CHAPTER III

MATERIAL AND METHOD

This cross-sectional descriptive research study was designed to examine the validity of a submaximal cycle ergometer test and step test to evaluate cardiorespiratory fitness in Thais. The study protocol was approved by Chulalongkorn University Ethic Committee.

Population

In this study, the target population was healthy Thai men and women ranging in age from 18 to 60 years old. The study samples were recruited following the inclusion criteria. The volunteers were recruited from individuals who lived in Bangkok and Metropolitan area.

Screening

Subjects were qualified for the study if they were aged 18-60 years and had no documented diseases or conditions listed in the exclusion criteria. All volunteers were initially contacted by telephone to determine their qualification before included in the study. Of the 212 volunteers who passed the initial screening, 125 individuals completed the study.

Inclusion criteria

1. Thai people aged between 18-60 years.

2. Blood pressure $\leq$ 140/90 mmHg.

3. Consent to participate in the study.

Exclusion criteria

1.   History of cardiac or pulmonary disease.

2.   History of hypertension (blood pressure > 140/90 mmHg).

3.   History of diabetes mellitus.

4.   History of neuromuscular disease, claudication, severe musculoskeletal problems affecting the lower extremity or spine or using of walking aid, orthopedic limitation to exercise.

5.   History of hepatitis, nephritis, thyroid problems, or chronic lung disease.

6.   History of asthma.

7.   Being pregnant.

8.   Using medications potentially affecting heart rate (eg. beta blocker).

9.   Tests not completed.

Sample

Sampling technique

This study used quota sampling technique and voluntariness for recruiting subjects.

Sample size determination

In this study, the sample size determination was obtained from Power Analyzer and Sample Size Program (Number Cruncher Statistical System, USA). Used Equation for sample size calculation based on predetermined intraclass correlation coefficient (Walter, Eliasziw, and Donner, 1998 and Winner, 1991).

This study divided subjects into 5 age groups (18-20, 21-30, 31-40, 41-50, and 51-60 years old) to get adequate sample size and the subjected were equally distributed in all age groups.

- Intraclass correlation = 0.70 (Santo A. et al., 2003 found correlation between maximal exercise test and submaximal exercise test is moderate to high (r = 0.73))

- Power = 0.80

- Alpha = 0.05

The sample size calculation resulted in 10 subjects per group. For 5 groups, a total of 50 men and women was required to complete the study.

Instruments

1. Case record form
2. Sphygmomanometer
3. Stethoscope
4. Height measuring board
5. Weight measuring scale (Yamato, DP-6100GP, Japan)
6. Heart rate monitor (Polar Accurex Plus, Polar electro, Finland)
7. Step bench (12 inch height)
8. Meternome
9. Monark cycle ergometer (Monark 818E, Sweden)
10. Quinton motor-driven treadmill (Quinton 4500, USA)
11. Metabolic equipment (Cortex Meta Max 3B, Germany)
12. Stop watch

Procedure

Subject Preparation

Prior to each test session, subjects were asked to abstain from food, caffeine, all tobacco product, and alcohol for 6 hours. In addition, vigorous physical activity was not allowed 24 hours prior to testing. Upon arrival to the laboratory, weight, height, resting heart rate, and resting blood pressure were recorded. Before test session started, all subjects performed streching and warm up for 3-5 minutes. The subjects wore a heart rate monitor to determine their heart rate during all exercise tests.

Standard measurements

Measurements of height, weight, resting heart rate, and blood pressure provide a baseline characteristics of the subjects. The following procedures were performed and baseline characteristics of the subjects were recorded.

Standing height: The participant was standing barefoot with the heels together, then stretching upward to the fullest extent. Heels, buttocks, and upper back were touching a wall. The chin was not lifted. Measurement was recorded in centimeter.

Weight: Weight was recorded with the individual wearing comfortable clothes and no shoes. Weight was recorded kilograms.

Resting heart rate: The resting heart rate was counted for 15 second and multiple 4 for heart rate per minute. The individual was sitting and had an adequate rest period of at least 5 minutes prior to this test. Adequate rest was indicated when the heart rate had stabilized at a low rate and had not changed.

Resting blood pressure: The individual was sitting upright in a straight-backed chair. Both feet were flat on the floor, and the left arm was resting on a table with the elbow flexed. The position was relaxed and comfortable, and the individual was allowed to relax for a few minutes in this position. Conversation was discouraged. The blood pressure was measured with a device called a sphygmomanometer and with a stethoscope. The first phase systolic pressure and the fifth diastolic pressure were recorded in millimeters of mercury (mmHg) as indicated on the sphygmomanometer scale.

