1. Detailed Experimental Protocol for PNF Therapy

1） Scapular Diagonals

①) Diagonal Movements

Scapular and pelvic diagonal movements include anterior elevation–posterior depression and posterior elevation–anterior depression, forming an arc along the curvature of the participant's trunk. During diagonal movements, the participant should avoid rocking forward and backward.

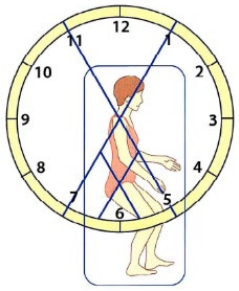

Figure 1 Scapular and Pelvic Diagonal Movements

②) Purpose

Scapular muscles control or influence the cervical and thoracic spine. They help coordinate movement, reduce fatigue of scapular or trunk muscles, and promote cervical and upper-limb motion and stability. Upper-limb function also requires adequate scapular mobility and stability, which may help improve uneven shoulders and thoracic kyphotic posture.

Table 1 ScapularMuscles Involved in Movement

Movement	Muscles
Anterior elevation	levator scapulae, rhomboids, serratus anterior
Posterior depression	lower serratus anterior, rhomboids, latissimus dorsi, lower trapezius
Posterior elevation	trapezius, levator scapulae, rhomboids
Anterior depression	rhomboids, serratus anterior, pectoralis minor, pectoralis major

③) Resisted scapular anterior elevation

The participant lies in a side-lying position. The scapula is drawn downward and backward toward the lower thoracic spine, so that the inferior angle rotates toward the spine. The glenohumeral joint complex is positioned posterior to the mid-axillary line, and the anterior cervical muscles are tense. During this process, avoid lifting the participant's head, rolling the trunk backward, and rotation of adjacent spinal segments. The examiner applies an arc-shaped line of resistance to the participant's scapula, resisting the inferior angle along the direction of the spine. Hand placement is anterior to the glenohumeral joint, with both hands grasping the acromion to apply pressure. The participant then moves the scapula upward and forward, bringing the acromion toward the nose. The scapular retractors and depressors are stretched; the inferior angle moves away from the spine, and the scapular retractors and depressors are activated.

④) Resisted scapular posterior depression

The participant lies in a side-lying position. The scapula is pushed anteriorly and superiorly, with the inferior angle moving away from the spine until the muscles posterior and inferior to the scapular spine become tense. During this process, avoid rolling the participant forward. The examiner applies an arc-shaped line of resistance, resisting movement of the inferior angle away

from the spine. As the scapula moves posteriorly, resistance is directed anteriorly; at the end of the movement, resistance is directed upward with a rotational component away from the spine. Hand placement: the heels of both hands are placed along the vertebral border of the scapula; the fingers rest on the scapula pointing toward the acromion, applying pressure below the scapular spine. The participant then depresses and retracts the scapula; the glenohumeral joint complex is posterior to the mid-axillary line, and the vertebral border of the scapula lies flat.

Figure2 Resisted ScapularAnterior Elevation Figure 3 Resisted ScapularPosterior Depression

⑤) Resisted scapular anterior depression

The participant lies in a side-lying position and lifts the scapula upward and posteriorly. The glenohumeral joint complex is positioned posterior to the mid-axillary line, and the abdominal wall muscles are tightened. Avoid rolling the participant backward or rotating adjacent spinal segments. The examiner applies resistance along the curvature of the participant's body. Hand placement: one hand is positioned behind the shoulder, with the fingers grasping the lateral border of the scapula; the other hand is placed anterior to the shoulder to grasp the axillary border of the pectoralis major and the coracoid process. The participant then rolls forward.

⑥) Resisted scapular posterior elevation

The participant lies in a side-lying position. The scapula moves in an arc anteriorly and inferiorly toward the contralateral iliac crest, with the inferior angle moving toward the spine until the trapezius tightens. Avoid rolling the participant forward or rotating adjacent spinal segments. The examiner applies resistance along the curvature of the participant's body. Hand placement is behind the upper trapezius, with both hands overlapped and maintained above the scapular spine.

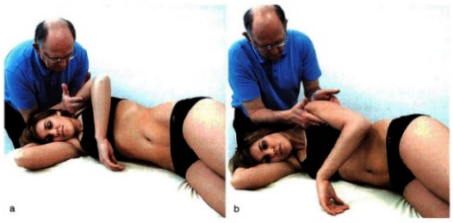

Figure 4 Resisted ScapularAnterior Depression Figure 5 Resisted Scapular

2） Pelvic Diagonals

①) Purpose

Pelvic muscles play a role in controlling or influencing pelvic alignment. They help coordinate movement and prevent or reduce fatigue of the working muscles, promote trunk and lower-limb movement and stability, and have significant effects on improving pelvic height asymmetry, tilt, and rotation.

