Original Article

The Effect of Exercise Programs on Pain Management and Motor Control in Patients with Nonspecific Chronic Low Back Pain: A Randomized Matched Subjects Trial

Abstract

Backgroud: Many exercise approaches have been suggested for the treatment of nonspecific chronic low back pain. However, the best exercise approach is still unknown. The purpose of this study was to compare the effect of three exercise approaches based on the Postural Restoration Institute (PRI) and National Academy of Sports Medicine (NASM) on the pain management and motor control of men with nonspecific chronic low back pain. **Methods:** The study was designed with matched subjects. Thirty-three participants were randomly assigned to three training groups: NASM (n = 11), PRI (n = 11), and NASM-PRI integration (n = 11). Interventions: The participants in each group performed the exercise for eight weeks, three sessions per week and about one hour each session. Pain was measured using a visual analog scale (VAS) scale and functional disability using the Roland–Morris questionnaire. Also, the movement control impairment was measured by the movement control impairment test set. **Results:** Repeated measures ANOVA showed no significant interaction effect between pain perception, functional disability, and movement control impairment of the groups (P >.05). **Conclusions:** The findings suggest that different types of exercise rehabilitation were not significantly different on pain reduction, functional disability, and movement control impairment. It is suggested that the participant's preference for an approach should also be considered for encouraging them to adhere to exercise.

Keywords: *Exercise, low back pain, movement control*

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Introduction

Spine-related disorders, specifically chronic low back pain, are a major cause of disability worldwide and a burden on societies.[1,2] Short-lived disabling back pain has been reported in most people during their lifetime. These episodes of back pain might be recurrent and become chronic.[3] In addition to social and disabling burden of back pain, its economic burden is considerable.[4]

The main cause of chronic low back pain is muscle dysfunction. Muscle dysfunction results in altered motor control leading to improper use of trunk muscles, particularly during voluntary activities.[5] Postural misalignment of the sacroiliac joint is considered a risk factor for lower extremity injury due to its effects on pelvic range of motion. It is also suggested as one of the mechanisms leading to nonspecific low back pain (NSLBP).[6] There are different mechanisms that explain the effect of motor control on pain. This process involves reducing mechanical load and increasing the coordination of muscle control and movement. These changes might be caused by plasticity changes in the cerebral cortex.[7] Exercise and physical activity are effective in improving the health and treatment of musculoskeletal pain. Therefore, exercise and lifestyle should be central to the self-management approach.[8]

Various exercise programs are suggested for the management of NSLBP. The exercises proposed by the National Academy of Sports Medicine (NASM) (focuses on muscular imbalance and motor system)[9] and the Postural Restoration Institute (PRI) (postural adaptive science, asymmetric patterns)[10] are adopted extensively in rehabilitation programs. The aim of the PRI is to discover and explain the science of postural adaptation, asymmetric patterns, and the influence of the polyarticular chains of muscles on the body.[10] In the NASM approach, specific static and dynamic assessments are performed to diagnose muscular imbalances. The obtained

