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Effects of Muscle Balance Therapy on Alleviating Pelvic Anterior Tilt in Middle-Aged Women

Gil-Ja Lee[1] and Myung-Sun Lee[*2]

[1]Graduate Student, Department of Beauty and Health Care, Daejeon University, 62 Daehak-ro, Dong-gu, Daejeon, 34520, South Korea

[*2]Professor, Department of Beauty Design, Daejeon University, 62 Daehak-ro, Dong-gu, Daejeon, 34520, South Korea

1001.ni@naver.com[1] and laura.2711@naver.com[*2]

Corresponding author*: laura.2711@naver.com

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ABSTRACT

Due to habitual poor posture and body movements, many people develop musculoskeletal disorders and experience changes in their body shape. This study aims to investigate the effects of muscle balance therapy on the improvement of body imbalances and vital capacity by applying them to the short & long lock muscles, which are imbalanced due to pelvic anterior tilt. As a result of the treatments, the muscle tone test reveals alleviation of muscle shortening in the upper trapezius, rectus femoris, and hamstrings, and the body imbalance test demonstrates that cervical, thoracic, pelvic, and knee tilts are aligned more closely with the sagittal vertical axis (0 degrees). These findings suggest that muscle balance treatments can positively affect the improvement of body imbalances

Keywords: Pelvic Anterior Tilt, Muscle Imbalances, Sagittal Plane (Lateral Body), Body Alignment, Vital Capacity, Muscle Balance Therapy

1. INTRODUCTION

The sedentary lifestyle of modern people has led them to suffer from musculoskeletal disorders and to have changes in body posture [1]. If one is sitting for a long time, the center of gravity of their body shifts to their pelvis, causing abdominal and back muscles fatigue. In particular, middle-aged women tend to slouch and stick their necks forward while sitting down, and they often develop a posture of protruding abdomen while standing. This is because their experiences of pregnancy, childbirth, and menopause have weakened their core and abdominal muscles, leading to instability in their pelvis [2].

The pelvis is a core skeletal structure in our body. It is central to the stability of our body, so habitually repeated poor postures and movements may cause detrimental changes to it, such as anterior or posterior pelvic tilts. Pelvic anterior tilt can be divided into two types: The tilt type, where the pelvis *tilts* forward, and the shift type, where the pelvis tilts and *moves* forward. The tilt type is characterized by the shortened rectus femoris due to knock-knee (Genu Valgum), while the shift type involves shortened hamstrings and imbalances in the lower body caused by back-knee (Genu Recurvatum) [3]. The issue of lower body imbalances may lead to excessive lumbar lordosis as they trigger the body's compensatory mechanism, which in turn lengthens the rectus abdominis and gluteal muscles while shortening the spinal erectors and upper trapezius. This results in a straight neck or turtleneck syndromes, characterized by a rounded back and forward head posture [2]. In other words, the anterior/posterior imbalances of the lower body caused by pelvic anterior tilt triggers the body's compensatory mechanism, leading to structural muscle imbalances of the entire body. These muscle imbalances cause abnormal curvature of the spine, and structurally shortened (locked-short) or lengthened (locked-long) muscles lead to restrictions in their own functional movements, thereby resulting in cosmetic changes [3].

A posture is considered ideal if one's joint axes are as close as possible to the midline while standing in the sagittal plane (line of gravity, LOG). The human body maintains a balanced muscle tone against gravity by regulating the tension (shortening) and relaxation (lengthening) of muscles along the body's anterior and posterior lines, and it also controls postures and movements by controlling muscle volume and pressure [4]. The body maintains optimal stability and moves freely without obstacles if the pelvis and spine are in a neutral position [5]. However, pelvic anterior tilt causes deviations in the cervical and thoracic spines, pelvis, and knees

from LOG due to imbalances between shortened and lengthened muscles. This also negatively affects respiratory function as it leads to a forward head posture [6].

The body imbalances caused by pelvic anterior tilt is not because of the damaged tissues but because of the prolonged persistence of abnormal posture. The holistic compensatory system of human body expands the local imbalances caused by the bad postures and accompanying muscle tensions to the overall muscle imbalances. Therefore, applying muscle balance therapy to locked-short and locked-long muscle is crucial for attaining proper body alignment [7].