Table 2 PelvicMuscles Involved in Movement

Movement	Muscles
Anterior elevation	internal oblique, external oblique
Posterior depression	contralateral internal obliqueexternal oblique
Posterior elevation	ipsilateral quadratus lumborum, ipsilateral latissimus dorsi, iliopsoas, longissimus thoracis
Anterior depression	contralateralquadratus lumborum, latissimus dorsi, iliopsoas, longissimus thoracis

②) Resisted pelvic anterior elevation

The participanta side-lying position, pelvisPosterior depressiondirection, arc-shapedposterior to contralateral, AvoidThe participantposteriorspinerotation. The examinerapplyresistance, Hand placement. ThenThe participantpelvissuperior, , trunk.

③) Resisted pelvic posterior depression

The participanta side-lying position, anteriorcontralateral, AvoidThe participantanteriorspinerotation. The examinerThe participantapply, anterior, Hand placement, direction. ThenThe participantpelvisposterior, trunk.

Figure 6 Resisted PelvicAnterior Elevation Figure7 Resisted PelvicPosterior Depression

④) Symmetrical and Asymmetrical Exercises

Symmetrical exercise: both pelvis and scapula move anteriorly or posteriorly

Asymmetrical exercise: scapular and pelvic diagonals are opposite and non-parallel

3） Upper Limb Diagonals

①） Diagonal Movements

Upper-limb diagonal movements primarily include two diagonals: flexion–abduction–external rotation with extension–adduction–internal rotation; and flexion–adduction–external rotation with extension–abduction–internal rotation. The shoulder and the wrist–hand complex are linked and work synergistically within these patterns.

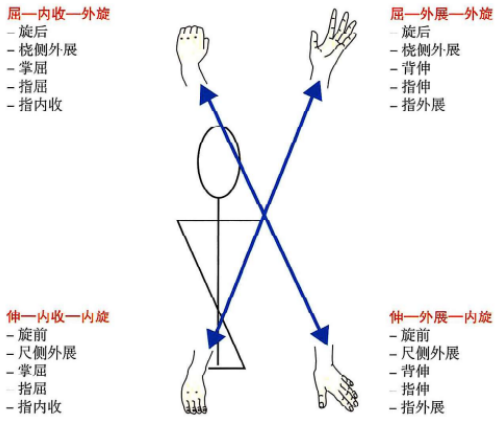

Figure 8 Upper-limb Diagonals

②） Purpose

Arm patterns are three-dimensional spiral movements connected to the trunk. They are commonly used to treat functional impairments caused by neurological problems, muscle disorders, or limited joint mobility, and are also applied in trunk training. Resisted activation of the upper-limb muscles can produce irradiation effects that facilitate weaker muscles in other regions.

Table 6Upper-limbMuscles Involved in Movement

Movement	Muscles
scapulaPosterior elevation	trapezius, levator scapulae, serratus anterior
scapulaPosterior depression	rhomboids
scapulaAnterior elevation	serratus anterior, trapezius
scapulaAnterior depression	serratus anterior, pectoralis minor, rhomboids
flexionabductionexternal rotation	deltoid, biceps brachii, coracobrachialis, supraspinatus, infraspinatus, teres minor
flexionadductionexternal rotation	pectoralis major, deltoid, biceps brachii, coracobrachialis
extensionadductioninternal rotation	pectoralis major, teres major, subscapularis
extensionabductioninternal rotation	latissimus dorsi, deltoid, triceps brachii, teres major, subscapularis
Elbow Extension	triceps brachii, anconeus
Elbow Flexion	biceps brachii, brachialis
Forearm Pronation	brachioradialis, pronator muscles
Forearm Supination	biceps brachii, brachioradialis, supinator
Wrist Ulnar Deviation	flexor carpi ulnaris
Wrist Radial Deviation	extensor carpi radialis
Finger Flexion with Radial/Ulnar Deviation	finger flexors, lumbricals, interossei
Finger Extension with Radial/Ulnar Deviation	extensor digitorum, lumbricals, interossei
Thumb Flexion–Adduction–Opposition	thumb flexors, adductor pollicis, opponens pollicis
Thumb Extension–Abduction	Thumb extensors, Extensor pollicis longus

③） Flexion–abduction–external rotation with elbow flexion (or elbow extension)

The participant lies in a **supine or standing position**, with the wrist placed in **ulnar deviation** and the forearm in **pronation**, maintaining the position of the wrist and hand. The elbow is flexed while the shoulder moves into **extension and adduction**, and the trunk laterally flexes to the right. Excessive wrist flexion should be avoided. The examiner's proximal hand moves upward to grasp the humerus or scapula, encircling the humerus medially and applying pressure opposite to the direction of movement, while providing traction to the participant's shoulder and hand. As the wrist moves into **radial deviation**, the fingers and thumb extend, and the radial side leads the shoulder into **flexion with abduction and external rotation**, with the scapula moving into **posterior elevation**. The examiner's distal hand applies rotational resistance through traction on the extended wrist, resisting **radial deviation**, **forearm supination**, and **shoulder external rotation**. The line of resistance is directed posteriorly toward the starting position, while maintaining traction to guide resistance along an appropriate arc. The participant then achieves full humeral flexion, with the scapula in posterior elevation, the elbow flexed (or extended), the wrist fully radially deviated, and the fingers and thumb deviated radially.