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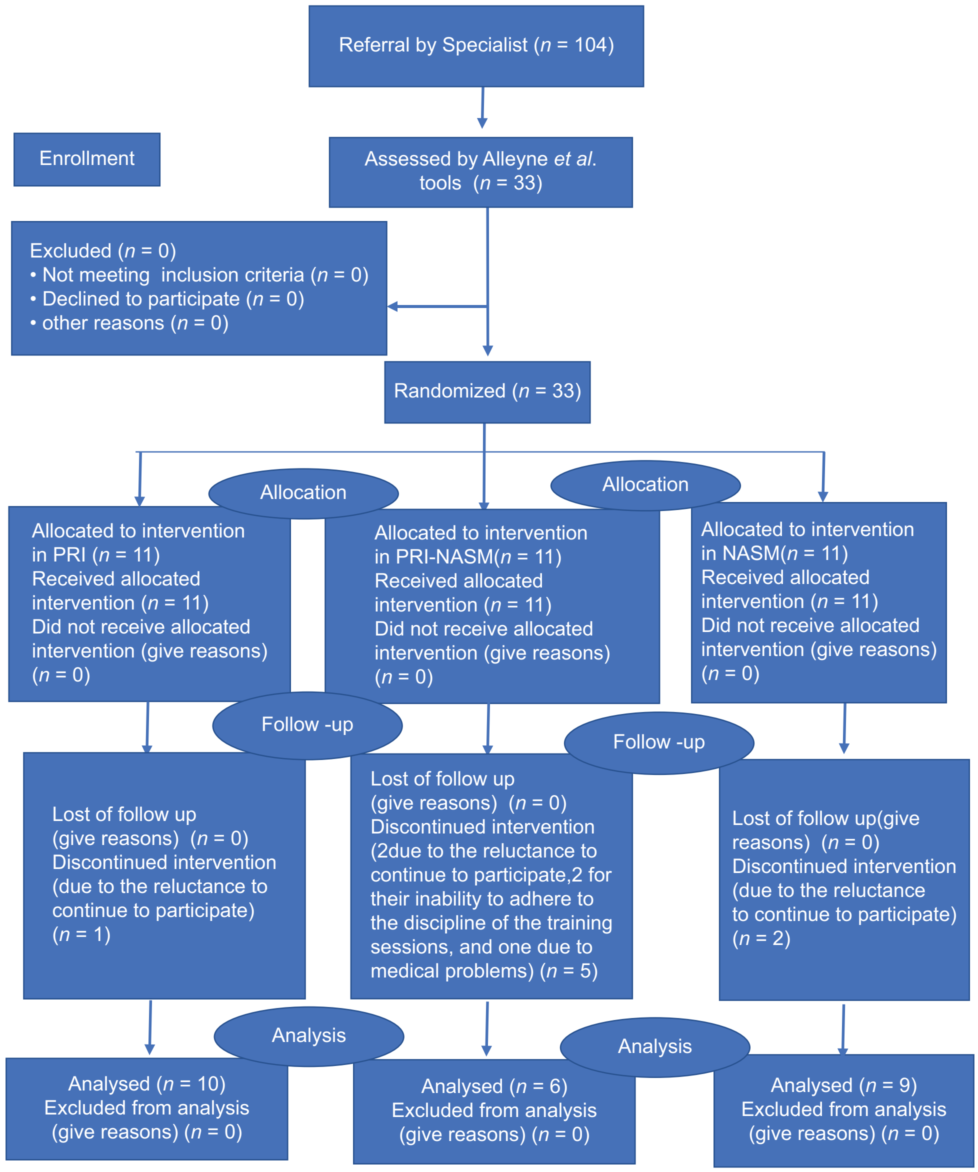

Figure 1: Flow of study

results are used to design effective programs based on the continuum of corrective exercises. The continuum of corrective exercises is a four-step, simple, and very effective process that professionals can use to treat common movement disorders.[9]

In this study, we investigated the effect of three integrative exercise approaches based on the PRI and NASM exercises on pain, disability, and movement control impairment of patients with chronic NSLBP caused by discogenic. We aim to find the best approach for managing low back pain cost-effectively as it is a major cause of disability and a burden on social activities.

Methods

Participants

This experimental research was designed with a matched subject design. The study was approved by the University of Isfahan Ethical Committee (approval ID: IR.UI.REC.1398.096) and the Iranian Registry of Clinical Trials (IRCT20191214045731N1). The patients suffering from chronic NSLBP were referred by their neurosurgeons and orthopedics to the Center of Exercise Rehabilitation, where the study took place. Patients were men aged between 30 and 50 years old. The tools in Alleyne *et al.*[11] were used to select the patients with discogenic chronic low back pain as the potential participants. Following the selection process, 33 patients participated in the study based on the following criteria: 1. The occurrence of non-specific chronic back pain diagnosed by a specialist, 2. No medical condition prohibiting the exercises in the study, 3. Time and physical availability to participate in the study, and 4. The absence of any moral opinion forbidding participation. Conditions for exclusion from the study were as follows: 1. Unwillingness to continue participation for any reason; 2.

Absent to more than one-third of the training sessions; 3. Failure to adhere to the discipline of the training sessions; and 4. The occurrence of medical problems that prevent performing the exercises.