Muscle balance therapy can alleviate muscle imbalances by directly stimulating the areas where muscle adhesion presents due to locked-short muscles, and they can improve the functional movements of these muscles by enhancing the flexibility and mobility of fascia [2,3]. Moreover, aligning the cervical and thoracic spines, pelvis, and knee to LOG will increase chest flexibility, thereby positively affecting respiratory capacity [8].

Previous studies on pelvic anterior tilt have mainly focused on pain relief or partial treatments of the body, such as the effects of rehabilitation exercise on the range of motion of the hip joint in patients with pelvic anterior tilt[9]; the effects of 12 weeks of weight training on the back pain scale and the angle of pelvic anterior tilt[10]; and changes in pelvic posture and back pressure pain thresholds due to the use of smartphones[11]. Some recent studies focus more directly on body alignment. These studies include: the effects of contract-relax interventions on pelvic alignment [12]; the effects of holistic myofascial release techniques on body alignment in the sagittal plane [13]; and the effects of manual therapy on improving lateral body imbalances [14]. However, they cannot provide a comprehensive answer to the issues of body alignment because they do not address the root of the problem: the holistic compensatory system of the body. From the perspective of the body's compensatory system, pelvic anterior tilt causes anterior-posterior imbalance issues in the lower body, and these issues lead to the disruption of posture in the sagittal plane since they may trigger muscle imbalances between abdomen and waist, chest and back, and neck and shoulders, which in turn may provoke several changes in one's body shape and reduction of vital capacity. This causal chain implies that without considering the holistic system, we cannot adequately address body alignment issues.

Therefore, this study 1) classifies pelvic anterior tilt into two types: tilt type and shift type, and 2) concentrates on the improvement of locked-short and locked-long muscles that restrict anterior/posterior pelvic movement. Throughout this process, the effects of muscle balance treatments on scoliosis and vital capacity will be verified, thereby suggesting strong evidence that muscle balance therapy are significantly useful for the improvement of body imbalances and musculoskeletal rehabilitation programs.

2. MATERIALS AND METHODS

2.1. *Research Participants*

This study recruited middle-aged women in their 50s from a church in Seo-gu, Daeieon, South Korea. They had not engaged in any treatments or exercises such as manual therapy, physical therapy, yoga, pilates, etc., in the past 6 months. After 3D body scan, 20 participants were selected excluding those who have pelvic posterior tilt. The purpose and procedure of the study were explained to the participants. After the sixth treatment, one participant in control group withdrew due to the infectious disease; other 19 participants consist of 9 in control group and 10 in test group finished treatments. The treatments were conducted once a week for eight weeks, from May 1st, 2023, to June 30th, 2023, and the results were analyzed as described in the following sections.

2.2. *RESEARCH METHODOLOGY*

2.2.1. Two Types of Pelvic Anterior Tilt

According to Janda's pelvic postures classification [3], pelvic anterior tilt can be classified into the tilt type that the pelvis is tilted, and the shift type that the pelvis is tilted and moved forward. The tilt type is characterized by the shortened rectus femoris (which acts as a femur extensor), hip and knee flexion, and the backward extension of a head which cause a straight neck syndrome and tension in the middle cervical spine. The shift type involves the forward movement of the pelvis relative to the feet, which shortens hamstrings, and the backward movement of the chest relative to the pelvis, resulting in upper cervical tension due to the turtleneck syndrome (as head is pushed forward relative to the chest) and back knees [2,3].

Table 1: Two Types of Pelvic Anterior Tilt

Category	Tilt type	Shift type
* Anterior/Posterior Myofascial Balance Treatment * Diaphragmatic Release	**Anterior:** Shortening of Rectus Femoris Shortening of Quadratus Lumborum (Middle Cervical	**Anterior:** Shortening of Hamstrings Shortening of Suboccipital Muscles (Upper Cervical Spine)

* Breathing Relaxation Treatment * Myofascial Release Therapy	Spine) **Posterior:** Lengthening of Hamstrings	**Posterior:** Lengthening of Rectus femoris
	Straight Neck Syndrome	Turtleneck Syndrome
	Knock Knees (Genu Valgum)	Back Knees (Genu Recurvatum)

2.2.2. Manual Movement Assessment for Setting Short & Long Lock Balance Treatment

① Cervical Spine Movement Assessment: Flexion, Extension

② Carpal Movement Assessment: Flexion, Extension

③ Spine Movement Assessment: Flexion, Extension, Lateral Flexion

④ Hip Joint: Flexion, Extension

⑤ If the premeasurements reveal that some participants already have scoliosis, check the status of their scoliosis (upper thoracic, middle thoracic, lower thoracic scoliosis).

