Musculoskeletal ultrasound to evaluate the effect of suspension rope training combined with Mulligan technique on nonspecific low back pain: a single-blind randomized controlled trial

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Research

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Abstract

Background

In addition to the symptoms and limitation of function, non-specific low back pain also presents the stability imbalance of the local muscle and the whole muscle of the trunk. The treatment mode of exercise combined with manipulation is widely recognized, but the effect of suspension rope training combined with Mulligan technology is unclear. Musculoskeletal ultrasound and clinical indicators were used to evaluate the effect of suspension rope training combined with Mulligan technique on non-specific low back pain.

Methods

From December 2020 to November 2021, a randomized controlled clinical trial was conducted in the Sports Medicine Rehabilitation Center of Hebei Institute of Sports Science. Sixty patients with clinically diagnosed non-specific low back pain were enrolled in the study. They were randomly divided into the suspension group and the control group for eight weeks. The two groups were also treated with Mulligan manipulation. The suspension group was treated combined with suspension rope training on this basis, and the control group was treated combined with traditional rehabilitation training. Pain (NRS score), lumbar function (ODI score) and spinal range of motion were measured by a specialist before and after treatment. In addition, musculoskeletal ultrasound was used to measure muscle thickness of bilateral transversalis and multifidus muscles. Patients in both groups did not know about the treatment of the other group, and the data collection and statisticians of the manipulation therapists were not aware of the grouping, only the researcher was aware of the grouping but did not participate in the whole treatment process. χ^2 test was used for counting the data of two groups, homogeneity of variance test was used for comparability of measurement data, independent sample T test was used for data comparison between groups, and paired sample T test was used for data comparison before and after treatment.

Results

After eight weeks, muscle thickness of bilateral transversalis and multifidus muscles, NRS, ODI and spinal range of motion in two groups were significantly better than those before treatment ($P < 0.05$)), and the amplitude of change in suspension group was significantly higher than that in control group($P < 0.05$).

Conclusions

Suspension rope training combined with Mulligan technology has a significant effect on the treatment of non-specific low back pain, which can significantly improve the patients' lumbar function, and its effect is better than traditional rehabilitation training combined with Mulligan technology.

Background

Nonspecific Low Back Pain (NLBP) is a group of symptoms with lower back, lumbosacral and hip pain, which is very common in orthopedics and rehabilitation departments [1–3]. Generally, there is no clear cause, such as tumor, infection, spinal stenosis, lumbar disc herniation, osteoporosis, etc [4]. About 85% of patients with LBP cannot find an exact histopathological change clinically, nor can confirm the causes through clinical objective examination [5]. However, the pain of these patients does exist in clinical practice, which brings many troubles to their work and lives. Statistics show that about 84% of people will experience LBP in their lifetime [6]. In addition, most people do not have much time to cure in the hospitals or rehabilitation clinics, so they are more likely to expect appropriate behavior or exercise advice from rehabilitation therapists, which can help them.

For NLBP, the current treatment methods mainly include medicine, physical factors, acupuncture, massage, etc. Although it can reduce the symptoms of NLBP, the weak chain of the body always exists, and low back pain is also prone to recurrent episodes. Therefore, more and more studies are focused on how to control the symptoms of NLBP while improving core stability, reduce the recurrence rate of NLBP and improve the long-term treatment outcome of NLBP patients [7]. Suspension training, a new exercise therapy, is thought to activate and enhance proprioception to achieve the effect of increasing local structural stability, thereby reducing pain, improving impaired postural adjustment ability, and restoring normal muscular response patterns [8–10]. Kang [11] studied the effects of suspension, Bobath ball to assist bridge movement and conventional bridge exercise on local and global trunk muscles of patients with LBP, and found that the surface EMG signals of the muscles related to suspension such as obliquus externus abdominis, multifidus, rectus abdominis muscles were greater than those of the above ball movement and bridge movement. Therefore, it is suggested that suspension exercise can increase the activation of local and global muscles of the trunk. In addition, spinal mobilization is a common clinical manipulative intervention, especially the Mulligan technique is based on the biomechanics of correcting joint errors. It achieves the effect of alignment correction by applying forces to the joint treatment plane to achieve the sliding treatment. In addition, guide patients to conduct self-help Mulligan technology with the help of a treatment belt and the results are immediate [12]. In conclusion, the treatment of NLBP with multi-means combined intervention is the general direction of future research, especially the comprehensive treatment program with manipulation combined with exercise is undoubtedly the focus of the study. Currently, suspension training and Mulligan technology have been gradually recognized by most researchers for the treatment of NLBP. However, the high cost and large size of suspension equipment in clinical studies are not suitable for home development, which limits its wide application. Suspension rope training by the elastic suspension rope will be suspended in part of the body, so that the body is in an unstable state of open chain or closed chain training, in order to stimulate the core stable muscle group physical rehabilitation training. The purpose of this study was to evaluate the efficacy of suspension rope exercise combined with Mulligan technique in the treatment of NLBP by musculoskeletal ultrasound and clinical indicators.