The matching process was done based on "functional disability" and "pain score." The participants were randomly assigned to three groups: the NASM group (n = 11), the PRI group (n = 11), and the NASM-PRI group (n = 11). A pretest was conducted and lifestyle change brochures were provided for the participants. Following the pretest, the patients participated in an eight-week exercise intervention. At the end of the research, 25 posttests were performed. Figure 1 showes the flow of study.

Procedures

All the exercise sessions were conducted by two sports specialists, who did not have any experience related to the PRI exercises. The exercise program for the NASM group included low back pain exercises proposed by the NASM [Appendix A].[12] Likewise, participants in the PRI group performed the low back pain exercises recommended by the PRI [Appendix B].[13] For the NASM-PRI group, we designed the self-myofascial releasing exercises based on the theory of the PRI. The exercise regime of the NASM-PRI group is designed based on the four techniques of NASM [Appendix C].

Three variables including pain, functional disability, and motor control impairment were measured by two examiners who were not blinded to group assignment. Pain severity was measured on an 11-point scale (0 to 10), wherein 0 and 10 indicated no pain and severe pain, respectively. The scale was a horizontal 10-cm strip. The patients were asked to look at the scale and specify the amount of pain they felt in the past seven days. This scale has been widely used in research to assess pain, with reported reliability between 0.85 to 0.95 as well as structural validity.[14]

The Roland–Morris Disability Questionnaire was used to measure the level of functional disability. The questionnaire includes 24 statements. To determine the score, the number of marked statements by the participants was summed and divided by the total number of statements (24 points) and then divided by 100. Its reliability is reported to be 0.91 to 0.96 and has structural validity.[9,14]

Motor dysfunction was measured using the test of movement control impairment.[10] The test consists of six measurements: Waiter's bow (hip flexion in the upright standing position without lumbar region movement: 70–50 degrees flexion), posterior pelvic tilt (active upright standing posture, neutral thoracic vertebrae, and lumbar spine shifts toward flexion), knee extension in sitting position (while sitting in the upright position and keeping lumbar lordosis neutral, extend knee without lumbar region movement: 30–50 degrees of extension is normal), rocking backward and forward in a quadruped position (120 degrees lumbar hip flexion without lumbar region movement when moving pelvic backward and 60 degrees lumbar hip flexion when bending forward), prone lying active knee flexion (active knee flexion at least 90 degrees without movement in lumbar and pelvic), and single-leg stance (the transfer distance between the left and right sides is symmetrical. No more than 2 cm between the sides).

Participants were given a score of 0 if they had no motor control and a score of 1 if they had motor control. The lowest score of motor control impairment (0) and the highest score (6) were reported. In previous studies, the kappa coefficient of this test was reported to be more than 0.6.[15]

The data were analyzed by descriptive statistics and repeated measures ANOVA by SPSS.16 and the level of significance was set at $P < 0.05$. The Shapiro–Wilk test was used for the normality test.

Results

The demographic properties of the participants are presented in Table 1. As shown, there was no significant difference between the demographic properties of the groups ($P > 0.05$). Figure 2a-c show the line charts of repeated measures ANOVA on three outcome measures of the study. In short, a non-significant interaction effect ($P > 0.05$) was observed between the three groups in all

Table 1: Demographic characteristics of the research population participants

Factor	Group	Mean±SD	ANOVA	Significance
Age (years)	NASM	45.8±8.8	0.647	0.533
	PRI	40.4±12.2		
	NASM-PRI	44.3±10.0		
Weight (kg)	NASM	76.5±6.7	0.180	0.837
	PRI	75.0±13.9		
	NASM-PRI	73.3±6.8		
Height (cm)	NASM	171.7±5.5	0.716	0.500
	PRI	174.9±6.6		
	NASM-PRI	174.3±6.1		
BMI (Kg/m^2)	NASM	26.0±1.9	0.839	0.445
	PRI	24.4±3.7		
	NASM-PRI	24.2±3.0		
Waist circumference (cm)	NASM	93.3±5.9	0.427	0.657
	PRI	91.1±12.9		
	NASM-PRI	88.7±7.5		
Hip circumference (cm)	NASM	97.9±3.8	0.045	0.956
	PRI	98.4±6.7		
	NASM-PRI	97.7±3.3		
Waist to hip ratio	NASM	0.95±0.04	0.965	0.397
	PRI	0.92±0.08		
	NASM-PRI	0.91±0.05		
Duration of back pain (years)	NASM	7.7±6.4	0.098	0.907
	PRI	8.5±5.2		
	NASM-PRI	9.3±10.7		