⑥ Thomas Test (Muscle Tone Assessment)

2.2.3. Short & Long Lock Balance Treatment

Table 2: Short & Long Lock Balance Treatment

Category	Short Lock	Long Lock
Muscle Treatments	Relaxation Treatment; from Origin to Insertion / Prior Treatment	Reinforcement Treatment; From Insertion to Origin / Posterior Treatment
Treatments for Cross Syndrome	**Cervical Spine:** Reinforcement and Relaxation of Neck Flexors / Relaxation of Suboccipital Muscles, Upper Trapezius, Levator Scapulae **Thoracic Spine:** Relaxation of Pectoralis Major and Minor / Reinforcement of Rhomboids and Lower Trapezius **Lumbar Spine:** Reinforcement of Erector Spinae / Relaxation of Abdominal Muscles **Sacrum Spine:** Reinforcement of Gluteal Muscles / Relaxation of Iliopsoas **Thigh 1) Tilt Type:** Relaxation of Rectus Femoris / Reinforcement of Hamstrings **2) Shift Type:** Relaxation of Hamstrings / Reinforcement of Rectus Femoris	
Common Treatments	**Abdominal:** Reinforcement Treatment **Gluteal:** Reinforcement Treatment **Posterior Oblique Slingpos (POS)** **Scoliosis Treatment:** Reinforcement and Relaxation Treatments of Upper, Middle, Lower Thoracic	

2.3. ***MEASUREMENTS DEVICES AND METHODS***

2.3.1. Device for Measuring 3D Body Shape and Muscle Tone Analysis

The Moti-Physio from MG Solutions was used for measurement. This device analyzes muscles and skeletons through the Musculoskeletal Analysis Technology (MAT), developed based on Vladimir Janda's theory. According to Jang et al., its high reliability may substitute X-rays [15]. It uses an RGB-D camera to extract body images and predict skeletal points, and then makes a 3D musculoskeletal simulation to show current musculoskeletal issues. Participants should wear tight-fitting clothing and maintain their usual daily postures. The RGB-D camera will then automatically capture the front, lateral, and rear views of their body.

2.3.2. Device for Measuring Vital Capacity

The SPIRO LENIS was introduced to measure vital capacity. It specifically measures Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and Peak Expiratory Flow (PEF). After receiving a detailed explanation of the procedure, the participant stands upright, inhales as deeply and quickly as possible, and then exhales forcefully and fully as fast as possible. The best value from three consecutive attempts is recorded.

2.4. ***Data Analysis***

The collected data were statistically processed using the SPSS 25.0 program. Cronbach's alpha was calculated to assess the reliability of the measurement tools. An independent samples t-test was performed to verify

baseline homogeneity. A repeated measures two-way ANOVA was conducted to analyze changes in body imbalances between the experimental and control groups.

3. RESULTS AND DISCUSSION

3.1. *The Test for Baseline Homogeneity Between Groups*

The baseline homogeneity test confirmed that there is a homogeneity between the experimental group (EG) and control group (CG) before the intervention. The tests were made based on various factors such as Muscle Tone (Table 3), Lateral Body (Table 4), Scoliosis (Table 5), Vital Capacity (Table 6), and the results are as follows:

Table 3: The Baseline Homogeneity Test for Muscle Tone

Category	Groups	Number of Cases (N)	Mean (M)	Standard Deviation (SD)	*t-value*	*p*
Upper Trapezius	EG	10	80.3	18.123	1.896	0.077
	CG	9	67.22	11.508		
Rectus Femoris	EG	7	80.71	13.099	2.174	0.058
	CG	4	64.25	9.743		
Hamstrings	EG	3	68.67	14.742	1.134	0.3
	CG	5	54.8	17.669		

