WALAILAK JOURNAL
http://wjst.wu.ac.th Health Sciences

Effects of Three-Dimension Schroth Exercises and Kinesio Taping on General Mobility of Vertebrae, Angle of Trunk Rotation, Muscle Strength and Endurance of Trunk, and Inspiratory and Expiratory Muscle Strength in Children with Idiopathic Scoliosis

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Received: 21 July 2017, Revised: 21 December 2018, Accepted: 21 January 2019

Abstract

This study aimed to compare the effects of 3-dimension Schroth exercises and Kinesio taping (KT) on several variables in children with idiopathic scoliosis. Female volunteers aged 10 - 18 years with an angle trunk rotation > 7 degrees participated in the study. The 16 volunteers were divided into 2 groups: 'Three-dimension Schroth exercises' (Con) and 'Kinesio tape with Schroth exercises' (KT). The training program comprised 2 sessions per week with 2 h per session for 6 consecutive weeks. Significant increases of maximal inspiratory pressure (Con; $p = 0.046$), maximal expiratory pressure (Con; $p = 0.046$, KT; $p = 0.047$), and back muscle endurance (Con; $p = 0.028$, KT; $p = 0.028$) were recorded. Significant decreases of angle trunk rotation at the thoracic level (Con; $p = 0.046$, KT; $p = 0.017$) and the lumbar level (Con; $p = 0.042$, KT; $p = 0.041$) were recorded. In conclusion, 3-dimension Schroth exercises and KT with Schroth exercises can increase maximal expiratory pressure, back muscle endurance, and angle of trunk rotation at the thoracic and the lumbar level.

Keywords: Three-dimension Schroth exercises, Kinesio tape, idiopathic scoliosis, angle of trunk rotation, inspiratory and expiratory muscle strength

Introduction

Idiopathic scoliosis (IS) is a disorder in which the spine shows an abnormal lateral curvature. IS occurs in 3-D; the spine is bent sideways in conjunction with its rotation, causing an altered curve of the scapula [1,2]. Scoliosis leads to deformities of the thoracic cage, weakness of the respiratory muscles, and limited mobility of the spine. In addition, there may be some pain involved [3-7]. A study by Inal-Ince *et al.* [8] found that the maximal inspiratory pressure, maximum inspiratory pressure (MIP) and maximal expiratory pressure, and maximal expiratory pressure (MEP) in patients with scoliosis that is caused by the nervous system is less than healthy. Furthermore, Martinez-Llorens *et al.* [9] reported that MIP and MEP in a group of IS patients were not normal.

Schiller *et al.* [10] suggested that people with scoliosis should be exercising to be able to move better. Šarčević *et al*. [11] studied the strength of the muscle groups used in the posture of children with scoliosis aged 10 - 16 years. The authors found that the quadratus lumborum and gluteus medius muscles

on the convex side of the spinal curvature were weaker than those on the concave side of the spine. The erector spine lumbalis and multifidus muscles of the concave side of the spine were weaker when compared with the convex side. In the thoracic region, the middle trapezius, lower trapezius, and serratus anterior muscles on the convex side were weak compared to the concave side. In addition, the rhomboid muscles on the concave side were weak compared to muscles on the convex side. If childhood scoliosis is left untreated, it will continue to cause problems in later life. Examples are low back pain disability, complications in the cardiopulmonary system and, associated with the limited body functionality, a low self-esteem [4,12-16].

The goal of the treatment of scoliosis with a conservative approach is to prevent curve progression throughout pubertal growth. This will reduce or even avoid development of respiratory cardiopulmonary problems and back pain caused by scoliosis. Treatment of scoliosis with specific exercises is a popular way to correct spine curvature. The 3-dimension Schroth exercises are a popular and widely known example of such exercises. Several studies demonstrated that exercise improved spinal conditions from 12 - 100 % [15,17-20]. The Cobb angle of 50 children (average age: 14.1 years) with scoliosis decreased from 26.18 to 17.88 after exercises for 6 weeks, 2 h per day, 5 days a week [17]. Afterwards the patients received a program to continue to work at home for 90 min a day. In another study, 43 children (average age: 12 years) with scoliosis and an average Cobb angle of 19.58 degrees underwent an exercise program [18]. The exercises continued for a period of 3 months, 2 h per day, 2 days per week. The patients did not receive any home exercise program. The results of the study showed that the participants improved their Cobb angle up to 44.2 %. Furthermore, Schroth treatment demonstrated a positive effect on back muscle strength and endurance [17,34]. In an RCT study, Schreiber *et al*. [34] revealed that Schroth treatment combined with the standard of care improved back muscle endurance in children with AIS after a 6-month training period. In addition, Otman *et al.* [17] reported Schroth treatment increased back muscle strength after 6 weeks, 6 months, and 1 year in all participants. To the best of the authors' knowledge, there are only a limited number of studies of Schroth exercises that report on these results.

