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THE EFFECTS OF DYNAMIC NEUROMUSCULAR STABILITY EXERCISE ON THE SCOLIOSIS AND PAIN CONTROL IN THE YOUTH BASEBALL PLAYERS

ILBONG PARK

NC Dinos baseball club
Changwon 51323, Republic of Korea
fnjboss@naver.com

CHANHEE PARK

Department of Physical Therapy, Yonsei University
Wonju, Gangwon-do 26493, Republic of Korea
chaneesm@gmail.com

KYOUNGTAE KIM* and YOUNGJOO CHA†

Department of Physical Therapy
Cheju Halla University
Jeju 63092, Republic of Korea
**kkt@chu.ac.kr*
†Chazoo2009@naver.com

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While the presence of dynamic neuromuscular stabilization (DNS) has been provided as an important component of the integrated spinal stabilization and associated abdominal stabilization prior to dynamic movement, no previous study has investigated the spinal mechanical effects scoliosis and pain control in youth baseball player with scoliosis. This study compared the effects of gymball exercise, with and without DNS core stability exercise, on spine kinematics and pain control in youth baseball player with scoliosis. A total of 28 participants with scoliosis were randomized into gymball exercise, with and without DNS core stability exercise. Clinical outcomes included the Cobb's angle and visual analog scale (VAS). Two-way repeated analysis of variance (ANOVA) was conducted at $p < 0.05$. Two-way repeated ANOVA showed that gymball with DNS showed superior effects, compared to gymball without DNS, on Cobb's angle ($P < 0.001$), but not on VAS ($P < 0.837$). Our results provide novel, promising clinical evidence that DNS improved scoliosis kinematics as well as pain control in youth baseball player with scoliosis.

*Corresponding author.

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Keywords: Scoliosis; baseball player; core stability; pain control; dynamic neuromuscular stabilization.

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1. Introduction

Scoliosis, a three-dimensional transformation of the spine,[1] is defined as a physical condition in which the spine is bent by more than 10 degrees in radiography.[2] About 85% of scoliosis patients are diagnosed with unexplained idiopathic scoliosis, which is known to be most prevalent from about 10 years of age to adolescence, when bone growth stops.[3] The clinical signs of scoliosis have been thoroughly investigated and well documented, while idiopathic refers to unknown causes.[4] Yoo *et al.* (2001) reported that the 116 growing elite players who perform unilateral movements had mild scoliosis with Cobb's angle less than 15°, it gets worse as they grow, and degenerative deformation begins even after their bone growth stops, which is accompanied by spinal cord malformation as well as deformation of the spine structure, and moreover it changes the characteristics of the muscles around the spine and proper posture and spinal alignment, leading to serious problems such as low back pain, reduced spinal movement, decreased cardiopulmonary function.[5–7]

In addition, Park (2018) reported that repetitive asymmetrical movements, such as baseball, result in the deformation of the spine structure, and that it is important for baseball players during the growth period to take good care of the spine, considering that the cause of adolescent idiopathic scoliosis occurs until they become adults. Therefore, the scoliosis of growing baseball players is accompanied by various spine problems, such as back pain, as well as their performance as they grow as reviewed in previous study, so especially at that time, the management of scoliosis is considered to be important.[8]

On the other hand, dynamic neuromuscular stabilization (DNS) is a rehabilitation approach that can be of great help in preventing recurrent thoracolumbar muscle tension injuries.[9,10] It is widely known that it can be used in the functional treatment of musculo-skeletal system syndrome, where patients feel pain, but that it is also used to increase exercise capacity as a different effect. The DNS approach is based on a model of developmental kinematics.[11] DNS contains innate motor patterns or programs that can develop a newborn baby-like ideal posture, functional joint centration, and optimal breathing and movement.[12] The main goal of the DNS approach is to restore the physiological motor patterns defined in developmental kinematics. Also, optimal trunk stabilization is a basic prerequisite for the ideal qualitative movement of all activities, including sports activities.[10] The role of intra-abdominal pressure control and the integrated stabilizing system of the spine in relation to functional spinal stability is to generate the torque required for joint motion through the stability of the spine and dynamic co-activation muscles.[9] In other words, the DNS exercise can be said to be helpful in the functional activity of the spine based on stabilization of the spine during exercise. However, it is known that the DNS exercise helps improve the function of the spine, and it is judged that

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the studies conducted on sports players are still insufficient. Therefore, the purpose of this study is to provide meaningful data for the maintenance of growing players by investigating the effects of the DNS exercise on scoliosis in players with scoliosis among the youth baseball players in republic of Korea during the growth stage, who mainly move unilaterally. We hypothesized that DNS exercise would produce greater changes in the scoliosis angle and pain scale than gymball exercise alone in youth baseball players in republic of Korea.