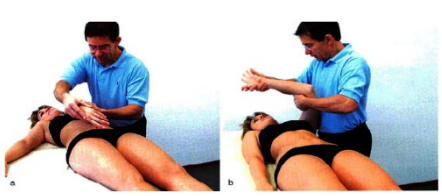

Figure 9 Flexion–abduction–external rotation with elbow flexion

Figure 10 Flexion–abduction–external rotation with elbow extension

④） Extension–adduction–internal rotation with elbow extension (or elbow flexion)

The participant again lies in a **supine or standing position**, with the wrist placed in **radial deviation** and the forearm in **supination**, lengthening the shoulder and scapular muscles. Full humeral flexion (or extension) drives the scapula into **posterior elevation**. The examiner's distal hand contacts the palmar surface of the participant's hand, with the fingers on the radial side and the thumb applying low pressure along the ulnar border. The proximal hand encircles the inferior aspect of the humerus, guiding the participant's trunk to be diagonally lengthened from left to right with a quick traction combined with rotation, while avoiding excessive shoulder flexion and wrist hyperextension. The examiner's distal hand applies traction and rotational resistance at the participant's flexed wrist to resist **ulnar deviation**, **forearm pronation**, and **shoulder adduction and internal rotation**. The proximal hand combines traction with rotational resistance, with the line of resistance directed toward the starting position and applied along an arc. The participant then moves the scapula into **anterior depression**, with the shoulder performing **extension, adduction, and internal rotation**, crossing and stabilizing beyond the midline to the right. The forearm pronates, the elbow fully extends (or flexes), and the wrist and fingers flex, with the palm facing the right iliac crest.

Figure 11 Extension–adduction–internal rotation with elbow extension

Figure 12 Extension–adduction–internal rotation with elbow flexion

⑤） Flexion–adduction–external rotation with elbow flexion (or elbow extension)

The participant lies in a supine or standing position, with the wrist placed in ulnar deviation and the forearm in pronation. The shoulder moves into extension and abduction, and traction facilitates the scapula into posterior depression. The trunk shortens with left lateral flexion, while excessive internal rotation that would cause anterior scapular tilting is avoided. The examiner's distal hand contacts the palmar surface of the participant's hand, while the proximal hand grasps the forearm; when the elbow is flexed, the humerus is grasped. Rapid traction and rotational input are applied to the shoulder joint and scapula.

The examiner's distal hand applies traction to the flexed wrist combined with rotational

resistance against radial deviation. Rotational resistance at the wrist provides resistance to forearm supination, shoulder adduction, and external rotation, while resisting flexion of both the wrist and shoulder. The line of resistance is directed toward the starting position, with traction maintained to guide resistance along an arc. The participant then moves the scapula into anterior elevation, with the shoulder performing flexion and adduction accompanied by external rotation. The humerus crosses the midline, the forearm supinates, the elbow flexes (or extends), and the hand may reach the right ear, inducing trunk rotation and elongation.

Figure 13 Flexion–adduction–external rotation with elbow flexion Figure 14 Flexion–adduction–external rotation with elbow extension

⑥） Extension–abduction–internal rotation with elbow extension (or elbow flexion)

The participant lies in a supine or standing position, with the wrist placed in radial deviation and the forearm in supination, maintaining the position of the wrist and hand. The shoulder moves into flexion and adduction, facilitating anterior elevation of the scapula and lengthening the shoulder musculature. The elbow is fully extended (or flexed), promoting trunk elongation with rightward rotation. The examiner's distal hand grasps the dorsum of the participant's hand, while the proximal hand grasps the medial aspect of the forearm, simultaneously providing traction to the shoulder and hand. The proximal hand applies rapid traction with rotation to the shoulder and scapula, while the distal hand applies traction to the wrist.

During wrist extension, the examiner's distal hand applies rotational resistance against ulnar deviation, with wrist rotational resistance opposing forearm pronation and shoulder internal rotation and abduction. The participant then moves the scapula into full posterior depression, the humerus extends toward the left, the forearm pronates, and the wrist assumes ulnar deviation.