Kinesio® taping method (KT) is linked to the tape that was developed by Dr. Kenzo Kase in 1979 and is still popular today. The tape is an elastic fabric and is designed to suit the properties of human skin. The flexibility of the tape is similar to skin, with an elasticity of 40 - 60 % of its resting length. It can also reduce the risk of skin irritation due to latex adhesive. The correct application of this tape is designed to fulfill 4 main objectives: (1) support muscle function, (2) adjust movement of the joints, (3) stimulate receptors in the skin, and (4) increase lymph flow under the skin [21-23].

A recent study found that KT is likely to stimulate muscle function. Hsu *et al*. [24] studied the effect of KT on the movement of the scapula and muscle function in baseball patients with shoulder impingement syndrome. They found that the use of KT with muscle facilitation techniques can activate the lower trapezius muscle during 60 - 30° abduction when compared with non-elastic tape. This finding is consistent with the study of Huang *et al*. [25] in which the authors found that the medial gastrocnemius muscle tends to work more in the KT group compared to the conventional elastic tape group. Also, Mirafzal *et al*. [26] presented results of high statistical significance showing that KT with exercise helps to shape a better posture in kyphotic adolescents. Chang *et al.* [27] studied the mistakes of grip strength in healthy athletes and found that KT has a lesser margin of error compared to placebo tape and no tape. This shows that KT can stimulate perception through skin and proprioceptive senses. The benefits of KT for the treatment of patients with idiopathic scoliosis have been demonstrated in additional researches. For example, KT was used with the objective to reduce pain, to activate muscles, and to stimulate awareness through receptors of the body [28]. Bac *et al*. [29] studied the effect of KT on children with scoliosis in comparison to non-elastic tape. The results showed a better angle of the spine and higher muscle tone in the KT group. The daily activities of the children improved and pain was reduced. In addition, these effects should persist for a longer time. Parents reported that KT motivated their children to exercise more.

The expectation of the present study was to see if there is a superior effect on health if Schroth exercises are combined with KT. The result could then be used as a clinical guideline for the physiotherapeutic treatment of adolescent idiopathic scoliosis. Therefore, the objectives of this study were to study the effects of 3-dimension Schroth exercises and KT on general mobility of vertebrae, angle of

trunk rotation, muscle strength and endurance of trunk, and inspiratory and expiratory muscle strength in adolescent idiopathic scoliosis.

Materials and methods

A total number of 16 female volunteers, aged 10 - 18 years and with an angle trunk rotation of more than 7 degrees [29], participated in the study. Inclusion conditions were: no history of spinal surgery, no history of allergies KT, and able to participate throughout the study. All included participants understood the purpose of this study and provided written informed consent prior to take part in this study. The protocol of this study was approved by the Ethical Review Sub-Committee Board for Human Research Involving Sciences, Thammasat University, No. 3.

Volunteers were required to attend a total of 14 days. Data were collected on the first and the last day, before and after exercise. The recorded data included: general mobility of vertebrae, angle of trunk rotation, muscle strength and endurance of trunk, and inspiratory and expiratory muscle strength.

Sixteen volunteers were randomly assigned into 2 groups 'Three-dimension Schroth exercises' (Con) or group 'Kinesio tape with Schroth exercises' (KT). Training sessions were scheduled for 2 days per week, 2 h per day for 6 consecutive weeks (total twelve days). In the KT group, the tape was changed every time before exercise.