Methods

Trial design

This was a single-center, single-blind, randomized [1:1] controlled trial. The subjects were randomly grouped by the researchers using computer-generated random numbers. The researchers did not participate in the entire evaluation and treatment intervention process. The manipulation therapist, data processor and subjects were unaware of the grouping.

Participants

This study has been approved by the Medical Ethics Committee of Hebei Provincial People's Hospital, China. Participants were recruited from patients with non-specific low back pain who visited our outpatient department of Hebei Institute of Sports Science from September 2020 to October 2021. All participants underwent a basic physical examination before enrollment and were told in person the purpose of the trial, but no details of other interventions were known. The patients signed the informed consent voluntarily and had the right to opt out at any time during the study without any reason.

Inclusion criteria[13]: □ pain from the 12th pair of ribs to the crease below the hip. □ Tenderness or muscle spasm. □ CT or MRI showed no obvious 3. □ Duration > 12 weeks. □ The age range from 20 to 45. □ The NRS score is greater than 3.

Exclusion criteria: □ symptoms of nerve root irritation. □ Complicated with pathological changes of lumbar spine (fracture, lumbar disc herniation, infection, etc.). □ Disturbance of consciousness. □ Severe cardiopulmonary dysfunction.

Shedding criteria□□ Failure to complete treatment as prescribed. □ Receiving other treatment during this study. □ Adverse reactions or difficulty in continuing treatment.

Intervention

The two groups were treated with Mulligan manipulation. On this basis, the suspension group was combined with suspension rope training, while the control group was combined with traditional rehabilitation training, including double bridge exercises, left and right plank exercises and plank exercises. Each movement was held for 6~8 seconds, and 2 groups were repeated 10 times per group. Patients in both groups received treatment 3 times per week for 8 weeks. Specific operations are as follows:

Mulligan technique: □ Flexion and extension. The patient sits beside the treatment bed, the therapist lunges and squats behind the patient, Mulligan treatment belt bypasses the patient's abdomen and below the therapist's hip, places the ulnar side of one hand on the upper spinous process of the spine to be treated, and the other hand supports the treatment bed for fixation. Let the patient slowly do lumbar flexion forward and extension back. When the patient is painless, the range of motion is proper, and the

range of activity should be gradually increased. At the same time, the therapist gives a continuous thrust obliquely upward along the treatment plane, maintains it for 10 seconds after flexing forward and extending back to the end, and then returns to upright; ▯ Lateral flexion. The patient straddles at one end of the treatment bed with his back to the therapist. The therapist bends standing behind the patient, places the palmar side of his thumbs on the upper spinous process of the spine to be treated, and lets the patient do the slow lateral bending movement on the left and right sides. At the same time, the therapist's hands give continuous thrust obliquely upward along the treatment plane. When the side bend reaches the end, hold it for 10 seconds and then return to upright. ▯ Rotate. The patient straddles at one end of the treatment bed with his back to the therapist, the therapist bends standing on one side of the patient, places the ulnar side of one hand on the upper spinous process of the spine to be treated, and another hand is fixed around the patient's abdomen and let the patient rotate slowly. At the same time, the therapist's hand gives a continuous thrust obliquely upward along the treatment plane, holds for 10 seconds when rotating to the end, and then returns to upright. ▯ Self-help SNAGS: guide patients to conduct self Mulligan technology with the help of a treatment belt. The above different operations were performed 10 times in each group, 3 times per week for 8 weeks.