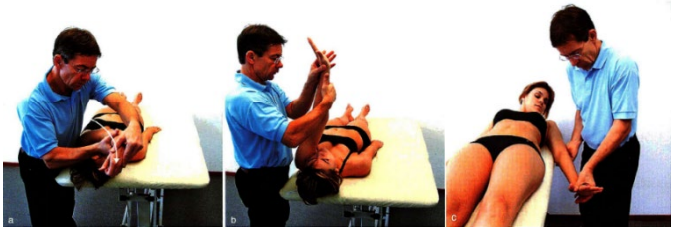

Figure 15 Extension–abduction–internal rotation with elbow extension

⑦) **Bilateral Arm Pattern Combinations**

- **Bilateral symmetrical:** flexion–abduction–external rotation
- **Bilateral asymmetrical:** right arm flexion–abduction–external rotation; left arm flexion–adduction–external rotation
- **Bilateral symmetrical alternating:** right arm flexion–abduction–external rotation; left arm extension–adduction–internal rotation
- **Bilateral asymmetrical alternating:** right arm extension–adduction–internal rotation; left arm flexion–adduction–external rotation

Positions: side-lying, elbow-supported, sitting, quadruped, and kneeling positions.

4） Neck Diagonals

①) Diagonal Movements

Cervical patterns include flexion, extension, lateral flexion, and rotation, using the nose, chin, and vertex lines as movement axes.

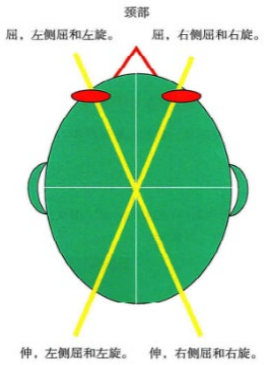

Figure 16 Scapular and Pelvic Diagonal Movements

②) Purpose

Optimal head control and correct cervical alignment and mobility form the foundation for performing activities of daily living. These patterns help guide trunk movement, improve posture, and produce irradiation effects to other parts of the body.

Table 7Cervical Flexion, Lateral Flexion, and RotationMuscles Involved in Movement

Movement	Muscles
flexion	longus capitis, rectus capitis anterior, suprahyoid muscles, infrahyoid muscles
flexion	longus colli, platysma, anterior scalene, sternocleidomastoid
rotation	scalenes, ipsilateralsternocleidomastoid, longus capitis, longus colli, rectus capitis anterior
lateral flexion	longus colli, scalenes, sternocleidomastoid
extension	iliocostalis, longissimus capitis, obliquus capitis muscles, rectus capitis posterior muscles, semispinalis capitis, splenius capitis, trapezius
extension	iliocostalis cervicis, longissimus cervicis, splenius cervicis, multifidus, rotatores, semispinalis cervicis, splenius cervicis, trapezius
rotation	multifidus, rotatores, semispinalis capitis, ipsilateraltrapezius, , splenius cervicis, splenius capitis
lateral flexion	iliocostalis cervicis, intertransversarii, longissimus capitis, , splenius cervicis, splenius capitis, trapezius

③) neckflexion-lateral flexion-

The participant sits with the chin elevated, the neck lengthened, and the head rotated and tilted to the right, stretching the soft tissues on the left side of the neck. Avoid compressing the participant's facet joints. The examiner instructs the participant to rotate the chin to the left, retract the chin, and look down toward the hip. The examiner's right hand applies traction along the mandibular line and provides resistance against left rotation, while the left hand applies a rotational force to the posterior aspect of the head. Hand placement: the left hand supports the vertex slightly left of the midline; the right hand is placed beneath the participant's chin and lifts along the diagonal direction. The participant then moves into full flexion of the head, neck, and upper thoracic spine.

④) neckextension-lateral flexion-

The participant sits with the chin retracted and the neck flexed. The head is rotated and tilted to the left, stretching the soft tissues on the right side of the neck. Avoid compressing the participant's facet joints. The examiner instructs the participant to rotate the chin to the right and

lift the head to look upward. The examiner's right hand applies pressure along the mandibular line, providing resistance to right rotation, while the left hand applies a rotational force to the posterior aspect of the head. Hand placement: the right hand is placed at the center of the chin; the left hand supports the vertex slightly right of the midline. The participant then positions the head, neck, and upper thoracic spine in extension and elongation.

Figure 17 Neck flexion–left lateral flexion–left rotation Figure 18 Neck extension–right lateral flexion–right rotation

5） Trunk Diagonals

①) Diagonal Movements

Trunk diagonal movements include flexion/extension, lateral flexion, and rotation, spanning from the coracoid process to the contralateral anterior superior iliac spine, representing trunk side-bending with rotational flexion or extension.

②) Purpose

Trunk control is the foundation for supporting limb movement. Resisted trunk patterns provide irradiation for indirect treatment of the cervical and scapular muscles and can be effective for managing thoracic kyphosis, lumbar lordosis, or scoliosis.