The Adam forward bending test with the Scoliometer, respiratory muscle strength, general mobility, and back muscle strength and endurance were measured in this study. All measurements were taken in random order to avoid a measurement order effect. Each measurement was separated by 10 min of rest to minimize fatigue. Angle of trunk rotation was measured during the Adam forward bending test using the Scoliometer. Subjects were asked to bend their trunk forward until it was parallel to the ground, keeping the palms of their hands together with their arms hanging down and perpendicular to their trunk. The investigator looked down the back for the presence of asymmetry in the rib cage or deformities along the back indicative of a structural scoliosis. The Scoliometer was then used at 2 areas of interest: one at the thoracic hump and the other at the lumbar hump. The axial trunk rotation (ATR) was obtained by positioning the centre of the Scoliometer over the spinous process and perpendicular to the spine. Subjects with ATR reading $\geq 7°$ would be assumed to be scoliosis [35-37]. Each exercise and measurement was done in triplicate and the mean of the recorded values, including its standard deviation, was used for data analysis. Test retest reliability of the Adam forward bending test and the Scoliometer were 0.89 and 0.90, respectively, as reported in a previous study [38].

Respiratory muscle strength was maximal expiratory pressure (MEP) and maximum inspiratory pressure (MIP) using a respiratory pressure meter (Micro RPM®, Micro Medical, United Kingdom). The subjects were seated during the test and were using a nose clip. They were instructed to hold a manovacuometer, and to tighten the mouthpiece firmly against the lips, preventing air leakage, making a maximum inspiration from the residual volume to measure MIP, and a maximum expiration from total lung capacity to determine MEP. Three measures of MEP and MIP were performed in each test, under the supervision and direction of a physiotherapist, with resting intervals of 1 min between tests. The highest value of 3 reproducible maneuvers was used for the analysis [9]. General mobility was determined by measuring the distance from the tip of the middle finger to the ground in centimeters in a forward flexion and a lateral flexion. During the test, the subject was instructed to stand erect and flex forward, as well as laterally bend their spine, while letting the hand slide down the leg as far as possible with knees fully extended. The distance between the fingertips and floor (FFD = Finger-Floor-Distance) was measured in cm [39].

The strength and endurance of back muscles were measured using the Sørensen test. The subject was asked to lie down on the examining table in the prone position with the upper edge of the iliac crests aligned with the table edge. The lower extremities were fixed to the table by straps at the pelvis, knees, and ankles. During the test, the subject was also instructed to maintain the upper body in a horizontal position, with the arms folded across the chest. The test was terminated when the subject could not hold the test position any longer, and the time during which the subject kept the upper body straight and

horizontal was recorded. In subjects who experienced no difficulty in holding the position, the test was stopped after 240 s.

Figure 1 Applied Kinesio-taping (posterior view).

Three-dimension Schroth exercises were used in this study. The whole process was under the supervision of a physical therapist trained in the Schroth technique and who received a diploma from the Institute of Asklepios in Germany. The exercise program was designed to suit each individual participant and consisted of breathing exercises, stretching and adjusting the curve of the spine with exercises. KT processes were carried out by specialist physiotherapists who were trained by the Kinesio Taping Association International. Strength and tightness of the shoulder and back muscles associated with the spine were evaluated for each volunteer. The KT was then applied depending on the detected impaired muscles. If a muscle was too weak, KT was applied to stimulate the muscle (muscle facilitation) at 15 - 35 % tension with mounting from the origin to the insertion of the muscle. If a muscle was too tight, KT was applied to achieve inhibition of the muscle (muscle inhibition) at 15 - 25 % tension with mounting from the insertion point to the origin of the muscle. An example is shown in **Figure 1**. In this case, physiotherapists detected that the upper trapezius muscle on the right side was very tight, and applied KT to inhibit the muscle. The lower trapezius rhomboid major muscle and the right side were weak, and KT was applied to stimulate the muscle.

Data were recorded both before and after exercise in each group and were compared using the statistical program SPSS version 22. The Mann-Whitney U test was used to compare variables between the Con and KT groups. The Wilcoxon signed-rank test was used to compare the recorded variable values of the pre- and post-program participants in each group. This study determined the level of statistical significance at p-value < 0.05.