Table 4: The Baseline Homogeneity Test for Lateral Body Imbalances

Category	Groups	Number of Cases (N)	Mean (M)	Standard Deviation (SD)	*t-value*	*p*
Cervical Spine Tilt	EG	10	5.54	3.383	1.998	0.062
	CG	9	2.87	2.268		
Thoracic Spine Tilt	EG	10	5.58	1.953	-0.968	0.347
	CG	9	6.4	1.712		
Pelvic Tilt	EG	10	5.09	2.404	1.953	0.068
	CG	9	3.32	1.323		
Knee Tilt	EG	10	7.85	1.83	1.821	0.086
	CG	9	6.51	1.293		

Table 5: The Baseline Homogeneity Test for Scoliosis

Category	Groups	Number of Cases(N)	Mean (M)	Standard Deviation (SD)	*t-value*	*p*
Scoliosis	EG	10	4.5	3.894	1.781	0.093
	CG	9	1.78	2.539		

Table 6: The Baseline Homogeneity Test for Vital Capacity

Category	**Groups**	**Number of Cases (N)**	**Mean (M)**	**Standard Deviation (SD)**	***t-value***	***p***
FVC	EG	10	2.47	0.597	-0.543	0.594
	CG	9	2.61	0.516		
FEV1	EG	10	2.2	0.609	-0.257	0.8
	CG	9	2.27	0.487		
PEF	EG	10	4.52	2.001	-0.802	0.434
	CG	9	5.24	1.925		

FVC: Forced Vital Capacity, FEV1: Forced Expiratory Volume in 1 second, PEF: Peak Expiratory Flow

3.2. *Verifications of the Effects of Muscle Balance Treatment*

3.2.1. Verifications of the Improvements in Muscle Tone

All muscles move from the origin to the insertion when they contract. Overused muscles will be shortened, and these locked-short muscles function more forcefully than normal, while locked-long muscles become weakened. Of the two types of pelvic anterior tilt, the tilt type causes shortening of the rectus femoris in the lower body. In the shift type, where the pelvis moves forward relative to the feet, the hamstrings become shortened, causing the torso to shift backward to maintain balance. Consequently, the neck protrudes forward from the ideal position, leading to in the shortening of the upper trapezius [3,4]. In this research, muscle balance therapy, and hamstrings. See Table 7. were applied in different directions for locked-short and locked-long muscles. For locked-short muscles, the treatments were administered from the origin to the insertion direction, while for locked-long muscles, they were applied from the insertion to the origin. The results indicate that, in terms of muscle tone, muscle balance treatment can yield statistically significant improvements for achieving balance in

the upper trapezius, rectus femoris

Table 7: Variance Analysis of Muscle Tones at Different Measurement Times after Short & Long Lock Balance Treatment.

Category		Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	*F-value*	*p*
Rectus Femoris	Between-Group	Group	127.326	1	127.326	0.53	0.485
		Error	2160.917	9	240.102		
	Within-Group	Measurement Time	133.773	2	66.886	1.072	0.363
	Measurement Time	Group	585.288	2	292.644	4.691*	0.023
		Error	1122.833	18	62.38		
Hamstrings	Between-Group	Group	6.944	1	6.944	0.009	0.927
		Error	4512.222	6	752.037		
	Within-Group	Measurement Time	12.356	2	6.178	0.135	0.875
	Measurement Time	Group	701.356	2	350.678	7.665**	0.007
		Error	548.978	12	45.748		
Upper Trapezius	Between-Group	Group	32.928	1	32.928	0.064	0.804
		Error	8810.3	17	518.253		
	Within-Group	Measurement Time	672.547	2	336.274	3.874*	0.03
	Measurement Time	Group	1774.021	2	887.011	10.219***	0
		Error	2951.067	34	86.796		

Rectus Femoris *p<.05/Hamstrings **p<.01 /Upper Trapezius *p<.05, ***p<.001/

These results align with the postural alignment protocol, which aims to reduce the tone of the upper trapezius and improve the range of motion through the functional role of the lower trapezius [16]. Also, in terms of research methodology, they are similar to the studies which suggest that both active release and myofascial release treatments can reduce the tone of muscles especially the rectus femoris through the compression of soft tissues [17]. Moreover, they are consistent with studies that performed a straight leg raise test on the hamstrings and rectus femoris after participants achieved increased flexibility in the shortened hamstrings through PNF muscle relaxation techniques [18].

