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Abstract: Aims The study investigated the influence of hydrotherapy method-based McKenzie and Williams among patients with non-specific low back pain (NSLBP). Methods Semi-experimental pretest-posttest with a control group design trial was conducted at Health Service Center, Qazvin, Iran. Twenty-eight NSLBP patients (16 men and 12 women, age: 42.5 ± 7 years) were recruited. Hydrotherapy program developed based on McKenzie and Williams therapy was performed individually 3 days per week for 20 sessions. Therefore, the study compared a hydrotherapy group (based on McKenzie and Williams therapy) to a control group. Participants attended a hydrotherapy program under the supervision of a hydrotherapist. The Numeric Pain Rating Scale (NPRS), Roland-Morris Disability Questionnaire (RMDQ), and Straight Leg Raise Test (SLRT) were measured at the beginning, middle, and at the end of the 20 sessions to determine pain and functionality of the patient's improvement. Results Overall, NPRS, RMDQ, and SLRT scores were improved in hydrotherapy group in the 10th session and 20th session compared with baseline ($p \leq 0.001$) and control group ($p \leq 0.001$). No difference in the treatment variables between the 10th session and the 20th session was observed ($p > 0.05$). Conclusions The results indicated that the NSLBP symptom was improved after 10 sessions of hydrotherapy program developed based on McKenzie and Williams therapy.

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Efficacy of hydrotherapy treatment for the management of chronic low back pain

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ABSTRACT

Aims: The study investigated the influence of hydrotherapy method-based McKenzie and Williams among patients with non-specific low back pain (NSLBP). **Methods:** Semi experimental pretest-posttest with a control group design trial was conducted at Health Service Center, Qazvin, Iran. Twenty-eight NSLBP patients (16 men and 12 women, age: 42.5 ± 7 yrs) were recruited. Hydrotherapy program developed based on McKenzie and Williams therapy was performed individually three days per week for 20 sessions. Therefore, the study compared a hydrotherapy group (based on McKenzie and Williams therapy) to a control group. Participants attended a hydrotherapy program under the supervision of a hydrotherapist. Numeric Pain Rating Scale (NPRS), Roland-Morris Disability Questionnaire (RMDQ) and Straight Leg Raise Test (SLRT) were measured at the beginning, middle and at the end of the 20 sessions to determine pain and functional of the patient's improvement. **Results:** Overall, NPRS, RMDQ and SLRT scores were improved in hydrotherapy group in 10th session and 20th session compared with baseline ($p \leq 0.001$) and control group ($p \leq 0.001$). No difference in the treatment variables between the 10th session and the 20th session was observed ($p > 0.05$). **Conclusions:** The results indicated that the NSLBP symptom was improved after 10 sessions of hydrotherapy program developed based on McKenzie and Williams therapy.

Keywords: Pain; Therapy; Disability; Health.

63 INTRODUCTION

64 Low back pain (LBP) is one of the most common conditions that impair individuals'
65 functional capacity in activities of daily living and at work, as well as their general health and
66 quality of life [1]. LBP is also responsible for significant part of the demand for health services and
67 is a multidimensional phenomenon involving psychosocial, behavioral and pathophysiological
68 processes [2]. So, since it is a disabling condition with high costs both for individuals and the
69 society, it represents an important global and socioeconomic problem [3]. Many patients also want
70 faster return of functional abilities and reduced pain for economic reasons [4].

71 Many therapies have been used for the treatment of LBP such as drug therapy, laser therapy,
72 ozone therapy, dry-land exercise, ultrasound, chiropractic, hydrotherapy and finally surgery [5]; but
73 the objectives are the same: pain control, disability prevention and resuming of suppressed daily
74 activities and of work [6].

75 Hydrotherapy an increasingly popular form of physiotherapy treatment for a large variety of
76 conditions likes subacute and chronic LBP. Hydrotherapy is defined as a pool therapy program
77 designed for individuals to improve neuromuscular and musculoskeletal functions, which is
78 conducted and supervised by qualified personnel ideally in a specifically built hydrotherapy pool
79 [7]. Effects of unique properties of the water (buoyancy, resistance, flow and turbulence) allow the
80 performance of movements which are normally difficult or impossible on land [4,8].