Suspension rope training: the portable 4D PRO suspension training belt is used, and the suspension rope training is completed under the guidance of a professional physiotherapist, 20 ~ 30min each time, 3 times/week, for a total of 8 weeks. ▯ Dorsal chain training. The patient is in the supine position, puts hands on both sides of the body, and bends one knee 90 degrees. Place one suspension belt on the patient's pelvis and the other on the popliteal fossa on the flexion side of the knee. The suspension height is the height of knee flexion. Let the patient straighten the leg in the suspension belt, lift the pelvis to the neutral position, keep the body in a straight-line position, and be careful not to tilt the pelvis. It mainly trains the dorsal motor chain of the core muscle group; ▯ Lateral chain training. The patient lies on his side and rests on his lower hand, the upper hand is placed on the patient's side, and the suspension belts are placed at the patient's pelvis and knee joint respectively. The suspension height is horizontal with the lateral condyle of the lower leg and the greater trochanter of the upper leg. Let the patient raise the upper leg, extend the lower hip joint, and press the lower leg down the suspension belt to raise the body in the same straight line. It mainly trains the lateral movement chain of the core muscle group; ▯ Inner chain training. The patient lies on his side and rests on his lower hand, with the upper hand on his side. Place one suspension belt on the patient's pelvis and the other on the knee joint of the upper leg. The suspension height is at the medial condyle of the upper leg, at the same level as the shoulder joint. Let the patient raise the lower leg, press the lower leg down the suspension belt to raise the body in the same straight line. It mainly trains the inner motor chain of the core muscle group; ▯ Front chain training. The patient lies prone with both upper limbs supporting the body. The suspension belts are placed at the patient's pelvis and knee joint respectively. The suspension height is at the level of the shoulder joint. Let the patient straighten the legs in the suspension belt, raise the pelvis to the middle area, and keep the body in a straight-line position. It mainly trains the anterior motor chain of the core muscle group. All the above training should be maintained for 60 seconds each time, with an interval of 40 seconds, and 4 ~ 6 groups should be trained.

Outcome measures

NRS score [14]: the number 0-10 indicates the pain degree, in which 0 indicates no pain and 10 indicates the most severe pain. The degree of pain was evaluated by numbers according to the patients' subjective feelings.

ODI score[15]: ODI score is a scale to judge the lumbar function based on whether the patient can carry out relevant daily life behavior. This scale includes 10 aspects of patients with low back pain, such as pain intensity and self-care. The higher the score, the more serious the lumbar dysfunction is. Considering the privacy of the subjects involved, the scoring option of sexual life in the ODI questionnaire was deleted. The highest score of ODI is 45 points.

Spinal mobility score: Spinal mobility score is mainly used to evaluate the quantitative table of spinal mobility of patients with low back pain. Patients stand and bend as low as they can, the score was based on the standard that the fingertips of both hands could reach the lowest part of the lower limbs. It is divided into seven levels. The higher the score, the smaller the range of activity of the lumbar spine and the more serious the corresponding symptoms.

Muscle-bone ultrasound was used to evaluate the muscle thickness of bilateral transverse abdominal muscle and multifidus muscle [16-18]. ALOKA DF-37 ultrasonic equipment was used, and the linear array ultrasonic probe frequency was 5.0 ~ 13.3MHZ. The thickness of the transverse abdominal muscle and multifidus muscle of the subjects in the resting position is measured before and after the intervention. The room temperature of the color ultrasound room is kept at 23 ~ 28 ℃, and the same professional ultrasound doctor measures the subjects before and after the intervention, and the doctor does not know the grouping of the subjects.

Evaluation of transverse abdominal muscle: the subject lies on his back, his upper limbs are relaxed naturally and placed on his side. The probe is placed at the intersection of the anterior superior iliac spine and umbilical horizontal line. The probe is placed vertically with the skin. The image of the third layer of the abdominal muscle is transverse abdominal muscle. The thickness of the transverse abdominal muscle is measured at the end of the subject's exhalation. Intercept three pictures respectively and take the average value.

Evaluation of multifidus muscle: the subject is in the prone position, the upper limbs are naturally relaxed and placed on the side of the body, and the probe is placed between the L4 spinous process and articular process. The probe is placed vertically with the skin. The observed image of the second layer of muscle between the spinous process and the inferior articular process is multifidus muscle. The thickness of the multifidus muscle is measured at the end of the subject's exhalation, and three pictures are intercepted respectively to take the average value.

Statistical analyses

All analyses were conducted by professionals who did not participate in the study using SPSS version 24.0. The measurement data of normal distribution were represented by Mean ± Standard deviation. After homogeneity of variance test, independent sample T test was used for comparison between-group, and paired sample T test was used for within-group comparison. Count data were expressed by frequency and χ2 test was used. P<0.05 was set as the significance level.