Due to anterior pelvic tilt, the shortening of rectus femoris in tilt type and of hamstrings in shift type cause a mutual compensatory mechanism of thoracic kyphosis and cervical lordosis, thereby leading to the shortening of the upper trapezius. Therefore, to improve not only the reduction of individual muscle shortening but also the overall improvement of muscle tone throughout the body, diaphragmatic releases on the occipital region, upper thoracic region, diaphragm, inguinal region, and posterior knees—areas that support the body and are involved in bodily movements—was performed during the 1st to 4th sessions [19]. For the 5th to 8th sessions, as shown in Table 2, pre-relaxation treatment from the origin to the insertion was applied to the locked-short rectus femoris, hamstrings, and upper trapezius, while reinforcement treatments from the insertion to the origin was applied to the locked-long cervical flexors, lower trapezius, and rhomboids. As a result, improvements in muscle tension could be observed in the rectus femoris, hamstrings, and upper trapezius.

3.2.2. Verification of Body Alignment in the Sagittal Plane

To achieve a proper body alignment in the sagittal plane, this study designed a research method that enables us to study posture changes with an integrated perspective and focused on the issue of attaining body balance in areas where upper and lower cross syndromes are present. As we can see in Table 2, the treatments first relaxed the locked-short muscles caused by the cross syndromes, followed by the reinforcement treatments for locked-long muscles. Moreover, a myofascial release technique (that can relax muscle stiffness) was applied along the direction of muscle fiber to the taut bands, namely, the collections of contracted muscles. The results of sagittal (lateral view) body alignment demonstrate that there are statistically meaningful improvements in the cervical and thoracic spines, pelvis, and knee angles. See Table 8;

Table 8: Variance Analysis of (Lateral) Body Alignments at Different Measurement Times after Short & Long Lock Balance Treatment.

Category		Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	*F-value*	*p*
Cervical Spine Tilt	Between-Group	Group	1.686	1	1.686	0.109	0.745
		Error	263.22	17	15.484		
	Within-Group	Measurement Time	9.258	2	4.629	1.15	0.329
	Measurement Time	Group	64.887	2	32.444	8.060**	0.001
		Error	136.855	34	4.025		
Thoracic Spine Tilt	Between-Group	Group	58.903	1	58.903	5.457*	0.032
		Error	183.486	17	10.793		
	Within-Group	Measurement Time	7.44	2	3.72	1.397	0.261
	Measurement Time	Group	19.989	2	9.995	3.754*	0.034
		Error	90.522	34	2.662		
Pelvic Tilt	Between-Group	Group	7.828	1	7.828	0.941	0.346
		Error	141.441	17	8.32		
	Within-Group	Measurement Time	6.96	2	3.48	3.456*	0.043
	Measurement Time	Group	8.682	2	4.341	4.311*	0.021
		Error	34.24	34	1.007		
Knee Tilt	Between-Group	Group	0.032	1	0.032	0.005	0.943
		Error	106.49	17	6.264		
	Within-Group	Measurement Time	6.32	2	3.16	1.587	0.219
	Measurement Time	Group	13.663	2	6.831	3.431*	0.044
		Error	67.697	34	1.991		

Cervical Spine Tilt **p<.01/Thoracic Spine Tilt *p<.05 /Pelvic Tilt *p<.05/ Knee Tilt *p<.05

The results are consistent with previous studies that report myofascial balance techniques will reduce myofascial tension and increase flexibility, thereby positively improving body alignment in the sagittal plane [13]. They also align with research that combine guidelines for proper posture with manual body shape treatment techniques [14]. This study focused more on the posterior oblique sling and flexed iliopsoas, as described in Table 2, in order to restore functions in areas with movement restrictions caused by upper and lower cross syndromes. As a result, improvements of body imbalances can be observed as the overall spinal alignment in the sagittal plane approaches closer to zero degrees (0°).

3.2.3. Effects on Scoliosis

Structural scoliosis can cause deformities if not properly treated. Moreover, if scoliosis is degenerative, it not only causes cosmetic issues but triggers several symptoms such as radicular pain, low back pain, intermittent claudication, gait disturbances, etc. The result on scoliosis demonstrates that the interactions between measurement time and group are statistically significant. See Table 9.

