CHAPTER V
DISCUSSION AND CONCLUSION

The objective of the present study was to validate two submaximal exercise tests compared with maximal treadmill exercise test. This study results showed, the high correlation coefficient was found between maximal exercise test (GXT) and YMCA cycle ergometer test ($r = 0.85$, $p < 0.001$, SEE = 4.57 ml/kg/min). The 3 minute step test showed a moderate to high correlation coefficient ($r = 0.73$, $p < 0.001$, SEE = 5.82 ml/kgg/min) with GXT. Hance, the measured VO_2max from GXT had a higher correlation with the YMCA cycle test than the 3 minute step test in Thais. However, predicted VO_2max by step test (35.8±10.6 ml/kg/min) overestimated measured VO_2max by GXT (33.5±8.6 ml/kg/min, $p < 0.001$), while predicted VO_2max by cycle test (32.3±8.7 ml/kg/min) underestimated measured VO_2max from GXT ($p = 0.007$).

Until now, there has no study simultaneously examining the validity of the YMCA cycle test together with 3 minute step test. However, other cycle test and step test protocols have been validated. Graan and Grayson compared the Bushmen cycle test and step test and reported a better test result obtained from cycle test in determining VO_2max. More recent study reported by Frank (2004) that the United Stetes Air Force Submaximal Bicycle Ergometer Aerobic Fitness Test was better in predicting VO_2max than the Air National Guard Submaximal Step Test. Taken together, cycle test regardless of protocol produce greater results than various protocols by step test.

This study reported YMCA cycle test (SEE = 4.57 ml/kg/min) having slightly more accuracy than 3 minute step test (SEE = 5.82 ml/kg/min). Matthew (2004) reported SEE between GXT and YMCA cycle test of 8.9 ml/kg/min., while Santo and Golding (2003) reported SEE between GXT and 3 minute step test of 8.76 ml/kg/min. Thus, the present study was able to show a better accuracy in predicting VO_2max by cycle and step test than previous investigations (Matthew,2004; Santo,2003). However, the differences in predicting accuracy between the studies were inconclusive.

This study confirmed previous findings that direct maximal oxygen uptake values measured during treadmill running test are higher than estimated VO_2max by submaximal cycle test. VO_2max by treadmill averaged 5.6-7% higher than the

predicted values by cycle test (Mark et al.,2004). Several authors suggested that inidividual variability in such factors as leg strength and previous experience with cycling may affect the predicted values found in various study (Davies,1968; McArdle et al., 1973; Patton et al., 1982).

In contrast, the present study found that 3 minute step test overestimated VO_2max compared to measured VO_2max by GXT. Previous investigators reported that the Chester step test tended to give lower prediction values of VO_2max (Sykes and Roberts, 2004). The discrepancy between the studies regarding submaximal step tests requires further investigations.

Gender may be a cause of different result predicted VO_2max

These results found a high correlation coefficient between YMCA cycle ergometer test and GXT in both men ($r = 0.86$, $p < 0.001$) and women ($r = 0.84$, $p < 0.001$). Three minute step test had a moderate to high correlation coefficient with GXT in both men ($r = 0.73$, $p < 0.001$) and women ($r = 0.68$, $p < 0.001$). Results from this study found that men appeared to have higher correlations between estimated VO_2max by both submaximal exercise tests and measured VO_2max by GXT than women. In agreement with the results by a study that validated the Queen's college step test with cycle maximal exercise test (Satipati et al.,2003). Similarly, Gursel et al. (2004) reported the boy's peak VO_2max higher than the girl's.

A previous study determined the relationship between YMCA cycle test and treadmill maximal exercise test (GXT) in men and women (Beekly et al., 2004). The results showed that estimated VO_2max from YMCA cycle test was greater than measured VO_2max in men (n=55). However, both VO_2max values were not different in women (n=47).

The present study found that men were likely to have better VO_2max prediction from 3 minute step test than women ($r = 0.72$, SEE ± 5.6 ml/kg/min, for men and $r = 0.63$, SEE ± 4.0 ml/kg/min, for women). In contrast, the results of a study validating the Chester step test with GXT (ramp protocol) (n=68, age range 18-52 years) show that the Chester step test appeared to be better in predicting VO_2max in women (SEE ± 3.1ml/kg/min) than in men (SEE ± 4.3 ml/kg/min) (Sykes and Roberts,2004).

The difference in VO_2max prediction between men and women has been attributed to differences in hemoglobin concentration, body size, and muscle mass (Gursel et al., 2004). Another explanation is based upon the fact that women have greater accumulation of subcutaneous body fat during the circumpubertal year. Difference in muscle strength between gender may also not be excluded to influence the prediction error (Beekly et al.,2004).

Age may be a cause of different result predicted VO_2max

In this study, it appeared that the highest correlation between measured VO_2max by GXT and predicted VO_2max from both two submaximal tests occurred in the youngest group (age 18 – 20 years). Sherphard (1966) indicated that differences of efficiency were attributable to age and sex. Besides, after age of 25 physique, physical fitness, and VO_2max decline approximately 1% per year (Olgun, 1980).