Results

Study population

The inclusion period is from September 2020 to October 2021. Among the patients with nonspecific low back pain who came to our clinic, 100 patients accepted the study and signed informed consent, of which 37 did not meet the inclusion criteria of the study and were excluded. The remaining 63 people were randomly divided into 33 cases in the suspension group and 30 cases in the control group according to the random number table generated by the computer. 3 cases in the suspension group and 2 cases in the control group fell off due to various reasons within the period, as shown in Fig. 1.

Baseline characteristics

There were no pronounced differences between the two groups in baseline characteristics such as age, sex, body weight, body mass index, average duration, NRS, ODI, and spinal mobility score (Table1).

Table1. Baseline Demographic and Clinical Characteristics

Characteristic	Mean（SD）		*P* value
	Suspension group	Control group	
	（n=30）	（n=28）	
Age, y	32.37±5.95	33.93±5.28	0.296
Male, No. (%)	18(60)	16(57)	0.825
Weight, kg	68.83±11.31	70.29±13.20	0.654
Body mass index[a]	24.45±0.55	24.21±2.59	0.710
Average duration (Month)	5.00±1.34	5.11±1.20	0.750
NRS	6.80±0.66	6.64±0.91	0.454
ODI	22.23±3.84	21.50±3.50	0.451
Spinal Mobility	3.53±0.78	3.75±0.84	0.313

Outcomes

In both the suspension group and the control group, there were significantly better during the study period in NRS, ODI and spinal motion scores. In the suspension group, the mean reduction in NRS was 6.17 compared with 4.72 in the control group (Table 2). Scores related to waist function also showed significant differences between the groups (ODI: P=0.000; Spinal Mobility: P=0.000) (Table 2). In particular, the duration of sitting, standing and walking had remarkably improved compared to the control group. Suspension training improved core stability while controlling NLBP clinical symptoms. Studies have shown that suspension training based on the principle of neuromuscular activation, which can realize static and dynamic training of core muscle group in unstable state, and increase the stimulation of stable muscle group in core area. In particular, the transversus abdominis and multifidus muscle are of great significance in maintaining the balance and rotation stability of the vertebral body in sagittal and coronal positions.

Musculoskeletal ultrasound was used to measure the thickness of the transverse abdominis and multifidus muscle before and after the intervention, which also proved that the stimulation of suspension training on the lumbar stable muscle group was obvious, especially the stimulation of the transverse abdominis and multifidus muscle. The result was in line with the research expectation.

Table 2 Results for the outcome

stic	Mean□SD□		*P* value
	Suspension group (n=30)	Control group (n=28)	
BL	6.80±0.66	6.64±0.91	0.454
8 weeks	0.63±0.67	1.92±0.81	0.000
BL	22.23±3.84	21.50±3.50	0.451
8 weeks	2.27±1.17	7.36±2.30	0.000
BL	3.53±0.78	3.75±0.84	0.313
8 weeks	1.07±0.58	2.21±0.69	0.000
BL	2.35±0.18	2.37±0.25	0.668
8 weeks	3.21±0.15	3.03±0.29	0.005
BL	3.29±0.15	3.29±0.15	0.880
8 weeks	3.71±0.15	3.36±0.14	0.000
BL	10.17±0.17	10.20±0.15	0.403
8 weeks	12.09±0.13	10.35±0.19	0.000
BL	14.33±0.17	14.31±0.20	0.727
8 weeks	17.13±0.26	14.55±0.19	0.000

Blinding

In order to ensure that the subjects were not aware of the grouping situation, the agreed treatment time of the suspension group and the control group was staggered and arranged to the treatment rooms on different floors. The same data collector evaluated the clinical effect before and after intervention to ensure the reliability and reliability of the data□

Adverse events

There have been no reports of adverse events in either group.