2. Methods

2.1. *Plan of study*

In this study, 28 patients with the Cobb's angle of 10° or more and the Visual Analog Scale (VAS) of low back pain were selected through scoliosis examination among 192 male baseball players from 14 (junior high school students) to 18 (high school students) years old living in Busan (Fig. 3). Their physical characteristics are shown in Table 1.

2.2. *Experimental design*

Scoliosis was evaluated through X-ray imaging by a certified radiologist who was expert in scoliosis evaluation at the Radiology Department in Busan, and players evaluated with the medical opinion of specialists on scoliosis examination were selected as subjects for the study. They were divided into two groups: 14 people who received a trunk stabilization exercise with a gym ball and 14 people who received both the trunk stabilization exercise with a gym ball and DNS exercise, and each group performed the experiment 3 times a week for 8 weeks. The exercise programs are as shown in Fig. 1 and Table 2.

2.3. *Inspection items and methods*

2.3.1. *X-ray Cobb's angle inspection*

In order to find the Cobb's angle, as shown in Fig. 2, the distal vertebrae tilted toward the most concave of the spinal curve should be determined at the upper and

Table 1. Demographic and characteristics of participating youth baseball player ($N = 28$).

Groups / (Unit)	Gym ball stabilization & DNS exercise group ($N = 14$)	Gym ball stabilization exercise group ($N = 14$)
Age (year)	15.94 ± 3.75	16.68 ± 3.99
Career (year)	6.15 ± 2.07	6.13 ± 2.27
Weight (kg)	70.94 ± 5.17	71.74 ± 6.04
Height (cm)	170.94 ± 4.11	172.45 ± 5.57
BMI (kg/m^2)	22.17 ± 4.07	23.96 ± 2.22

Note: Mean ± standard deviation (SD).

Side sitting arm reaching

Kneeling horizontal adduction reaching

Kneeling horizontal abduction reaching

Kneeling pseudo-closed kinetic reaching

Fig. 1. Asymmetric DNS Exercise using theraband and small ball.

lower levels of the curve, then one line needs to be drawn at the top of the upper end spine and the other line at the bottom of the lower end spine, and then draw lines orthogonal to each line to cross them.[2] Scoliosis was examined through X-ray (DK II525R-Korea) as above, and each score represents an angle. Cobb's angle obtained through this is also the size of the curve.

2.3.2. *Visual analog scale test*

Hawksley (2000)'s method, widely used as a pain scale, was used to measure the visual analog scale (VAS).[13] In case of pain, subjective pain is recorded using a visual pain scale, and the 10 cm straight line was used set to be 0 point for no pain and 10 point for severe pain.

2.4. *Statistical analysis*

Results were expressed as means and standard deviations. SPSS for Windows (25.0, SPSS, Chicago, IL, USA) was used to conduct statistical analyses. The Kolmogorov–Smirnov test was used to confirm normal data distribution; hence, parametric analyses were performed. Two-way repeated Analysis of Variance (ANOVA) was

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Table 2. Gym ball spine stability & DNS exercise intervention.

Exercise	Level	Exercise contents	Time
Gym Ball Stability Exercise	Warm-up	Angry cat, Chest & back stretching with the ball, Sitting position trunk side flexion on the ball, Supine pelvic rotation with the ball, Quadruped position arm gym ball roll out, Bird dog on the ball	10 min
	Main Exercise	Bridging on the ball, Supine gym ball arm-leg rich, Quadruped position arm side rich on the ball, Two arms rich trunk extension on the ball, Supine two-arm rotation with the ball, The scorpion (pelvic rotation) on the ball, Side lying trunk rotation on the ball	30 min
DNS Exercise	Main Exercise	Trunk flexion on knee band, Spider rotation, One arm horizontal rotation on knee band, Side lying one arm rich with band, DNS crawling, DNS 5-month position elbow support trunk DNS bear position arm crawling, DNS 8-month position arm rich, DNS 11-month position arm rich,	20 min

