CHAPTER V

DISCUSSIONS

The results showed that there were no statistically significant differences in cardiopulmonary variables and 6 MWD among females with mild, moderate, and severe scoliosis. The 6 MWD was significantly correlated with MVV ($r = 0.49$, $p < 0.05$). Also, the significant correlation between 6 MWD and preDBP was found ($r = -0.397$, $p < 0.05$).

Comparisons the systemic impairments and the functional capacity in females with mild, moderate, and severe scoliosis

There were no statistically significant differences in pulmonary variables (pred FVC, pred FEV_1, FEV_1/FVC, MVV, MIP, and MEP) comparing among mild, moderate, and severe AIS. However, the present study found that pred FVC, pred FEV_1, FEV_1/FVC, MVV, and MIP tended to decrease when the AIS severity was increased. In contrast, MEP was slightly increased from mild to severe AIS.

Previous study investigated in AIS with between 23º to 84º (mean Cobb angle = 50.7 ± 13.6º) showed that significant predicted FVC reduction was found in severe AIS group compared with the less severe group (58). Also, the other study reported that the restrictive lung was presented in 631 AIS with thoracic Cobb angle from 2º to 110º (mean Cobb angle = 52 ± 14º) when Cobb angle was greater than 70º (8). These results were different from the current study which the AIS severity had no effect on the reduction of the FVC. It is because the previous studies recruited more severe subjects than this study. Also, in this study no subjects with Cobb angle greater than

70^{o} was participated into the study. However, slowly progressive restriction was seen in this study.

This study showed no statistically significant differences of pred FEV_1 and FEV_1/FVC among three groups. According to the GOLD guidelines, none group could be labeled as the obstructive lung in this study. This is similar to the previous study (8). However, the pattern of airway obstruction in this study and the previous study was prominent as the AIS severity was progressed. Previous study reported that after using bronchodilator, mild to moderate AIS demonstrated increasing in predicted FEV_1 and FEV_1/FVC (10). Therefore, some degrees of obstructive lung may be found in scoliosis even in the early stage of AIS.

The 12-MVV was used to indicate the ventilatory capacity at rest. The statistically significant difference of MVV among groups was not found, but MVV tended to decline as the severity was advanced (mild = 103 ± 21.38, moderate = 99.63 ± 17.65, and severe 90.33 ± 16.93 L/min). Previous study showed reduction of ventilatory capacity in mild AIS by using MVV (6). These imply that some degree of ventilatory pump impairment can be found even in the mild degree of curvature. Previous study (9) showed the VE_{max} were negatively correlated with the severity of the scoliotic curvature ($r = -0.37$, $p < 0.05$). This implied that reduction of ventilatory capacity is much more explicit during exercise than at rest. This indicated that ventilatory pump impairment is really exited in mild to severe AIS, especially during exercise.

VE_{max} determines the ventilatory pump capacity during maximal exercise. Its measurement requires metabolic analyzer which is expensive and highly trained persons are needed. Thus, it may not be suitable for the clinical setting. In contrast, the MVV is measured at rest, but it is easy to perform and less time consumed. Additionally, the MVV test is imitate the ventilation for a short period of time while flow volume loop is the static test. For these reasons, MVV seems to be an appropriate choice to determine ability of the ventilatory pump in the clinics. Surprisingly, it is not frequently used in scoliosis research and clinical setting.

It is already known that MIP in AIS was lower than healthy individuals (11). In this study, MIP tended to decrease in mild, moderate, and severe scoliosis (73.75 ± 21.98, 71.50 ± 9.87, and 69.83 ± 15.00 cmH_2O; $p > 0.05$, respectively). Previous study also showed that degree of scoliosis deformity did not significantly reduce MIP (6, 58). Since this study found that the pred FEV_1 tended to decrease in mild to severe groups, it implies that RV is increased. This can possibly cause the change of respiratory muscles length and result in the reduction of force production. Additionally, when RV increases, TLC is increased. This leads to increase in MEP since MEP was positively associated with TLC. This change may potentially explain the raising of MEP as the severity was advanced from mild to severe (mild = 82.38 ± 15.49 cmH_2O, moderate = 83.63 ± 16.73 cmH_2O, and severe = 90.33 ± 15.71 cmH_2O; $p > 0.05$). However, degree of lung hyperinflation may not great enough to generate significant impact on MIP and consequently on MEP.

Even though the data of AIS related to cardiovascular system was limited, the deconditioning in the individuals AIS were mentioned (7, 8). The statistically significant difference in pre- and post-test HR among three severity groups was not found in the present study. The average of resting HR of all subjects was 91.32 ± 12.35 bpm. This is almost near the upper border of sinus rhythm rate which is 60 to 100 bpm. This implies that deconditioning exists in these subjects. Previous study showed significant reduction of resting heart rate after 4-month aerobic exercise training in severe AIS (108 ± 12.31 vs. 96.79 ± 8.67 bpm, $p < 0.0001$) (12). Furthermore, from interview, most of the subjects stated that playing computer and watching television were typical activities of their leisure time. This is similar to the other previous studies that mentioned about sedentary lifestyle in individuals with AIS (7, 8). Thus, cardiovascular impairment in AIS may partially derive from deconditioning. To improve cardiovascular impairment, exercise training specifically aerobic training should be targeted.

