MWD, percentage of the age-predicted maximal heart rate (%PMHR)] parameters. The coefficient values were classified as high ($r>0.7$) moderate ($0.5\leq r<0.7$) and low ($r<0.5$) correlations[8]. The equation model was developed for estimating energy expenditure for patients with postCABG and postPCI.

Results

Determination of the relationship among METs of EST, anthropometric parameters and functional capacity parameters

Subjects in the present study were post CABG (n = 17), and postPCI (n = 13) patients. The results revealed a high correlation between METs of EST and muscle strength ($r = 0.78$, $p<0.01$), VO_2 peak of 6MWT ($r = 0.94$, $p<0.01$) and 6MWD ($r = 0.92$, $p<0.01$). A moderate positive correlation was found between METs of EST and height ($r = 0.53$, $p<0.01$) and %PMHR ($r = 0.51$, $p<0.01$) but METs of EST correlated conversely with age ($r = -0.50$, $p<0.01$). In addition low correlation was found among METs of EST, step length ($r = 0.43$, $p<0.05$) and body weight ($r = 0.38$, $p<0.05$) (Table 1).

Multiple linear regression equations

The best multiple linear regression (highest R^2) equation was constructed from METs of EST, VO_2 peak of 6MWT and 6MWD: METs = -3.02+0.28 (VO_2)+0.01 (6MWD), $R^2 = 0.95$. The equation constructed from METs of EST and only 6MWD was METs = -2.94+0.02 (6MWD). The coefficient of determination, $R^2 = 0.85$, is recommended to be used in clinical practice because of its simplicity to estimate functional capacity of postCABG and postPCI patients by 6MWD only (Table 2).

Discussion

VO_2 peak of 6MWT and 6MWD are the best parameters that can be used to predict METs of EST (Table 1). Pollentier in 2010[6] studied 6MWT to determine functional capacity in chronic heart failure (CHF). The results showed that the 6MWT demonstrated moderate correlation with VO_2 peak and 6MWD. Myers and co-workers in 2006[5] measured functional and health status in CHF patients, and the results revealed that VO_2 peak was significantly related to METs from a treadmill ($r = 0.72$, $p<0.01$). The present

Table 1. Correlation among METs of EST, anthropometric and functional capacity parameters in postCABG and postPCI groups

Parameter	Age	Weight	Height	BMI	Muscle Strength	Step Length	VO_2 peak	6MWD	% PMHR
METs	-0.50**	0.38*	0.53**	0.07	0.78**	0.43*	0.94**	0.92**	0.51**

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed)
METs = metabolic equivalents of EST; BMI = body mass index (kg/m^2); VO_2 peak = peak oxygen consumption (ml/kg/minute); 6MWD = six-minute walk distance (meters); %PMHR = percentage of age-predicted maximal heart rate

Table 2. Regression analysis β-coefficients and R^2 to predict METs of EST

Model		β-coefficient	SD	R^2	*p*-value
1	(Constant)	-3.02	0.44	0.95	0.001*
	VO_2 peak	0.28	0.04		
	6MWD	0.01	0.01		
2	(Constant)	-2.94	0.74	0.85	0.001*
	6MWD	0.02	0.01		

VO_2 peak = peak oxygen consumption of six-minute walk test (ml/kg/minute); 6MWD = six-minute walk distance (meters)
* = statistical significance at $p<0.05$

study concerned the relationship among METs of EST and other variables such as age, weight, height, BMI, muscle strength, step length and rating perceive exertion (RPE). The results showed that METs of EST had only high correlation with muscle strength and moderate correlation with step length. Enright in 2003[9] stated that muscle strength and step length were factors associated with longer 6MWD. From the results of the present study, 6MWD significantly correlated with METs of EST; therefore, high muscle strength and step length caused high METs of EST as well. The present study tried to predict METs instead of VO_2 peak because of the use of METs in clinics. Physical therapists can use METs as a unit of intensity to exercise patients. When compared with previous studies[10,11], the multiple regression equation of this study showed the highest R^2 (coefficient of determination), and used fewer and simpler variables to predict exercise capacity. Therapists and clinicians can use the multiple regression equation from this study: METs = -2.94+0.02 (6MWD), ($r = 0.923$, $R^2 = 0.85$), for training functional capacity of cardiac patients. In addition, this equation can be used for suggesting appropriate and cautious activities. For example; if cardiac patients achieved 300 meters when performing 6MWT, they would have 3.06 METs, then the activities which are safe and appropriate for them will be walking downstairs, doing house work, slow dancing, bowling and other low intensity activities[12].