81 Applying an appropriate treatment is important given the duration of flares and the relapses
82 rate. Therefore, this study will explore the two most widespread methods, Williams and
83 McKenzie which is simulated in water. Mackenzie and Williams are two methods of exercise
84 therapy that have a favorable effect on some passive therapy methods. Because it is unpleasant due
85 to training in therapeutic or sports treatment environments as well as dry-land exercises, some of
86 which have muscle weakness and have to perform therapeutic exercise in the face of gravity. For
87 this reason, we proposed a simulated method in water [9,10]. Since aquatic therapy is safe, well-
88 tolerated, and an enjoyable form of exercise produced improvement in disability and quality of life

of the patients with LBP, the aim of this study is to evaluate the efficacy of hydrotherapy method-based McKenzie and Williams on chronic back pain by conducting a randomized controlled trial. Accordingly, we hypothesized that 20 sessions of hydrotherapy protocol has a positive effect on pain intensity scale and disability in patients with NSLBP.

METHODS

Ethical approval

The research was approved by local ethical committee of Imam Khomeini International University (ref. no: 11596).

Participants

This study was a semi experimental pretest-posttest with a control group. Twenty-eight patients suffering from subacute and chronic non-specific LBP (16 men and 12 women, age: 42.5 ± 7.0 yrs, height: 173.2 ± 8.0 cm, weight: 72.5 ± 9 kg, and BMI: 24.3 ± 2.0 kg.m⁻²), who were not familiar with either McKenzie's or William's exercises, volunteered to participate in this study. The sample size was estimated based on G power software (G-Power for Windows, Version 3.1, Duesseldorf, Heinrich-Heine University) with a statistical power of 95%, effect size of 0.5 and alpha of 0.05, 26 subjects estimated [11]. To compare an hydrotherapy group (based on McKenzie and Williams therapy) to a control group, the participants were divided into two equal groups by Covariate-Adaptive Randomization (CAR) procedure based on the variable Numeric Pain Rating Scale (NPRS) of patients in initial evaluation. For observing the ethics, besides getting consent from all participants, it was explained that the results of the study were purely for research purposes and would be published collectively without mentioning the names of the individuals. Their participation in the study was also optional, and they could leave it at any stage.

The inclusion criteria included all patients with age 18-60 years with NSLBP for more than one year. The patients experience LBP for at least the previous 3 months; Roland-Morris Disability Questionnaire (RMDQ) score was 4 or more in patients. They performed not regularly physical exercises. MRI of lumbar spine were performed and evaluated before inclusion by radiology specialists. Disk dehydration, bulging, protrusion, extrusion and degeneration were cases involved in the study. Patients agreed to avoid physical treatments, other than trial treatments, for two

months. They did not have histories of rheumatic, neurological and congenital diseases, cognitive and nervous systems disorders, waist and hip fractures or dislocations, sacroiliac joint dysfunctions, malignancy on vertebrae and lumbar spinal stenosis. All potential participants underwent Mini Mental State Examination (MMSE) and those with a score of less than 24 were excluded [12]. Patients with increased back pain and inability to continue treatment were excluded from the research.

Procedure

Patients, upon entering the study, were evaluated by NPRS, RMDQ and Straight Leg Raise Test (SLRT) as common Provocative test. Investigators for each questionnaire and test were blinded to allocations of interventions.

NPRS is a rating scale 0-10 in which 0 means no pain and 10 means the worst pain ever experienced. Patients had their pain assessed and allocated a number from zero to ten to them [13].

The RMDQ-24 is most sensitive for patients with mild to moderate disability due to acute, sub-acute or chronic low back pain. RMDQ is a self-administered disability measure in which greater levels of disability are reflected by higher numbers on a 24-points scale [12].