Table 8 Trunk Muscles Involved in Movement

Movement	Muscles
Chopping to the left	Left external oblique, rectus abdominis, right internal oblique
Bilateral lower-limb flexion to the left	Left internal oblique, rectus abdominis, right external oblique
Lifting up to the right	Cervical and back extensors, left multifidus and rotatores
Bilateral lower limbs to the right	Back and cervical extensors, right quadratus lumborum, left multifidus and rotatores
With extension bias and rotation	Quadratus lumborum, iliocostalis lumborum, longissimus thoracis, latissimus dorsi
With flexion bias and rotation	Right internal oblique, right external oblique

③) Chopping

The participant lies in a supine position (to facilitate trunk flexors). The left arm is in flexion–adduction–external rotation; the right hand grasps the left wrist, and the right arm is in abduction and external rotation. Traction is applied to the left arm and scapula to lengthen the arm and trunk muscles. The examiner's left hand grasps the participant's left wrist, and the right hand is placed on the participant's forehead with the fingers pointing toward the vertex, applying resistance to the arm movement and guiding both arms toward the contralateral shoulder. The examiner primarily guides head and neck movement to facilitate trunk activation. The participant moves the arms and head against resistance, maintaining contraction of the trunk flexors. Then the

participant laterally flexes the upper trunk to the left as much as possible.

④) Lifting

The participant lies in a supine position (to prevent excessive cervical and lumbar lordosis during movement). The left arm is in extension–adduction–internal rotation; the right hand grasps the wrist, and the right arm is in extension–abduction–internal rotation. The participant looks at the left hand, the neck laterally flexes to the right, and traction is applied to the left arm and scapula to lengthen the arm and trunk muscles. The head and neck extend toward the left; the upper trunk moves into extension with left rotation and left lateral flexion. The examiner's left hand grasps the participant's left wrist, and the right hand is placed on the top of the head. Resistance is applied to the arm and head and transmitted toward the contralateral hip to facilitate activation of the back extensors. The arm and head complete the movement against resistance while maintaining contraction of the trunk extensors. Then the participant fully flexes both arms, extends the head toward the left, and extends and lengthens the trunk to the left.

Figure 19 Chopping

Figure 20 Lifting

⑤) Bilateral Lower Limbs Facilitating Trunk Flexion

The participant sits supported at the edge of a platform/step. The left leg is extended–abducted–internally rotated; the right leg is extended–adducted–externally rotated. The trunk is extended and lengthened to the left with left rotation and lateral bending, avoiding excessive lumbar extension. The examiner's left hand grasps both feet and resists rotation of the trunk and hips. Then the participant fully flexes, adducts, and internally rotates the right leg, and fully flexes, adducts, and externally rotates the left leg; the lower trunk flexes with rotation and right lateral flexion.

⑥) Bilateral Lower Limbs Facilitating Trunk Extension

The participant sits supported at the edge of a platform/step. Both legs are flexed to the right: the right leg in flexion–abduction–internal rotation with knee flexion; the left leg in flexion–adduction–external rotation with knee flexion. The trunk is lengthened with rotation and left lateral bending, then moves into flexion with rotation and right lateral flexion, avoiding excessive lumbar extension. The participant's left hand grasps both feet; the right arm is placed under the participant's thighs. Pressure applied to the feet resists trunk and hip rotation. Then the participant extends the left leg into abduction and internal rotation and extends the right leg into adduction and external rotation; the lower trunk is lengthened with rotation and left lateral flexion.

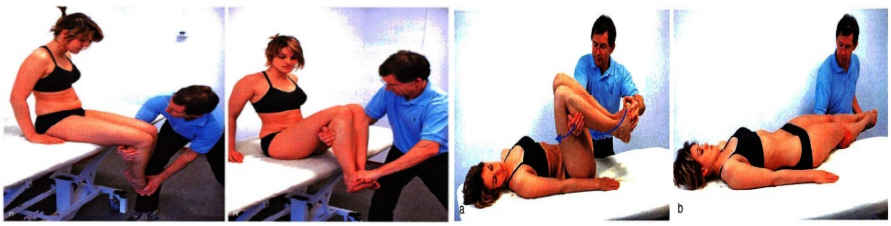

Figure 21 Bilateral Lower Limbs Facilitating Trunk Flexion

Figure 22 Bilateral Lower Limbs Facilitating Trunk Extension

⑦) Left lateral flexion with flexion bias

The participant sits supported at the edge of a platform/step and performs full hip rotation while performing trunk motion with a flexion bias. The examiner provides traction through the femur, shortens the hip into flexion, applies lateral pressure to resist hip lateral movement, and stabilizes both knees and feet to resist hip rotation. Then the participant rotates both hips to the left; the lumbar spine bends to the left, and the pelvis moves toward the rib cage.

⑧) Right lateral flexion with extension bias

The participant sits supported at the edge of a platform/step. With both legs fully flexed to the left, the participant begins full hip rotation. The examiner instructs a static contraction of hip and knee extension; the examiner resists hip extension and lateral movement, while the distal hand stabilizes the knee and foot to resist dynamic hip rotation. Then the participant fully rotates both hips to the left; the lumbar spine extends and bends to the right.