These results are consistent with previous studies, which suggest that muscle relaxation and posture correction exercises (aimed at achieving muscle balance and spine shape correction) can have a positive effect on improvements in scoliosis [20]. We can observe an improvement in scoliosis as a result of applying Short & Long Lock Balance therapy to the spinal erector muscles (upper, middle, and lower thoracic), following the manual assessment of scoliosis described in Table 2.

Table 9: Variance Analysis of Scoliosis at Different Measurement Times after Short & Long Lock Balance Treatment.

Category	Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	*F-value*	*P*
Scoliosis	Between-Group					
	Group	0.001	1	0.001	0	0.995
	Error	318.385	17	18.729		
	Within-					

	Group					
	Measurement Time	15.392	2	7.696	3.323*	0.048
	Measurement Time * Group	56.234	2	28.117	12.140***	0
	Error	78.748	34	2.316		

Scoliosis*p<.05, ***p<.001.

3.2.4. Effects on Vital Capacity

The most important cause of vital capacity reduction is body imbalances. Abnormal posture and body imbalances lead to the weakening of respiratory muscles. If the head is lowered due to the changes of body posture, vital capacity decreases by 19.9% [6].

The study of vital capacity in this paper measured forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and peak expiratory flow (PEF). The results demonstrate that the interactions between measurement time and group are statistically significant for all three parameters. See Table 10.

Table 10: Variance Analysis of Vital Capacity at Different Measurement Times after Short & Long Lock Balance Treatment.

Category		Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	*F-value*	*p*
FVC	Between-Group	Group	0.359	1	0.359	0.5	0.489
		Error	12.193	17	0.717		
	Within-Group	Measurement Time	0.251	2	0.125	2.115	0.136
	Measurement Time	Group	0.657	2	0.329	5.548**	0.008
		Error	2.015	34	0.059		
FEV1	Between-Group	Group	0.605	1	0.605	0.761	0.395
		Error	13.516	17	0.795		
	Within-Group	Measurement Time	0.319	2	0.159	3.089	0.059
	Measurement Time	Group	0.593	2	0.297	5.754**	0.007
		Error	1.753	34	0.052		
PEF	Between-Group	Group	0.095	1	0.095	0.011	0.916
		Error	141.43	17	8.319		
	Within-Group	Measurement Time	14.043	2	7.022	5.594**	0.008
	Measurement Time	Group	9.421	2	4.711	3.753*	0.034
		Error	42.675	34	1.255		

FVC **p<.01/FEV1 **p<.01/ PEF *p<.05, **p<.01

These results are consistent with research suggesting that the improvement of muscle tension and body alignment in the sagittal plane can lead to an expansion of vital capacity, as these factors not only improve scoliosis but also restore thoracic flexibility [8]. Therefore, achieving proper body alignment through the application of Short & Long Lock Balance Treatment can improve overall body imbalances and thereby positively affect vital capacity.

4. CONCLUSION

This paper classified pelvic anterior tilt into two types and applied Short & Long Lock Muscle Balance Therapy to them. The final conclusion of this paper can be drawn as follows.

First, this paper proved that muscle balance treatments have positive effects on alleviating muscle tone in body

shapes with muscle imbalances caused by pelvic anterior tilt.

Second, this paper demonstrated that muscle balance treatments can contribute to the improvement of body imbalances by aligning the cervical spine, thoracic spine, pelvic, and knee tilts closer to the vertical axis of the sagittal plane.

Third, this paper presented that muscle balance therapy can positively affect scoliosis and vital capacity.

Regions with locked-short and locked-long muscles are the products of a compensatory mechanism of the body, fundamentally triggered by pelvic anterior tilt. Muscle balance therapy applied on those regions can relieve muscle tone, improve body alignment in the sagittal plane, and contribute to the improvements in scoliosis and vital capacity.

Maintaining proper body alignment is essential for improving musculoskeletal disorders. However, it is challenging for one with misaligned body shapes to attain proper body alignment on their own. In this regard, the argument presented in this paper—that muscle balance therapy can achieve proper body alignment in the sagittal plane—holds practical significance; muscle balance therapy can significantly contribute to the improvement of musculoskeletal disorders.

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