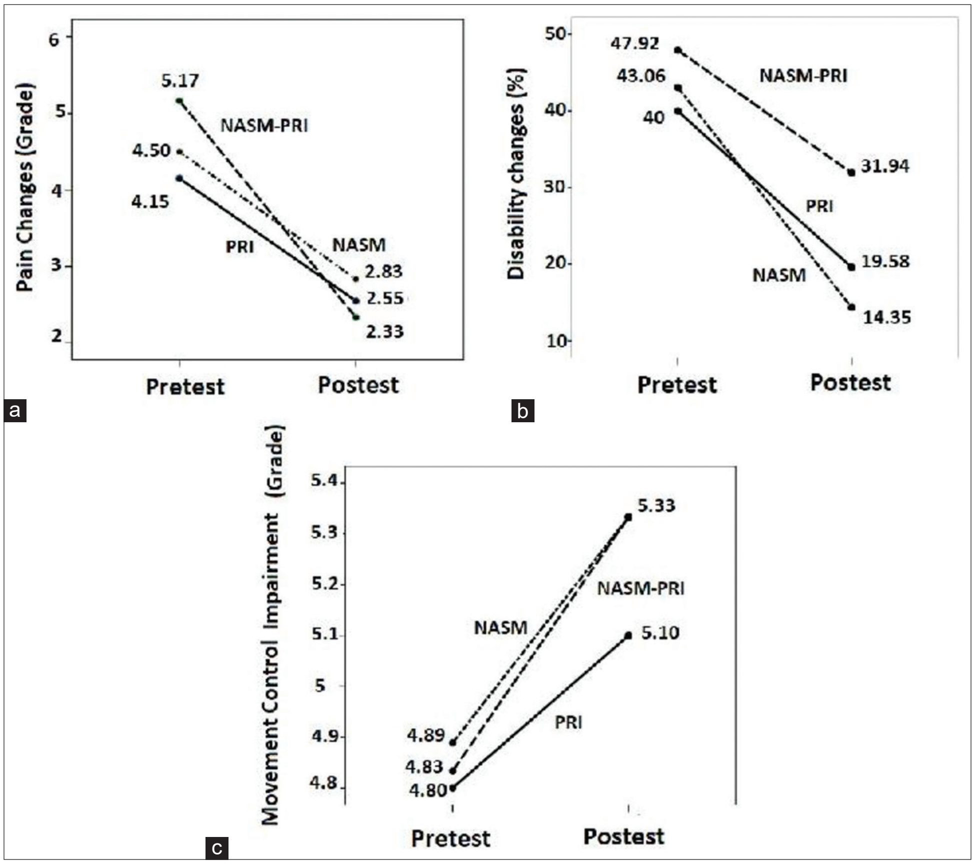

Figure 2: (a) Linear diagram of pain changes, (b) functional disability, (c) movement control impairment in two test times

outcome measures. The eta-squared () coefficients were .06, .04, and .01, respectively, for pain, functional disability, and movement control impairment.

The results of the present study shows that intragroup effects were significant ($P < 0.05$ and $F_{1,22} \geq 9.182$), intergroup effects were nonsignificant ($P \geq 0.05$ and $F_{2,22} \leq 0.675$), and interactive effects were also found nonsignificant ($P \geq 0.05$ and $F_{2,22} \leq 0.716$) for pain perception, functional disability, and movement control impairment in three groups [Figure 2a-c].