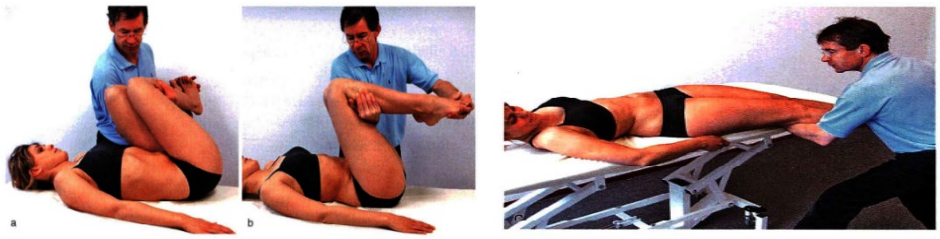

Figure 23 Right Lateral Flexion with Extension Bias

Note: The images above are sourced from the book Practical PNF (5th ed.): Illustrated Guide to Proprioceptive Neuromuscular Facilitation Techniques.

2. Detailed Experimental Protocol for SPS Training

1） Muscle Chain Anatomy

①) ES (Erector Spinae) muscle chain: erector spinae, longissimus thoracis, iliocostalis, piriformis, gluteus maximus, adductor magnus, biceps femoris, semitendinosus, semimembranosus, peroneal muscles

②) OL (Quadratus Lumborum) muscle chain: rectus capitis posterior major, semispinalis capitis, semispinalis cervicis, quadratus lumborum, intertransversarii, intertransverse ligaments, iliacus, rectus femoris, biceps femoris, peroneal muscles, soleus

③) SA (Serratus Anterior) muscle chain: splenius capitis, rhomboids, transversus thoracis, serratus anterior, external oblique, internal intercostals, serratus posterior inferior, internal oblique, transversus abdominis, gluteus maximus, fascia lata, adductor group, soleus, tibialis anterior, tibialis posterior

④) PM (Pectoralis Major) muscle chain: transversus thoracis, pectoralis major, external oblique, internal oblique, internal intercostals, serratus posterior inferior, transversus abdominis, gluteus maximus, fascia lata, tibialis anterior, tibialis posterior

⑤) LD (Latissimus Dorsi) muscle chain: latissimus dorsi, rotatores, levator costarum, external intercostals, external oblique, gluteus maximus, fascia lata, sartorius, adductor group, soleus, tibialis anterior, tibialis posterior

⑥) TR (Trapezius) muscle chain: trapezius, rotatores, levator costarum, external intercostals, transversus thoracis, external oblique, transversus abdominis, serratus posterior inferior, internal oblique, psoas major, gluteus maximus, adductor group, hamstrings, soleus, tibialis

anterior, tibialis posterior

⑦) IP (Iliopsoas) muscle chain: rectus capitis anterior, longus capitis, longus colli, spinalis, psoas major, biceps femoris, peroneal muscles

⑧) RA (Rectus Femoris) muscle chain: sternocleidomastoid, anterior scalene, pectoralis minor, external intercostals, sternalis, rectus abdominis, gracilis, flexor hallucis longus

⑨) SS (Semispinalis) muscle chain: rectus capitis posterior major, semispinalis cervicis, scalenes, levator costarum, external intercostals, quadratus lumborum, external oblique, multifidus, psoas major, gluteus medius, hamstrings, vastus lateralis, soleus, peroneal muscles

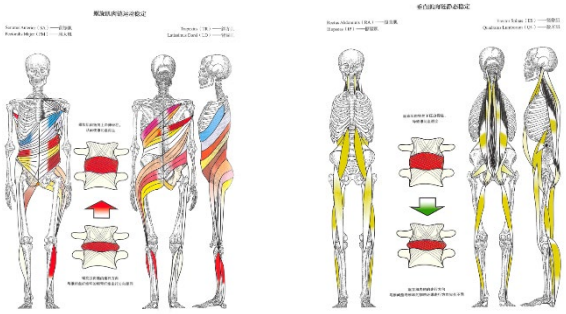

Figure 1 Dynamic Stability Diagram of Spiral Muscle Chain Movements

Figure 2 Static Stability Diagram of Vertical Muscle Chains

2） Reciprocal Inhibition within the Muscle Chain

①) Active inhibition: contraction of agonists within the spiral muscle chains TR (trapezius) and LD (latissimus dorsi) relaxes the vertical muscle chains ES (erector spinae) and IP (iliopsoas); this occurs during standing exercises.

②) Postural response: increased plantar pressure enhances activation of abdominal muscles that stabilize posture; this reflects the motor nervous system for postural maintenance.

③) Sensorimotor effect: activation of spiral muscle chains TR and LD activates the center of the foot, increases leg muscle tone, generates trunk traction, and stretches/elongates the spine; this reflects the motor nervous system governing movement.

④) Spiral stabilization “muscle straps”: the muscle straps stabilize the spine, straighten it along the midline, provide centralized traction, and maintain stable movement of the spine.