Passive SLRT is one of the most commonly performed tests in clinical practice. To conduct this test, have the patient lay supine and passively elevate the fully extended leg of the affected side to 30-70 degrees. The measurements were taken by the freeware motion analysis software Kinovea (version 0.8.15, available for download at: <http://www.kinovea.org>) and and Lumix digital camera (Panasonic Corporation, Osaka, Japan). The reflective markers were attached on the major anatomical landmarks. At the moment the participant expressed the perception of LBP or leg pain, he raises the hand to camera and the angle between two assumptive lines between greater trochanter to the lateral malleolus and greater trochanter to the internal malleolus was measured [10].

Patients were randomly divided into treatment and control groups and were evaluated in three stages: initial (one day before first session), middle (10th session) and final (20th session).

Hydrotherapy sessions were conducted 3 days/week for 20 sessions based on **Table 1**. These exercises are designed based on the McKenzie and Williams methods and the exercises of the Aquatic Exercise Association (AEA) recommendation [14]. Exercises in water were administered in the hydrotherapy pool unit (water temperature range 32°C -34°C) by the researchers with the assistance of an experienced hydrotherapist (the hydrotherapist was one of the instructors and coaches of the Iranian Sports Medicine Federation) in aquatic exercise protocols.

Following a 1-week washout period (during the washout, the patients stopped any nonsteroidal anti-inflammatory drugs or any other analgesic drug that used previously), the patients were invited to the therapy sessions. Questionnaires consent and tests were obtained from all patients one day before exercise (baseline). Specific exercises were prescribed for hydrotherapy group using classical approach of warm-up, exercise-phase and cool-down principles. Warm-up and cool down phases comprised 5 min of high spot stepping 2 widths of pool walking forward, backward and sideways for hydrotherapy group [14]. The control group was followed up for a period of 20 sessions. All participants had no occupational activity during the 20 sessions of the treatment and were told to not perform bad daily habits in sleeping, sitting and standing.

Participants in hydrotherapy group follow the two hours pain rule. If pain was higher than normal two hours after exercising (might indicate overexertion), the exercise should be less intense in the next session according to the AEA instructions [14,15]. Also, all functional exercises were performed in the ROM up to pain threshold and when the sensation pain started, one would either stop exercising or increase ROM.

Hydrotherapy method-based McKenzie and Williams

In the Williams's method, the purpose was to reduce pain and to ensure stability of the lower trunk by toning the abdominal muscles, buttocks and hamstrings, altogether with the passive extent of hip flexors and sacrospinalis muscles [10]. A vicious circle of mechanical overloading, muscle contractions of the abdominals and of the iliopsoas, catabolic cell response, and degeneration of the water-binding extracellular matrix leading to an increase nerve root irritation in the lumbosacral

area [16]. Supine position and implementation of the Williams's protocol in stage 1 leading to relaxation of the paravertebral muscles and help to the inhibition phenomenon. In stage 2, vertical positions allow the patient to make transition painlessly with gradual loading. Finally stage 3, toning the abdominal muscles and back extensors, in orthostatism, is to achieve a neutral position of the pelvis and to create an abdominal pressure capable of taking some of the pressure placed on the lower lumbar intervertebral discs [17].

In the McKenzie's method, the purpose was based on lumbar extension exercises, and on lumbar flexion ones. These are not fixed or divided into different stages, but comply with the principle of progressivity, and their aim is centralizing pain, pain relief and regaining functionality. McKenzie believes that pain occurrence is natural because the nucleus pulposus edges are highly innervated and pressure acts like a mechanical aggression on the annulus [9,3].

The hydrotherapy program designed based on the Williams and McKenzie mechanisms involves the following stages: Stage (1) includes horizontal floating and relaxation, which relieves excess pressure on the lumbar discs, and water flow and turbulence also helps the patient to recover mentally and physically [8]. Stage (2) includes vertical floating with/without the weight cuffs are attached to the ankles which causes release to the vertebral discs and proper spacing between the vertebrae and reduced pressure on the nerve roots [6]. Stage (3) includes release the intervertebral discs in four anterior, posterior, and lateral directions that place the nucleus pulposus in position and the pressure is removed from the fibrous layers and helps to feed the disc and to restore its height by absorbing unauthenticated liquid can withstand compressive forces [10]. Stage (4) includes strengthening muscles, especially in the body's anti-gravity muscles to maintain body structure in a static and dynamic posture [15]. Stage (5) includes flexibility and mobility in different directions to affect the body's ability to function properly [4].