Discussion

In this study, muscle bone ultrasound technology is used to objectively evaluate the functional state of locally stable muscles before and after the intervention, which has the characteristics of objectivity, quantification and accuracy. It makes up for the diagnostic assessment defects that the commonly used clinical evaluation scales cannot obtain the quantitative data that truly reflect the functional state of patients, and can only subjectively evaluate the functional state. Since animal and human experiments have confirmed that the muscle structure of patients with nonspecific low back pain is characterized by the reduced cross-sectional area of paraspinal muscles, increased muscle fiber stiffness, reduced muscle contractility, and increased fat deposition [19–20]. Many studies also found that the degree of multifidus and transverse abdominis atrophy was positively correlated with the duration of non-specific low back pain [21–23]. Therefore, through the measurement of the thickness and cross-sectional area of the target muscle transverse abdominal muscle and multifidus muscle, the prevalence and recovery of patients with nonspecific low back pain can be truly reflected. In addition, Cho et al. [24] also found that the flexion and extension ratio and flexion and extension strength of trunk were significantly improved after suspension training. This study showed that after 8 weeks of suspension rope training combined with Mulligan technology, the NRS, ODI and spinal activity scores of patients were significantly better than those before treatment; In addition, the evaluation of muscle-bone ultrasound also showed that the thickness of transverse abdominal muscle and multifidus muscle increased significantly on both involved and non-involved sides; Mulligan technology was also used in the control group, combined with the traditional rehabilitation training program. The results showed that after 8 weeks of comprehensive treatment, the clinical functional indexes and the thickness of transverse abdominal muscle and multifidus muscle also changed correspondingly, but the change range was significantly weaker than that in the suspension group.

This paper further proves the therapeutic effect of the comprehensive intervention scheme of exercise therapy combined with manipulation. Many scholars have confirmed that spinal muscle is an important influencing factor in the whole spinal system. For the muscle atrophy and disability of trunk core muscle group in patients with NLBP, the training of core muscle group, especially the joint activation of trunk front and rear chain extension and flexion muscle group, is very important to maintain the stability of the spine, to avoid repeated attacks after "recovery"[25–27]. Compared with traditional rehabilitation training, suspension rope training increases more unstable factors, improving the delayed activation or non-activation state of muscles, correcting the original adverse action feedback mode of the body, giving the opportunity for the reconstruction of long-term damaged spine-related muscles, and finally improving the phased control and adjustment ability of patients to the spine, which improve the functional state of patients [28]. At the same time, the simple and portable suspension rope training equipment is worthy to be popularized and applied in clinical work or home fitness.

Methodological Considerations

An 8-week intervention period have been sufficient to capture changes in muscle shape. Therefore, in addition to the subjective evaluation of pain and function in previous studies, musculoskeletal ultrasound

technology was used in this study to measure the changes in muscle thickness before and after the study period which objectively evaluate the effects of suspension rope training on the transverse abdominis and multifidus muscle. Previous studies also used non-invasive ultrasound technology to confirm that suspension exercise can significantly improve the thickness of the transverse abdominis muscle, and ultrasound imaging showed that whether low-intensity control exercise or high-intensity suspension exercise can activate the transverse abdominis muscle [29]. However, there are also some deficiencies in this study, (1) The effect of suspension training on muscle activation sequence was not considered. Studies have found delayed activation of the deep core muscles in NLBP patients during bending and other activities, and the time difference becomes particularly obvious when there is no visual feedback [30, 31]. (2) Due to the sample size, there was no discussion on the difference in training effect between suspension rope training adopted in this study and SET red rope suspension training commonly used in clinical rehabilitation. These questions will be discussed in the following research.

Conclusion

In conclusion, we found that eight weeks of suspension rope training combined with Mulligan significantly reduced the symptoms of lumbar pain, improved lumbar function. enhanced muscle circumference of transverse abdominis and multifidus muscles compared with the control group. Considering that suspension rope training emphasizes core stability, especially by stimulating the transverse abdominis and multifidus muscles, patients with nonspecific low back pain with core stability imbalance may benefit more.

Abbreviations

NLBP
Nonspecific low back pain
NRS
Numerical rating scale
ODI
Oswestry disability index
ITA
Involved transverse abdominis
NTA
uninvolved transverse abdominis
IM
Involved multifidus
NM
uninvolved multifidus
BI
Baseline.

Declarations

Ethics approval and consent to participate

This Ethical review approval has been obtained from medical ethics committee of Hebei provincial people's hospital, Ethics Review Number: (2020) Scientific Research Review No. 318. All participants have signed informed consent. All methods were performed in accordance with relevant guidelines and regulations.

Consent for publication

We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

We would like to declare on behalf of all authors that the work described was original research that has not been published previously and is not under consideration for publication elsewhere. The publication of the manuscript is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out. If accepted, it will not be published elsewhere in the same form, in English or in any other language, without the written consent of the Publisher.

Availability of data and materials

The data that support the findings of this study are available from Hebei Institute of Sports Science. Restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. With the permission of Hebei Institute of Sports Science, data are available from the authors upon reasonable request.

Competing interests

All the authors declare that they have no competing interests.