The DBP in this study was increased from 69.64 ± 6.46 to 74.36 ± 11.36 mmHg during the 6 MWT. About 59 percents of all subjects showed such response. Even though the change in DBP was not greater than 115 mmHg considering as abnormal physiological response (63), they seemed to have diastolic dysfunction. Twisting of aortic arch may cause the diastolic dysfunction. Previous studies showed changing aortic position in both right and left adolescent idiopathic scoliosis (64-67). When thoracic Cobb angle was greater than 40º, the aorta-vertebral angle was increased (65). This causes the difficulty of heart to expel the blood out off the left ventricle and results in increasing pressure in the ventricle during diastolic phase. Heart may progressively congest and result in raising pulmonary pressure. These eventually lead to cardiac and ventilatory pump failure due to restrictive lung as the severity is advanced. The long term follow up study reported that cardiorespiratory failure was one of the mortality causes in patients with idiopathic scoliosis (2). Thus, the cardiovascular system can be a serious problem in the individuals AIS.

The degree of scoliosis curve seems to affect the walking distance compared to previous studies. The 6 MWD in the AIS with Cobb angle from 13º to 68° in this study was 561.16 ± 46.34 m. It is lower than in the normal individuals which was 642.70 ± 58.9 m. (46), but it is greater than the previous study in AIS with Cobb angle 45º to 88º which was 400.71 ± 49 m. (12). Nevertheless, severity of thoracic scoliosis does not cause the walking distance reduction in this study. This may be due to small sample size.

Correlation between the systemic impairments and the functional capacity in female with mild, moderate, and severe scoliosis

The present study firstly reveals the relationship between the systemic impairments and the functional capacity indicated by 6 MWD in adolescent idiopathic scoliosis. Previous studies found that demographic data (age, weight, and height) significantly correlated with 6 MWD in normal subjects (42, 46, 48, 51, 54). However, this may not the case in this study. The small sample size may produce less variation in demographic data. The significant correlation between Cobb angle and 6 MWD was also not found in this study ($r = -0.064$, $p > 0.05$). This may be due to the small sample size as well.

Positively significant correlated between 6 MWD and MVV was found in this study ($r = 0.49$, $p = 0.01$). The similar characteristics of these two tests may play the role. Both of the 6 MWT and the MVV maneuvers are tested in dynamic fashion whereas flow volume loop and respiratory muscle strength maneuvers is the static test. Thus, MVV may be a good variable to elucidate respiratory impairment system during daily activities than the flow volume loop and respiratory muscle strength. The effect of spinal deformities on the position of aorta may cause the significant relationship between 6 MWD and preDBP ($r = -0.397$, $p < 0.05$). The twisting aorta may cause somewhat diastolic dysfunction even at rest.

Conceptually, functional capacity is the integration of musculoskeletal, cardiovascular, and pulmonary systems. The four equations which was derived from MVV, preDBP, preHR, and the Cobb angle can be used to estimate 6 MWD. The demographic data in this study did not contribute to the walking distance. This may be the demographic data in this study are constantly held since significant differences on these variable were not found. However, these four predicted equations should be applied only in the adolescent females with MVV 58 to 151 l/min, preDBP 60 to 80 mmHg, preHR 73 to 124 bpm, and thoracic Cobb angle from 13º to 68º.

LIMITATIONS

The small sample size may contribute to the results in the present study. From the previous study, the variables (6 MWD, FVC, and HR) in severe AIS (12) was used to estimate sample size prior to the data collection. The calculation suggested that 14 to 20 participants would be needed if the power at 0.8 was required. However, MVV, MIP, MEP, and blood pressure, and the wide range of AIS severity may contribute to decrease the power in this study. Due to the ethical clearance, subject recruitment had to be conducted at one hospital. This results in small sample size. Another limitation is the method of determining thoracic deformity. Using X-ray photograph in the Cobb method may not be appropriate for research purposes. This is because the scoliosis deformity is simultaneously changed in three dimensions, but two-dimensional change is detected by the Cobb method. However, Cobb method is widely used in clinical setting and X-ray photograph is inexpensive investigation.

CONCLUSIONS

There was no difference in the cardiopulmonary impairments and in 6 MWD among adolescent females with mild, moderate, and severe group. Also, 6 MWD was positively correlated with MVV and negatively correlated with preDBP. Four predicted equations for 6 MWD were established. MVV, preDBP, preHR, and Cobb angle were used in the equations. The study suggested that the secondary impairments caused by scoliosis such as ventilatory pump impairment, deconditioning, and possibly diastolic dysfunction should be emphasized in the individuals with scoliosis in order to improve their systemic impairments, functional limitation, and eventually quality of life. For clinical application, the MVV maneuver and 6 MWT should be introduced.

FUTURE STUDY

More subjects needs to be recruited. Multi-center study is suggested for further study because the prevalence of AIS in Thailand may not high in one hospital. Moreover, Magnetic Resonance Imaging (MRI) or Computerized Tomography (CT) is highly recommended in the future study because of the better reflecting the spinal deformity than the X-ray. However, the cost of MRT and CT scan are expensive and they are not practical for clinical used.