Conclusion

The equation model for METs of EST was explained by the 6MWD and R^2 (0.85). Therefore, the six-minute walk test is useful to assess the exercise capacity at the early stage of postCABG and postPCI patients.

What is already known on this topic?

The 6MWT is simple submaximal exercise testing worldwide. The oxygen consumption (VO_2) is a main parameter of functional capacity but it is difficult for clinical use. The METs of EST is the gold standard for evaluating functional capacity in the patients post cardiac surgery. At present, there were few studies of VO_2 of 6MWT and METs of EST in the patients such as CABG.

What this study adds?

There was no study determining relationships of the a forementioned parameters in postCABG and postPCI patients. Based on the regression equation model, 85% of METs of EST can be explained by the 6MWT. Therefore, the 6MWT can be used as an alternative choice for estimating energy expenditure to design exercise programs for these post operation groups.

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Potential conflicts of interest

None.

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ค่าพลังงานที่ใช้ในการเดินสายพานอธิบายด้วยการทดสอบเดิน 6 นาที ในผู้ป่วยภายหลังได้รับการผ่าตัดทำทางเบี่ยงหลอดเลือดหัวใจโคโรนารี่และผู้ป่วยภายหลังได้รับการเปิดหลอดเลือดหัวใจโคโรนารี่

เวทสินี เขื่องศิริกุล, วรรธนะ ชลายนเดชะ, รุ่งชัย ชวนไชยกูล, รุ่งโรจน์ กฤตยพงษ์, ชุณหเกษม โชตินัยวัตรกุล, พันธุ์ศักดิ์ ลักษณบุญส่ง

วัตถุประสงค์: *เพื่อศึกษาความสัมพันธ์ระหว่างค่าพลังงานที่ใช้ในการเดินสายพาน (METs of EST) และการใช้ออกซิเจนสูงสุดในการเดิน 6 นาที (VO_2 peak of 6MWT) และระยะทางเดิน 6 นาที (6MWD)*

วัสดุและวิธีการ: *ทำการวัดความสามารถในการออกกำลังกายหลังการรักษา 6 สัปดาห์ ด้วยการเดิน 6 นาที และการเดินสายพานในผู้ป่วยภายหลังได้รับการผ่าตัดทำทางเบี่ยงหลอดเลือดหัวใจ (n = 17) และผู้ป่วยภายหลังได้รับการเปิดหลอดเลือดหัวใจ (n = 13)*

ผลการศึกษา: *METs of EST มีความสัมพันธ์ 1) ระดับสูง ($p<0.01$) กับค่า VO_2 peak of 6MWT ($r = 0.94$), 6MWD ($r = 0.92$) และกำลังกล้ามเนื้อขา ($r = 0.78$), 2) ระดับปานกลาง ($p<0.01$) กับส่วนสูง ($r = 0.53$), 3) มีความสัมพันธ์ผกผันกับอายุ ($r = -0.50$), 4) มีความสัมพันธ์ระดับต่ำ ($p<0.05$) กับความยาวก้าวเดิน ($r = 0.43$) และน้ำหนักตัว ($r = 0.38$), และไม่มีความสัมพันธ์กับค่าความเหนื่อย (RPE) ของการเดินสายพานและการเดิน 6 นาที สมการถดถอยที่ดีที่สุด คือ METs of EST = -2.94+0.02 (6MWD), ($r = 0.923$, $R^2 = 0.85$, $p<0.001$)*

สรุป: *การเดิน 6 นาที นำไปใช้วัดความสามารถในการออกกำลังของผู้ป่วยโรคหัวใจที่มีความเสี่ยงต่ำถึงปานกลางได้*