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Authors' contributions

Cong Wang and Wen-dong Zhang came up with the design idea of the study and worked with ultrasound therapist Yu Zhang, statistician Di Zhang, and data collector Guan-nan Zhang to complete the whole process of the study. The manipulation intervention was conducted by Wen-dong Zhang, the director of rehabilitation. All authors participated in the interpretation of data. Cong Wang, as the prime principal of

this study, prepared the first draft. Di Zhang has revised and polished the article, and all authors have read and approved the final manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Figures

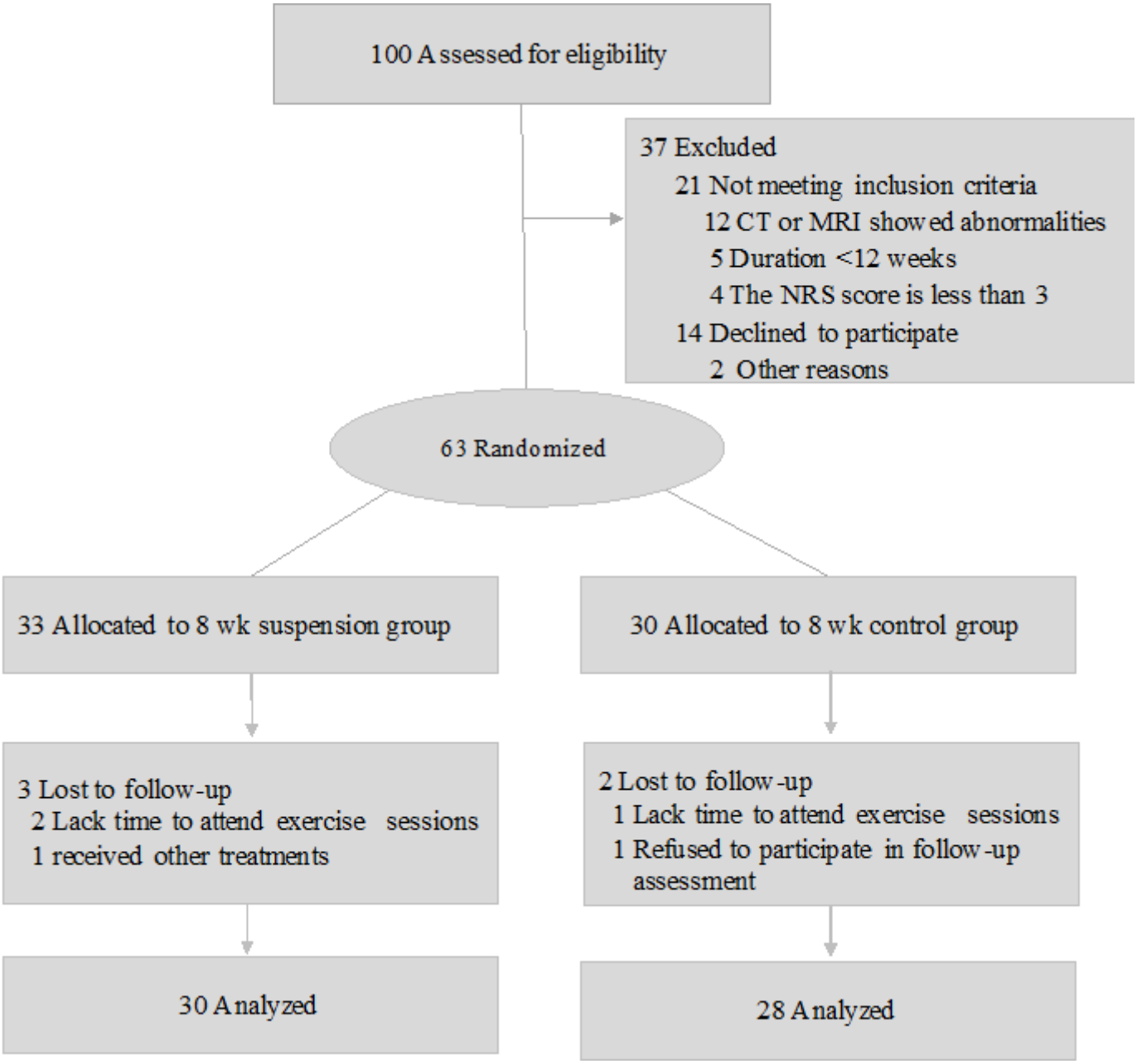

Figure 1

Flow Diagram Depicting the Study Design