Figures 2a-c clearly show that the slopes of the research groups are approximately similar to each other. In the posttest 1.6, 1.67, and 2.84 increase in the pain score was observed in the PRI, NASM, and NASM-PRI groups, respectively. In addition, functional disability was reduced by 20.42% in the PRI group, 28.71% in the NASM group, and 15.98% in the NASM-PRI group. For movement control impairment, scores were increased by 0.30, 0.50, and 0.44 in PRI, NASM-PRI, and NASM groups, respectively.

Discussion

In this study, pain and functional disability were measured by the visual analog scale and the Roland-Morris questionnaire, respectively. The results of intergroup comparisons showed that pain and functional disability decreased significantly in all three groups after exercise rehabilitation, but there was no significant difference between groups after interactive comparisons.

Several studies reported reduced back pain relief following a workout. In addition, studies have suggested that a variety of exercise protocols have similar effects on pain relief and functional disability improvement. In Miyamoto *et al*. (2018), all patients received counseling and instructions and were randomly assigned to four groups (74 patients each): 1) Brochure group, 2) Pilates group once a week, 3) Pilates group twice a week, and 4) Pilates group three times a week. Pain and disability were measured six weeks following the intervention. Compared to the brochure group, the Pilates groups showed a significant decrease in pain and functional disability.[15] In a review study by Lin *et al*. (2016), it was reported that different kinds of exercise programs that focused on lumbar and trunk movements and lasted for 20 hours overall had similar effects on reducing pain and functional disability in people with low back pain.[16]

Paolucci *et al*. (2019) has suggested that all techniques including pilates, McKenzie, Feldenkrais, and Back Schooling are effective in reducing pain and functional disability and that the techniques have no superiority. Their study examined 14 studies of pilates, six studies of McKenzie exercises, one study of Feldenkrais, three studies of global postural rehabilitation, and two studies of neuromuscular facilitation. The visual analog scale (VAS) and numerical rating scale (NRS) were mainly used to measure the pain. Some studies used the Oswestry scale, the Quebec scale, and the McGill pain questionnaire. In addition, in these studies, the Roland–Morris Questionnaire, the Oswestry Disability Index, the Weddell Disability Index, and the Patient-Specific Functioning Scale were used for the measurement of functional disability.[1]

Shiri *et al*. (2017) reviewed 13 randomized controlled trials as well as three nonrandomized controlled trials. Their findings suggested that muscle strengthening combined with stretching or aerobic exercise performed two to three times a week is effective in reducing low back pain as well as functional disability improvement.[17]

Another study reported that performing pilates is more effective than minimal physical exercise in reducing low back pain.[18] The authors highlighted that there are not enough studies indicating that pilates exercise is better than the other types of exercises. The effectiveness of pilates in people with low back pain is also reported in another study that assigned 38 subjects to either the experimental group or control group.[19]

In another review study by Saragiotto *et al*. (2016), no difference between the effects of movement impairment training and other exercise programs on the degree of pain and functional disability reduction in people with low back pain was found. In this review, 13 studies that used a visual analog scale and numerical rating scale to measure pain were examined. The examined studies mainly used the Roland–Morris Questionnaire and the Oswestry Disability Index to measure functional disability.[20]

A review study by Gomes-Neto *et al*. (2017) suggests that stabilizing exercises did not differ from manual therapy in reducing pain and functional disability. However, stabilizing exercises are significantly different from general exercises in reducing pain and functional disability in patients with low back pain. They investigated 413 studies to evaluate stabilizing exercises, 297 studies for general exercises, and 185 studies for therapy.[21]

In addition, in the present study, movement impairment was measured by the movement impairment test set. According to intragroup comparisons, the results showed that there was a significant improvement in movement dysfunction in all three groups after the eight-week exercise program. No significant difference was observed between the groups after interactive comparison. Our result shows the effectiveness of different exercise rehabilitation protocols on movement dysfunction, although no significant differences were found between different types of exercise rehabilitation protocols in improving movement dysfunction.