Results and discussion

This study investigated the effects of 3-dimension Schroth exercises and KT on the general mobility of vertebrae, angle of trunk rotation, muscle strength and endurance of trunk, and inspiratory and expiratory muscle strength in children with idiopathic scoliosis. Originally, 17 children with adolescent idiopathic scoliosis were recruited in this study, but one participant was excluded due to travel problems. The remaining 16 participants underwent the full training program. Ten children were assigned into group KT and 6 into group Con. General and idiopathic scoliosis characteristics of the subjects are shown in **Tables 1** and **2**, respectively.

Table 1 Characteristics of research participants (mean ± SD).

General characteristics	KT (n = 10)	Con (n = 6)	Mann-Whitney U	p-value
Age (years)	17.00 ± 1.63	14.67 ± 2.34	10.50	0.031*
Weight (kg)	45.30 ± 3.56	40.25 ± 8.97	22.50	0.428
Height (cm)	162.30 ± 4.74	156.83 ± 8.60	20.50	0.313

*Level of statistical significance at p-value < 0.05.

Table 2 Curve and side of curve characteristics.

Participant	Group	Curve	Number of Curves	ATR(°)	
				Thoracic	Lumbar
1	KT	Thoracic/Lumbar	2	14.67	9.33
2	KT	Thoracic/Lumbar	2	18.33	18.67
3	KT	Lumbar	1	5.00	25.00
4	KT	Lumbar	1	5.00	12.67
5	KT	Thoracic	1	8.00	2.00
6	KT	Thoracic/Lumbar	2	8.67	9.33
7	KT	Thoracic	1	8.00	3.00
8	KT	Lumbar	1	3.00	9.67
9	KT	Thoracic	1	8.33	5.33
10	KT	Thoracic	1	8.33	2.00
11	Con	Thoracic/Lumbar	2	24.67	9.33
12	Con	Thoracic	1	10.00	4.67
13	Con	Thoracic/Lumbar	2	13.33	8.67
14	Con	Thoracic/Lumbar	2	16.00	13.33
15	Con	Thoracic/Lumbar	2	9.33	13.00
16	Con	Thoracic	1	14.33	7.00

The mean age of the subjects showed a statistically significant difference between the KT and Con groups. However, the subjects in both groups were classified as adolescent by their age [2].

The mean and standard deviation of each variable before and after training are shown in **Table 3**.

Table 3 Mean and SD of variables before and after training in group Con and group KT.

Variables	KT			Con		
	Before training	**After training**	**p-value**	**Before training**	**After training**	**p-value**
Inspiratory muscles strength (mmH_2O)	37.77 ± 18.68	47.40 ± 17.00	0.114	27.11 ± 31.52	36.33 ± 31.77	0.046*
Expiratory muscles strength (mmH_2O)	43.13 ± 19.38	49.53 ± 18.37	0.047*	28.44 ± 18.73	35.78 ± 26.15	0.046*
Muscle endurance of back (second)	90.5 ± 49.98	121.2 ± 69.57	0.028*	71.83 ± 62.56	118.5 ± 109.9	0.028*
Angle of trunk rotation thoracic level (degree)	8.63 ± 4.62	6.97 ± 3.80	0.017*	14.61 ± 5.55	11.61 ± 3.67	0.046*
Angle of trunk rotation lumbar level (degree)	9.50 ± 7.26	8.17 ± 7.64	0.041*	9.33 ± 3.38	7.72 ± 3.42	0.042*
General mobility (cm)						
- Forward reach	13.84 ± 11.04	12.22 ± 8.47	0.401	10.46 ± 6.44	11.14 ± 7.23	0.916
- Right reach	42.70 ± 4.53	42.82 ± 5.10	0.838	39.59 ± 3.07	41.25 ± 2.49	0.080
- Left reach	43.10 ± 4.30	43.11 ± 5.41	0.767	38.94 ± 4.22	40.36 ± 3.77	0.116

*Level of statistical significance at p-value < 0.05

The results indicated that expiratory muscle strength, back muscle endurance, and angle of trunk rotation had increased in both groups after 6 weeks of exercises (**Table 3**). Inspiratory muscle strength increased in the control group only. Furthermore, the general mobility did not differ between the pre- and post-program in the 2 groups after 6 weeks of exercises (**Table 3**).