Potential sources of error for predicted VO_2max by cycle test

This study presented the significantly high correlation (r= 0.85) between YMCA cycle ergometer test and VO_2max measured by GXT. It is supported the result from another study (n = 102, age range 18-54 years) while reported the moderate to high correlation (r = 0.79) between YMCA cycle test and GXT (Beekly et al.,2004). Recently, John et al. (2005) reported concurrent validity YMCA cycle test in predicting VO_2max with high correlation (r = 0.83, $p<0.001$). However, Golding (1989) reported in the United States a very high correlation (r= 0.94, p = 0.05) between YMCA cycle test and GXT. The discrepancies of the test validity were probably due to the factors affecting the VO_2max determination including :

1. The researcher could not control constant pedal rate for all participants.
2. Anxiety can elevate heart rate (Park et al., 1997), the researcher could not control anxiety of subjects.
3. Estimated VO_2max from subjects unfamiliar with the mechanics of cycling would be expected to be lower than the true VO_2max.
4. Seat height can affect mechanical efficiency and inturn, oxygen consumption (McArdle et al.,1991). Although, the seat height adjustment

has been standardized and controlled to minimize position effects on efficiency, it is believed that the limited adjustment in cycling efficiency and VO_2max predict.

Potential sources of error for predicting VO_2max by step test

The present study found that three minute step test had middle to high correlation with GXT ($r= 0.73$, $p<0.001$). It is similar to the result of Donahue and Judy (1998) who reported that 3 minute step test had middle to high correlation with GXT ($r=0.70$, $p< 0.05$). Another study also reported a similar results that 3 minute step test had a middle to high correlation with GXT ($r=0.75$, $p< 0.05$) (Santo and Lawrence,2003). Potential sources of error included :

1. The work load increases with the body weight (Ryhming, 1954; Santo and Lawrence,2003). The present study did not control for body weight of the subjects.
2. Leg length has been shown to influence the results from step tests (Rhyming, 1954; Keen and Sloan.,1958; Ricci et al.,1966; Santo and Lawrence,2003). This study used a fixed bench height. Therefore, variation on the subject's leglength remains the source of error.
3. Accurate reading and recording of heart rate are necessary (Sykes and Roberts, 2004). In this study the tester carefully monitored the heart rate to ensure that the correct counting was recorded. However, the nature of heart rate countimg has its in hereat limitation.
4. The subject's ability to maintain the correct stepping tempo and technique is important (Sykes and Roberts, 2004). In this study the tester made an effort to ensure that the subject maintained the correct stepping rate. Since the ability to control the stepping tempo was not altered, individual performance on maintaining stepping tempo and technique may be accounted for the VO_2max estimation error.
5. Anxiety can elevate heart rate and can reduce rate of recovery heart rate (Park et al., 1997). Although the researcher made an attempt to comfort the subjects to partly reduce the effect of anxiety on heart rate,

the remaining influence of anxiety on test results may not be totally excluded.

Observed maximal heart rate and predicted maximal heart rate

The classic prediction of maximal heart rate has been obtained from 220 – age. In this study, the subjects had a higher observed maximal heart rate than predicted maximal heart rate (185.4 ± 11.8 vs 183 ± 13.1, p = 0.013). The study result agree with another study reporting that age-predicted maximal heart rate underestimated maximal heart rate by approximately 7 beat/min (Park et al., 1997). Therefore, the equation used for predicting maximal heart rate contained some errror. The accurately of age-predicted maximal heart rate may be improved by changing the prediction equation.

Correlation between heart rate of submaximal exercise tests and VO_2max by GXT

The present study found the steady stage heart rate in the final stage of YMCA cycle test to be lower than heart rate immedieatly after 3 minute step test. Since heart rate is a good index of exercise intensity, higher heart rate during 3 minute step test indicating a higher intensity of this exercise test. Hence, YMCA cycle test should a more appropriate test for individuals with lower fitness.

Recommendation for future research

This study provide the preliminary data for developing submaximal step test protocols. Adjusting step height, changing step rate, or modifying the equation for predicting VO_2 max to provide better accuracy and validity than the original 3 minute step test. Similarly, cycle test protocol may be further modified. An adjustment on equation to predict VO_2 max or a newly made cycle ergometer to give a better mechanical efficiency for Thai people than Monark cycle ergometer should provide more accuracy and validity than the original YMCA cycle test.

Conclusion

This study found that the YMCA cycle ergometer test has higher validity to predicting VO_2 max than three minute step test in Thai men and women. Factors affecting the cardiovascular selective method are the testing cost expense, fitness level of participant, validation of test and test complication. Although, the YMCA cycle ergometer test has more validity, the 3 minute step test method may be more attractive for cardiovascular fitness assessment because the 3 minute step test method is less expensive, requires little equipment, takes less time, and better suits for sedentary people. Therefore, the 3 minute step test may be more suitable for initial assessment and YMCA cycle test is more appropriate for estimating cardiorespiratory fitness with good accuracy and validity results for Thais.