Other studies reported improvement in movement control impairment following exercise training and reported that a variety of exercise protocols have similar effects on reducing movement control impairment. In a study, 106 patients with low back pain were divided into two groups—an experimental group of 52 individuals with a specific exercise program focusing on movement impairment and a control group of 54 individuals with general exercise programs that focused on endurance, strength, and spine flexibility. Both groups had a movement impairment score of 3.9 before the intervention. Following the intervention, the experimental group had a score of 1.8 while the control group had a score of 2.8. Both groups recovered and their difference was not statistically significant.[22] In a prospective study, it is shown that personalized exercise programs improved movement dysfunction by 59%, which was statistically significant.[23] In a study conducted by Gutknecht *et al*., the effect of a combination program including movement control exercises and tactile acuity training on subjects with nonspecific low back pain was investigated. Their results showed that movement impairment had a significant improvement in the pretest phase compared to the posttest phase, but was not significantly different from the control group in a previous study that received only movement control exercises.[24]

In the present study, it was shown that NASM, PRI, and a combination of these two approaches had similar effects on nonspecific chronic low back pain markers. Our results show that exercise can improve chronic NSLBP and that different exercise approaches designed for low back pain have no superiority over each other. Further studies with a larger sample size would be necessary to replicate the present findings. It is important to mention that due to the limited research on the effects of PRI exercise on low back pain, a direct comparison between the results reported here and the previous literature is not possible.

In addition, for encouraging participants to adhere to exercise, patients' preferences should be considered. This consideration optimizes the effects of exercise rehabilitation and inhibits nonspecific chronic low back pain.

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Conflicts of interest

There are no conflicts of interest.

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Appendix A: Training Protocol of NASM Group.

Stages	Self-myofascial Release exercises	Sets	RepS	Duration	Rest	Tips
Warm up	TFL/IT Band	1	1-3	30S	10-30 S	Exercises performed at 12 week. At First week we start at low level of repetition and this item increased gradual by every two weeks. Also Rest was decresed in reverse manner. Exercises performed for two side of the body.
	Adductors	1	1-3	30S	10-30 S	
	Piriformis	1	1-3	30S	10-30 S	
	Activation exercises	**Sets**	**RepS**	**Tempo**	**Rest**	**Tips**
	Side-lying Hip abduction	1-3	12-20	Slow-Controlled	0-60s	Exercises performed at 12 weeks. At First week we start at low level of sets and repetition and these items increased gradual by every two weeks. Also, Rest was decreased in reverse manner. Exercises performed for two side of the body.
	Quadruped, opposite arm/leg raise	1-3	12-20	Slow-Controlled	0-60s	
	Stability Ball Bridge	1-3	12-20	Slow-Controlled	0-60s	
	Integration exercises	**Sets**	**RepS**	**Tempo**	**Rest**	**Tips**
	Lateral Tube Walking	1-3	10-15	Controlled	0-60s	At first week we performed this exercise at 10 steps by each leg in 1 set. By every week increased in set and steps.
	Multiplanar step-up, curl, to press	1-3	10-15	Slow	0-60s	Exercises performed at 12 weeks. At First week we start at low level of sets and repetition and these items increased gradual by every two weeks. Also, Rest was decreased in reverse manner. Exercises performed for two side of the body.
	Single leg squat to PNF pattern	1-3	10-15	Slow	0-60s	
	Lengthening exercises	**Sets**	**RepS**	**Duration**	**Rest**	**Tips**
Cool down	Kneeling hip flexor stretch	1-2	1-3	30S	30-10 S	Hold stretching for 30s at the limit of pain-free range. At First week we start at low level of sets and repetition and these items increased gradual by every two weeks. Also, Rest was decreased in reverse manner. Exercises performed for two side of the body.
	Standing adductor stretch	1-2	1-3	30S	30-10 S	
	Supine ball piriformis stretch	1-2	1-3	30S	30-10 S	