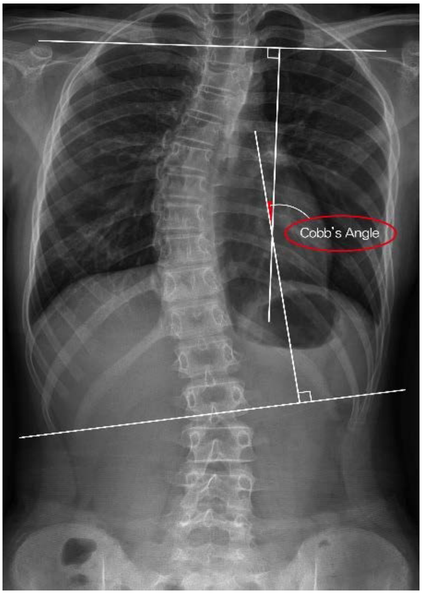

Fig. 2. Cobb's angle evaluation using X-ray imaging.

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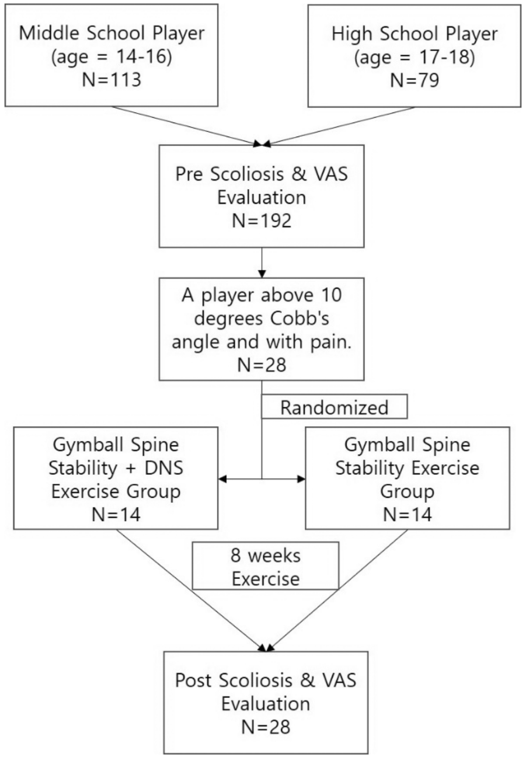

Fig. 3. Flow chart of the study.

used to compare the difference in the dependent variables, such as Cobb's angle and VAS scale ($\alpha = 0.05$).

3. Results

3.1. *Cobb's angle*

The ANOVA analysis showed significant decrease in Cobb's angle between the GSD and GS groups ($p < 0.001$), indicating that the GSD group was superior in the reduction of scoliosis angle than GS group (Table 3).

Table 3. Changes of Cobb's angle between GSD and GS group.

Variable	Group	Pre	After 8 weeks	*f*-value	Δ%	*p*
Cobb's Angle	GSD (N = 14)	16.21 ± 4.43	12.50 ± 2.87	61.791***	−3.71	0.001***
	GS (N = 14)	15.35 ± 3.79	14.19 ± 3.84	6.071*	−1.16	

Notes: Values are Mean ± SD. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
GSD = Gym Ball Stability with DNS Exercise Group
GS = Gym Ball Stability Exercise Group

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Table 4. Changes of VAS pain scale between GSD and GS group.

Variable	Group	Pre	After 8 weeks	f-value	Δ%	p
VAS	GSD ($N = 14$)	2.32 ± 0.99	0.32 ± 0.50	67.947***	−2.00	0.837
	GS ($N = 14$)	2.57 ± 1.22	0.50 ± 0.48	72.887***	−2.07	

Notes: Values are Mean ± SD. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
GSD = Gym Ball Stability with DNS Exercise Group
GS = Gym Ball Stability Exercise Group

3.2. *VAS score*

The ANOVA analysis showed no significant difference in VAS score between the GSD and GS groups ($p = 0.837$), supporting that the GS group was superior in the reduction of pain than GSD group (Table 4).

4. Discussion

The present randomized control trial is about the initial demonstration of the effects of the GS group and GSD group on the VAS pain scale and the Cobb's angle on thoracic and lumbar spine angle kinematics of youth baseball players. The aim of this study is to compare the effects of the DNS exercise on scoliosis in players with scoliosis youth baseball players. It was consistent with our hypothesis that the GSD group (−22%) had reduced Cobb's angles, compared to the case of gym ball exercise (−7%) alone. Most importantly, data on Cobb's angles demonstrated that DNS exercise had contributed to a clinically meaningful reduction in bilateral muscle imbalance and appearance of the spinous process.