Maximal oxygen consumption test (VO$_2$max test)

Each subject was prepared for ECG monitoring prior to testing. Maximal oxygen uptake was determined on a motor driven treadmill (Quinton 4500, USA). The expired gas was sampled continuously breath by breath for the measurement of oxygen consumption (Cortex Meta Max 3B,Germany). Cortex Meta Max 3B was calibrated gas and pressure one time per month, calibrated volume every day.

After a few minutes of stretching, the subject was asked to perform a warm up on the treadmill for 3-5 minutes. The VO$_2$max test was then started using a treadmill protocol consisting of walking or running at a speed equivalent to roughly 70% age predicted maximal heart rate, with a 2% grade as stage 1. throughout the test, the treadmill speed remained constant. The treadmill grade was increased to 6% at the second stage. While each stage was maintained for 2 minutes, the grade was increased 2% until VO$_2$max was achieved.

The test was terminated VO$_2$max was accepted when at least three of the following four factors were achieved:

(a) A plateau in oxygen uptake with an increased work rate.

(b) A respiratory exchange ratio (RER) greater than 1.15

(c) Achievement of an age-predicted maximal heart rate ± 5% [{220 - age (in year)} ± 5%].

(d) An RPE Borg Scale of 19 or 20.

In addition, the test administrator subjectively evaluated and the characteristics of maximal performance if:

1. The exhaustion of the subject was expressed with body language.

2. The subject could not continue to run properly and safely because of exhaustion.

Participants who failed to meet the maximal level of VO$_2$ were not included in the analysis in this study. During the VO$_2$max test, 12-lead ECG, and heart rate were continuously monitored.

Three minute step test

The 3 minute step test was conducted according to the description in the Y's way to physical fitness. It was done as described here.

Equipment

1. Bench stepping height 12 inch
2. A meternome set at 96 bpm or 24 cycle per minute (four clicks of the meternome equal one step up, up, down, down).
3. A timer for the 3 minutes and a timer for the recovery.
4. A Heart rate monitor

Procedure

The test administrator demonstrated the stepping. The instruction given to the subject included the followings. Face the bench and, in time with the meternome, step one foot up on the bench (first beat), step up with the second foot (second beat), step down with the first foot (third beat), and step down with the other foot (fourth beat). The sequence was alternating feet. It did not matter which foot led or if the led foot changed during the test. The participant was not allowed to practice, as it was affect the heart rate.

The participant was explained both the test and the importance of sitting down quickly at the end of 3 minutes and remaining still for 1 minute so that the tester was able to count the heart rate. During test, the participant was positioned facing the bench and allowed to pick up the beat of the meternome by marking time in place. When the participant started stepping, the timer was started. The rhythm was re-checked and corrected if necessary. The participant was informed the time as it passed by saying "one minute, two minutes," and so on.

When 20 seconds remained, the participant was reminded that he or she was to sit down quickly at the end of the stepping and waited for the test administrator to take the heart rate. On the last step, the test administrator said "last step up, up, down, down, and sit." The meternome was turned off during the last 15 seconds stepping and the cadence was countedfor the participant until the last step.

When the participant sat down, the rhythm heart rate was immediately obtained and the counting was continued for 1 full minute. The count was began on a beat. That beat was counted as "zero." The recovery rate count was started within 5 seconds or the heart rate to avoid error of the heart rate count. The 1-minute count reflects the heart's rate at the end of stepping as well as the rate of recovery.

The total 1 minute postexercise heart rate was the score for the test and was recorded and compared to the norms in the scoring sheets (Golding, 1989). The total 1-minute post exercise heart rate was scored in beats per minute. VO_2max was calculated using recovery heart rate and table in the Y's way to physical fitness.

YMCA cycle ergometer test

The YMCA cycle ergometer test was administered in the same manner for both men and women.

Equipment

1. An accurate, easily calibrated, constant torque bicycle ergometer with a range of 0 to 2, 100 kilogram-meters (kgm) per minute. A kilogram-meter is a unit of work that is equal to the energy required to lift 1 kg vertically a distance of 1 m. Each major gradition should be at 300 kgm, with intermediate marks at 150 kgm. As the Monark bicycle ergometer is the one most commonly used in YMCA's.

2. A metronome set at 100 bpm.

3. A timer to time riding duration.

4. A stopwatch to time heart rate.

5. A heart rate monitor

Procedure

Prior to testing, the calibration of the bicycle was checked. On the Monark the red line on the pendulum weight had to be sure to read 0 on the workload scale before starting.

The concept of the test was briefly explain to the participant. Later, the participant was asked to sit on the ergometer seat which height had been adjusted. When the pedal is at its lowest point the knee should be straight, with the ball of the foot on the pedal and the leg stretched.