Appendix B: Training Protocol of PRI Group

Stages	Exercises	Sets	RepS	Tempo	Rest	Tips
Warm up	Left sidelying trunk lift	1-3	12-20	Slow	10-30s	Exercises performed for one side of the body as mentioned.
	Right SLR crossover	1-3	12-20	Slow	10-30s	
Complected exercises	**Exercises**	**Sets**	**RepS**	**Tempo**	**Rest**	**Tips**
	90-90 hip lift with hemibridge	1-3	12-20	Slow-controlled	0-60s	Exercises performed for one side of the body as mentioned.
	Left sidelying left flexed adduction with right extended abduction and left abdominal coactivation	1-3	12-20	Slow-controlled	0-60s	
	Left sidelying right glute max	1-3	12-20	Slow-controlled	0-60s	
	Right sidelying left adductor pullback	1-3	12-20	Slow-controlled	0-60s	
Complected exercise	**Exercises**	**Sets**	**RepS**	**Tempo**	**Rest**	**Tips**
	Standing right glute max with resisted left proximal hamstring and left knee flexion	1-3	10-15	Controlled	0-60s	Exercises performed for one side of the body as mentioned.
	Left retro stairs	1-3	10-15	Slow	0-60s	
	Resisted trunk around with left AF IR and right trunk rotation	1-3	10-15	Slow	0-60s	
	Exercises	**Sets**	**RepS**	**Tempo**	**Rest**	**Tips**
Cool down	Paraspinal release with left hamstring	1-3	10-15	Slow	10-30S	
	PRI wall squat with balloon	1	1-3	Slow	10-30S	

Appendix C: Training Protocol of NASM- PRI Group

Stages	Self-myofascial Release exercises	Sets	RepS	Duration	Rest	Tips
	Left TFL/IT Band	1	1-3	30S	30-10 S	
Warm up	Left illiacus	1	1-3	30S	30-10 S	
	Left pectoralis	1	1-3	30S	30-10 S	
	Left glut max	1	1-3	30S	30-10 S	
	Right adductors	1	1-3	30S	30-10 S	
	Right biceps femoris	1	1-3	30S	30-10 S	
Complected exercises	**Activation exercises**	**Sets**	**RepS**	**Tempo**	**Rest**	**Tips**
	90-90 Hip lift with hemibridge	1-3	12-20	Slow-controlled	0-60s	Emphasis placed on left hamstring facilitation to assist with left ilium positioning in the sagittal plane.
	Left sidelying left flexed adduction with right extended abduction and left abdominal co-activation	1-3	12-20	Slow-controlled	0-60s	Emphasis placed on left IC adductor, right glute max, and left oblique facilitation to assist with frontal plane positioning.
	Left sidelying right glute max	1-3	12-20	Slow-controlled	0-60s	Emphasis on shifting into left AF IR with facilitation of the right glute max for forced closure of the right SI joint.
	Right sidelying left adductor pullback	1-3	12-20	Slow-controlled	0-60s	Emphasis on left posterior capsule inhibition and work on actively shifting into a left AF IR position with facilitation of the left IC adductor
	Right sidelying trunk lift	1-3	12-20	Slow-controlled	0-60S	Emphasis on left oblique facilitation and right tricep facilitation.
	Integration exercises	**Sets**	**RepS**	**Tempo**	**Rest**	**Tips**
	Standing right Glute max with resisted left proximal hamstring and left knee flexion	1-3	10-15	Controlled	0-60s	Emphasis on left hamstring facilitation in a left AF IR position
	Left retro stairs	1-3	10-15	Controlled	0-60s	Emphasis on left AF IR with left glute med and left adductor facilitation.
	Resisted trunk Around with left AF IR and right Trunk rotation	1-3	10-15	Controlled	0-60s	Emphasis on achieving and maintaining a left AF IR position with right trunk rotation.
	PRI wall squat with balloon	1-3	10-15	Controlled	0-60s	Emphasis on regaining a left AF IR position with left spinal rotation to maximize inhibition of the left posterior capsule and use of the balloon to promote resisted exhalation and increased intraabdominal pressure for spinal stabilization
	Lengthening exercises	**Sets**	**RepS**	**Tempo**	**Rest**	**Tips**
Cool down	Right SLR crossover	1-3	10-15	Slow	10-30s	Emphasis on bilateral abdominal and serratus facilitation and inhibition of lumbar paraspinal musculature.
	Paraspinal release with left hamstring	1-3	10-15	Slow	10-30S	Emphasis on left hamstring and right quad facilitation while regaining a zone of apposition and inhibiting the lumbar paraspinal muscles.