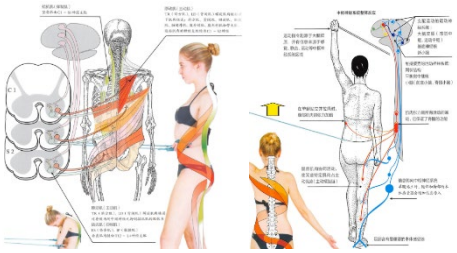

Figure 3 Schematic Diagram of Active Inhibition in Muscle Chains

Figure 4 Whole-System Response Diagram of the Central Nervous System

3） Spiral Stabilization Training Method

①) Training 1A, 3A, and 4A

The participant faces (or stands with the back to) the elastic band, standing (or kneeling) in a relaxed posture. Both arms cross in front of the body, the back is rounded, and the legs are slightly flexed. The hips are stabilized, the pelvis is aligned, and lumbar lordosis is reduced/straightened, gradually forming standing balance. At the same time, the elbows are pulled downward and gradually approach the posterior trunk; the palms face upward, and the area below the elbows

approaches the spine.

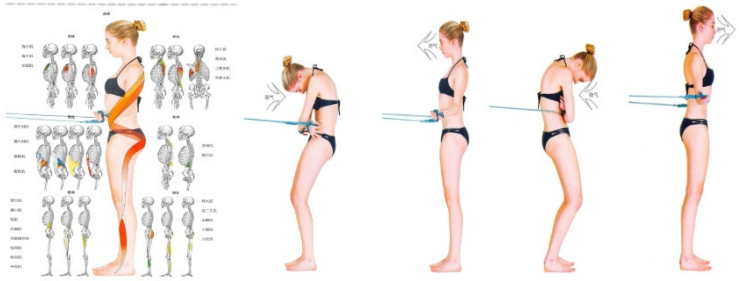

Figure 5 Muscle Balance Diagram for Training 1A/2A/3A

Figure 6 Training 1A and 3A Movement Illustration

②) Training 2A

The participant stands relaxed, side-on to the elastic band. The back is rounded, the legs are slightly flexed; stabilize the hips, align the pelvis, and straighten lumbar lordosis, gradually forming standing balance. The right (or left) elbow is pulled horizontally backward, gradually approaching the posterior trunk; the right (or left) scapula moves toward the spine and slightly depresses, with the training-side shoulder lower than the contralateral side. Then the participant raises the right (or left) hand over the head and moves it backward until the forearm is level and extended; the palm faces upward. The right scapula draws firmly toward the spine and depresses.

The participant stands with the back to the elastic band, rounds the back, slightly flexes the legs, stabilizes the hips, aligns the pelvis, and straightens lumbar lordosis to gradually form standing balance. The elbows are pulled backward, gradually approaching the posterior trunk; the palms face upward, and the area below the elbows approaches the spine.

Figure 7 Training 2A Movement Illustration

Figure 8 Training 4A Movement Illustration

③) Training 5A

The participant faces the elastic band and kneels on one knee on a mat; the left leg is extended. Both arms move toward the knee side of the flexed leg. The back is rounded; both arms pull toward the mat. Stabilize the hips, align the pelvis, and straighten lumbar lordosis. The body gradually becomes upright along the vertical axis. The elbows are pulled backward, gradually approaching the posterior trunk; the palms face upward, and the scapulae draw toward the spine.

④) Training 6A

The participant faces away from the elastic band, lifts the arms backward, and pushes the elbows and palms backward as far as possible; lift the head. The arms are fully raised and extended; the rear knee flexes. The body continues to bend downward, pulling the chest toward the pelvis, and the arms slowly extend to complete a circular movement.

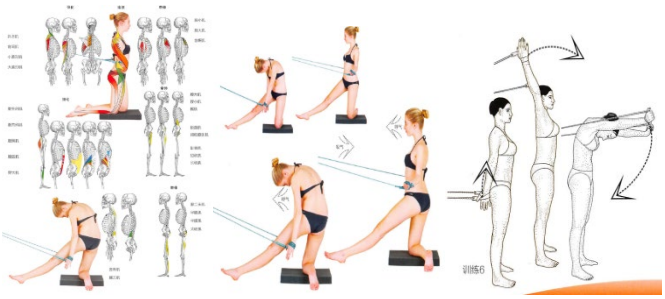

Figure 9 Muscle Balance Diagram for Training 4A/5A

Figure 10 Training 5A Movement Illustration

Figure 11 Training 6A Movement Illustration

⑤) Training 7C

The participant faces the elastic band, stands relaxed, rounds the back, and slightly flexes the legs. The left (or right) arm naturally extends forward. Stabilize the hips, align the pelvis, and straighten lumbar lordosis to gradually form standing balance. The left (or right) elbow is pulled backward to the back with the palm facing upward. The inferior part of the left (or right) scapula draws forcefully toward the spine and slightly depresses. Alternating leg lifts are performed by hip hiking.