Scoliosis is a condition that leads to deformities of the spine, causing loss of movement and flexibility. Therefore, the goal of exercise for scoliosis patients is to increase mobility and flexibility of the spine [1]. In this study the variables recorded for general mobility of the spine showed no significant difference between before and after exercises in each group, nor between both groups. This is different from the study of Zakaria *et al.* [30] in which the effects of motion in the spine in anteroposterior direction between stretching back muscles and mechanical traction on scoliosis patients were analyzed. The authors reported that the motion of the spine increased in both groups. Their study and our study are not directly comparable, because of differences in the exercise program. The program of Zakaria *et al.* [30] included stretching and strengthening of back muscles. Moreover, the exercise program had a duration of 3 months.

This study found that the angle of trunk rotation was reduced in both groups after 6 weeks, which is consistent with the study of Yang *et al.* [31]. They studied the effects of Schroth exercises. The subjects exercised 3 times per week for eight weeks. The results showed a decrease of angle of trunk rotation, which meant a decrease of scoliosis curve. It is also consistent with the results reported by Mohamed *et*

al. [32]. They studied the effects of exercise and KT in scoliosis and found that the Cobb angle was reduced in both groups, an exercise group and an exercises with KT group. Both kinds of exercises similarly helped to reduce the Cobb angle. The study found no significant change of the angle of trunk rotation in KT, because KT may stimulate the trunk rotation muscles only in the short term. It may not be enough to cause a change of the spine [33].

In terms of strength and endurance of back muscles, this study used the Biering-Sørensen test. The results of this study showed that the strength and endurance of back muscles were increased in both groups. This is consistent with the studies of Schreiber *et al.* [34]. They found that scoliosis patients who received standard care and performed Schroth exercises increased strength and endurance of the back muscles when compared to patients receiving only standard care. In addition, a study of Otman and colleagues [17] studied the effects of Schroth exercise on the strength of the back muscles. The results showed that back muscle strength had increased after 1 year of exercise.

We found that there were no significant differences between the Con and KT groups after 6 weeks of training, as shown in **Table 4**. The results were related to the observations reported by Mohamed and colleagues [32], as discussed above.

Table 4 Differences of variable values between baseline and 6 weeks of exercises in KT and Con groups (Mean and SD are shown).

Variables	**KT**	**Con**	**p-value**
Inspiratory muscles strength (mmH_2O)	9.63 ± 15.87	9.22 ± 8.96	0.140
Expiratory muscles strength (mmH_2O)	6.40 ± 10.99	7.33 ± 9.85	0.918
Muscle endurance of back (second)	30.69 ± 43.07	46.67 ± 49.81	0.657
Angle of trunk rotation thoracic level (degree)	1.67 ± 2.10	3.00 ± 2.15	0.906
Angle of trunk rotation lumbar level (degree)	1.33 ± 1.83	1.61 ± 0.98	0.091
General mobility (cm)			
- Forward reach	-1.63 ± 4.49	0.68 ± 4.31	0.755
- Right reach	0.12 ± 3.27	1.66 ± 1.80	0.338
- Left reach	0.01 ± 3.48	1.42 ± 1.89	0.364

*Level of statistical significance at p-value < 0.05

This study is limited by the small number of research participants. Furthermore, the participants in this study were heterogeneous (differences in type of scoliosis and number of curves). Thus, the outcome of the present study cannot be generalized. In addition, some volunteers were treated with a brace. However, volunteers who were treated with a brace did not enter the full number of hours the doctor had ordered. Future studies should significantly increase the number of participants. Measurements of the Cobb angle before and after joining the program should be added as a way to evaluate scoliosis standard.

Conclusions

The Schroth exercises alone, as well as combined with KT and Schroth exercises, can improve inspiratory muscle strength, expiratory muscle strength, back muscle endurance, and angle of trunk rotation in the thoracic and the lumbar level in children with idiopathic scoliosis. No other significant differences were found between the 2 groups. The combination of KT and Schroth exercises was not more efficacious than Schroth exercises alone.

Acknowledgements

This research was funded by the Sports Authority of Thailand. We would like to thank the Physical Therapy Department, Faculty of Allied Health Sciences, Thammasat University, for their support of the research project.

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