The metronome was set at either 50 or 100 bpm and the participant was then allowed to pedal freewheel (no load) for a minute to get the pace. At 50 revolutions per minute (rpm) the right foot makes 50 complete revolutions in one minute. The meternome set at 100 bpm means that at each "click" a foot should be on the downstroke. This is still 50 rpm.

YMCA Cycle Ergometry Protocol

Stage 1	150 kgm/min (0.5 kg)

	HR < 80	HR 80 – 89	HR 90 – 100	HR > 100
Stage 2	750 kgm/min (2.5 kg)	600 kgm/min (2.0 kg)	450 kgm/min (1.5 kg)	300 kgm/min (1.0 kg)
Stage 3	900 kgm/min (3.0 kg)	750 kgm/min (2.5 kg)	600 kgm/min (2.0 kg)	450 kgm/min (1.5 kg)
Stage 4	1050 kgm/min (3.5 kg)	900 kgm/min (3.0 kg)	750 kgm/min (2.5 kg)	600 kgm/min (2.0 kg)

Figure 1. YMCA cycle ergometry protocol (Golding, 1989)

The initial workload was set at 150 kgm/min. On the Monark ergometer, one complete turn of the pedal on the bicycle moves the wheel 6 m. At a pedaling rate of 50 rpm, the total distance covered in 1 minute is 300 m. If the scale is set so that 1 kg of force is acting on the wheel, then 300 m/min* 1 kg = 300 kgm/min.

The participant was allowed to work at the first workload for 3 minutes. The heart rate was counted at the second and third minutes. The difference in heart rates between the second and third minutes should not vary by more than five beats; if it did, the ride for an extra minute was extended or until a stable value was obtained. The workload was subsequently changed. The heart rate was properly recorded after each workload before the next workload was initiated. As each participant's second and third

workload differed, those were entered on the score sheet as soon as they were determined to avoid errors later. After the second workload was completed, the heart rate was recorded at the end of the second and third minutes. Again, these should not differ by more than five beats.

Thoughout the test, exertional intolerance or other signs of undue fatigue or unusual response was continuously monitored. The participant was instructed to indicate how he or she felt from time to time. During the testing, the participant was not permitted to engage in conversation.

When the heart rate at the end of the second and third minutes of the third workload were recorded, the test is now complete. The participant was allowed to cool down by riding at no resistance.

Scoring

Once the test was complete, the final heart rate in each of the workloads to be used (the two between 110 bpm and 150 bpm) was plotted against the respective workload. The first load was not used in this calculation unless it exceeded to that participant's predicted maximal heart rate.

The point at which the diagonal line intersects the horizontal predicted maximal heart rate line represents the maximal working capacity for that participant. A perpendicular line was dropped from this point to the baseline where the maximal physical workload capacity was read in kgm/min. Maximum oxygen uptake was predicted from this test. VO_2max was calculated using formula (Golding, 1989)

$$VO_2max = SM_2 + b(HR_{max} - HR_2)$$

b   = Slope of graph between ploting of heart rate. Slope can calculated by

$$b = (SM_2 - SM_1)/(HR_2 - HR_1)$$

HR_2 = Steady stage heart rate in last stage.

HR_1 = Steady stage heart rate in before last stage.

SM_2 = Volume of oxygen consumption in last stage.

SM_1 = Volume of oxygen consumption in before last stage.

SM_1 and SM_2 can be calculated to rate of oxygen consumption by the following ACSM formula (ACSM,2000).

$$VO_2 \ (ml*min^{-1}) = (kgm*min^{-1}*1.8)*(Body \ Weight \ (kg)*7)$$

Data collection

1.   Heart rates from submaximal cycle ergometer test and step test were obtained by a heart rate monitor. VO_2max was predicted by equations of Gloding,1989 for cycle test and step test.

2.   Data from maximal exercise test such as VE, VO_2, VCO_2, RER, METS, HR. were recorded and calculated by software program of gas analyzer meta max 3B, cortex meta max 3B, Germany.

Statistical Analyses

All statistical analyses were performed using Statistic Package for the Social Sciences (SPSS for Windows version 13.0, Chicago, IL, USA). Standard statistical methods were used to calculate mean (M) and standard deviation (SD).

Intraclass correlation coefficients (ICC) were calculated to determine the strength of the relationship between predicted VO_2max from three minute step test, YMCA cycle test and maximal oxygen consumption test by treadmill test (GXT).

Standard Error Estimations (SEE) was obtained by linear regression analysis.

Pearson correlations were employed to determine the relationship between VO_2max by GXT and two submaximal heart rates of 3 minute step test and YMCA cycle test.

Paired t-test was calculated to determine difference between predicted heart rate maximal and maximal heart rate, heart rate after 3 minute step test immedieatly and steady stege heart rate in last stage by YMCA cycle test.

An alpha level of 0.05 was used to determine statistical significant.