An analysis on scoliosis revealed more significant reduction in Cobb's angles (mean difference between groups = 15%) in the GSD group compared to the GS group. This previous finding is consistent with Schroth Exercise for adolescents (mean age ± standard deviation = $15.50 \pm 1, 79$) recovering idiopathic scoliosis, which also shows a reduction in Cobb's angles (21%).[14] The DNS exercise is comparable to the Schroth Exercise among various exercises for scoliosis.

Our study found that the VAS scale had been reduced in both groups. Previous study assumed that GS could help reduce the risk of pain. The GS maintained the neutral spine and was suitable for targeting a specific function of local muscles in the early stages of motor programming to improve superficial spinal stability. Since the DNS involves the greater movement of the descending diaphragm than that of GS,[15] an effective intra-abdominal pressure is generated by the oblique chain. However, the GS is significantly effective for the pain control, compared to GSD.

There is one important underlying mechanism by which the DNS exercise enhances a decrease in pain and physical and social disabilities during daily activities, as evidenced by the VAS data.[16] A previous study by Kolar *et al.* (2014) proved that the abnormal postural activation of the diaphragm and the greater strain in the ventral region of the spine during isometric resistance could be a fundamental

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mechanism to the extremities of chronic low back pain. According to the previous author, the insufficient postural function of the diaphragm resulted in an implement to the control of thoracic compression and to the intra-abdominal pressure regulation and integrated spinal stabilizing system. The compensation activity of the superficial spine extensor increases the pressure on the spine and causes an abnormal location of the chest or ribs due to the imbalance between upper and lower chest musculature.[10]

A possible underlying rationale is that the DNS focuses on the thoracic-lumbar-hip chain's dynamic stabilization and axial elongation movement control,[17–19] whereas a gym ball emphasizes the selective activation of the latissimus dorsi and co-activation of the upper and lower abdominal muscles.[20] It has theorized that externally, the first oblique core chain is automatically stimulated immediately by the shoulder supporting zone interacting with the floor surface which generates the punctum fixum (stable basis) for the pectoralis — ipsilateral external oblique, rectus abdominis, contralateral internal oblique connected with transverse abdominis, multifidus, encapsulated by thoracolumbar fascia, hip muscles while another (second) oblique chain is facilitated as the ipsilateral hip supporting zone comes in contact with the surface, activating the opposite oblique chain muscles. These first oblique chains may be connected by the posterior chain muscles to correct and stabilize the cervical–thoracic–lumbar spinal segments during the dynamic hip movement of youth baseball players, producing an externally (negative) stabilizing force movement. The IAP force is internally generated by a deep diaphragm, transvers abdominis, pelvic floor, multifidus frontal and dorsal core chains during inspiration, which then provides a counterforce for the further improvement of the oblique chain.

When rehabilitating youth baseball players, one should not just focus on stretching or mobilizing a tight glenohumeral capsule/joint and on strengthening the local muscles, but one may require to ask the question of "why" the local muscles are being impaired. The movement pattern analysis (e.g. arm elevation or the throwing mechanics) must be performed, for the determining whether the core stability is adequate and/or if a "weak link" in the kinetic chain is present. Such weak links may include poor scapular dynamic stability, impaired lower extremity mobility, stability and/or proprioception, and poor trunk mobility or stability.[21]

In addition to our results that the gym ball exercise was effective for pain control, the DNS exercise was also effective for pain and scoliosis control.

Despite the meaningful findings, this study has limitations that it did not measure the anterior superficial, deep chain muscles and intra-abdominal pressure. Therefore, future studies are required to develop sophisticated sensors and MRIs to precisely measure the underlying chain muscle's motor control during dynamic movement.

5. Conclusion

In this study, we demonstrated the superior effects of the GS combined with the DNS on pain control, and of the control of a reduction in the scoliosis from youth baseball players when compared to the gym ball exercise alone. Most importantly, the DNS exercise rapidly improved Cobb's angles and relieved pain with improved cervical-thoracic-lumbar spinal stability. These promising results suggest that the use of exercises for scoliosis alongside the DNS exercise with a gym ball is beneficial for scoliosis patients with a core instability.

Ethical Compliance

Research experiments conducted in this paper with animals or humans were approved by the Ethical Committee and responsible authorities of our research organization(s) following all guidelines, regulations, legal, and ethical standards as required for humans or animals.

Conflict of Interest

There are no conflicts of interest to declare.

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