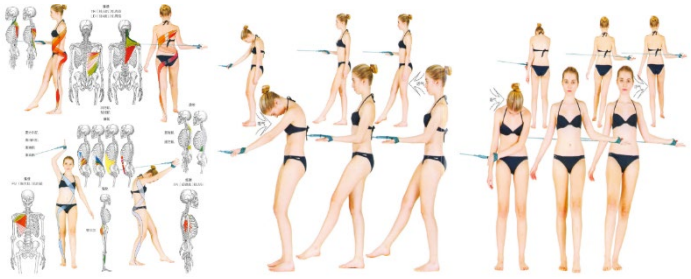

Figure 12 Muscle Balance Diagram for Training 7/8/9/10C

Figure 13 Training 7C Movement Illustration

Figure 14 Training 8C Movement Illustration

⑥) Training 8C

The participant stands relaxed side-on to the elastic band, rounds the back, and slightly flexes the legs. The left (or right) arm naturally extends in front of the body toward the right (or left) side. Stabilize the hips, align the pelvis, and straighten lumbar lordosis to gradually form standing balance. The left (or right) arm is lifted overhead and extended backward until the forearm is level and extended; the palm faces upward. The left (or right) scapula draws firmly toward the spine and depresses. Alternating leg lifts are performed by hip hiking.

⑦) Training 9C

The participant stands relaxed with the back to the elastic band. Stabilize the hips, align the pelvis, and straighten lumbar lordosis to gradually form standing balance. The left arm is pulled backward over the head; the head lowers and the chest moves toward the pelvis. The back is rounded, and alternating leg lifts are performed by hip hiking.

⑧) Training 10C

The participant stands relaxed side-on to the elastic band with both legs extended. The left (or right) arm naturally extends to the side; stabilize the hips. The left (or right) arm is pulled to the front of the body and upward over the head. Alternating leg lifts are performed by hip hiking.

4） Stretching Exercises

①) Training 33

The participant stands relaxed beside the exercise bar. Both hands firmly grasp the bar, and the legs are crossed. The left (or right) hip is stabilized, and the pelvis is pushed anteriorly and inferiorly.

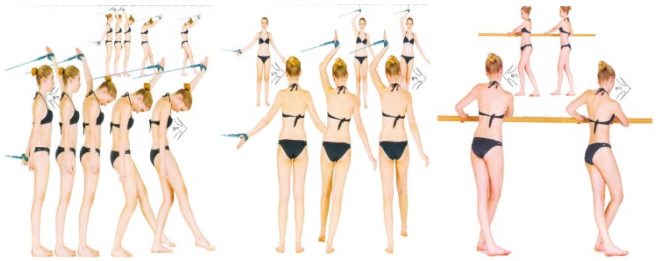

Figure 15 Training 9C Movement Illustration

Figure 16 Training 10C Movement Illustration

Figure 17 Training 33 Movement Illustration

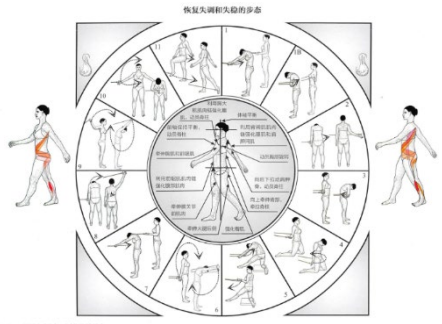

Figure 18 Gait Adjustment Diagram for 11 Training Movements

Note: The images above are sourced from the book Spiral Muscle Chain Training: Treatment for Disc Herniation and Scoliosis .

3. Experimental Schedule for PNF Therapy and SPS Training

Table 9 SPSTable

SPS	Repetitions	Sets	Exercise Time	Rest Time
Training 1A				
Training 2A				
Training 3A				Rest 2 min
Training 4A	10	2	20mins	
Training 5A				
Training 6A				
Training 7C				
Training 8C				Rest 2 min
Training 9C				
Training 10C				
Training 33	5	1	15s/	
Total	30	13	21.25mins	4mins

Table 10 PNFTable

Region/Method	PNF Techniques	Repetitions	Sets	Exercise Time	Rest Time
pelvis	Resisted scapular anterior elevation, resisted pelvic posterior depression	2	1	45s	Rest 1 min
	Resisted scapular anterior depression, resisted pelvic posterior depression	2	1	45s	
	Resisted scapular posterior elevation, resisted pelvic posterior depression	2	1	45s	
	Resisted scapular posterior depression, resisted pelvic anterior elevation	2	1	45s	
	neckflexionextension	2	1	45s	
trunk Figure	flexionextension	2	1	45s	
	flexionextension	2	1	45s	Rest 1 min
	flexion	2	1	45s	
Bilateral Arm Patterns	flexion	2	1	45s	
	Flexion–abduction–external rotation with elbow flexion to Extension–adduction–internal rotation with elbow extension	2	1	45s	Rest 1 min
	Flexion–adduction–external rotation with elbow flexion to Extension–abduction–internal rotation with elbow extension	2	1	45s	
Bridge Exercises	Bilateral glute bridge with resistance	4/	1	45s	Rest 1 min
	Single-leg glute bridge with resistance	4/	1	45s	
Total		30	13	9.7mins	4mins