Statistical Analysis

Statistical analysis was performed using SPSS (SPSS for Windows, Version 19.0, Chicago, SPSS Inc, UnitedStates). Normality of the data was examined with Shapiro-Wilk test ($p>0.05$). Nonparametric methods were applied when data fell outside the normal distribution. Two-way repeated measures ANOVA were used to measure a dependent variable over three time periods (before the 1st session, after the 10th session and after the 20th session) between hydrotherapy and control groups (SLRT). Nonparametric tests (Friedman, Wilcoxon signed-rank and Mann-Whitney U tests) were used to determine whether differences existed among the over three time points and groups for categorical baseline variables and the study outcome measures. Friedman's test with Wilcoxon signed-ranks tests as a post-hoc test was applied to assess inter-group differences and Mann–Whitney U-tests were then used to examine intra-group differences for nonparametric data (NPRS, RMDQ). Statistical significance was set at $p<0.05$ and Bonferroni correction was applied to allow for multiple comparisons (**Figure 1**).

RESULTS

Demographic data were compared between the control group and the LBP group using independent t-tests and chi-square tests for scale data (e.g., age, body weight) and for nominal data (gender, NPRS, RMDQ), respectively (**Table 2**).

Each pre-measure of groups was analyzed by Mann-Whitney U test which demonstrated no significant differences between the groups with respect to NPRS ($P=0.251$), and RMDQ ($P=0.644$). Pre-measure of groups was analyzed by independent t-test which demonstrated no significant differences between the groups for SLRT ($P=0.527$).

The result of the analysis on periods (before the 1st session, after the 10th session and after the 20th session) of NPRS and RMDQ in both groups by Friedman's test with Wilcoxon signed-ranks tests as a post-hoc test indicated that the hydrotherapy group have showed a significant difference in the time series ($\chi^2(2) = 24.81$, $p < 0.001$; **Table 2**) and hydrotherapy group have a positive effect on NPRS and RMDQ in 10th session ($Z = -3.32$, $p = 0.001$) and 20th session ($Z = -3.22$, $p = 0.001$) with baseline (Figure 2). The Mann-Whitney U test showed that hydrotherapy exercises in 10th session and 20th session were significantly more effective than control group. Means and standard deviations of the measured variable are also shown in **Table 3**.

As shown in Table 3, the results of two-way repeated measures ANOVA for SLRT show that there is a significant difference within-group ($F_{2, 13} = 8.18$, $p < 0.001$) and there is a significant difference between groups ($F_{1, 26} = 9.87$, $p < 0.015$). There is no significant difference between interactions of groups and session. A Bonferroni post hoc test showed that hydrotherapy group has higher SLRT in 10th session ($p < 0.001$) and 20th session ($p < 0.001$) than baseline. Also, hydrotherapy exercises in 10th session and 20th session were significantly more effective on SLRT than control group ($p < 0.001$; **Figure 2**).

DISCUSSION

With regard to the results of this study, the hydrotherapy protocol has a positive effect on self-administered pain intensity scale and disability based on health status measure in patients with chronic LBP after 10th and 20th sessions compared to baseline. Also, this protocol can increase the range of motion (ROM) in SLRT for decrease nerve root irritation in the lumbosacral area. Based on our results, there was no significant difference between the 10th and the 20th sessions of the treatment variables.

We hypothesized that, the hydrotherapy protocol has a positive effect on pain intensity scale and disability in patients with NSLBP after the 10th and 20th sessions and based on the findings, this hypothesis was confirmed. We also hypothesized that continuing the training treatment for 20th sessions has a greater impact on reducing the patient's LBP; however, based on the findings, this hypothesis was not confirmed and no difference was found between 10th and 20th sessions of the treatment variables.

Based on our findings, hydrotherapy shows significant positive changes in the pain intensity, disability in physical functioning and reduce nerve root irritation in LBP after 10 sessions which affirms the findings of some meta analyses on exercise therapy and therapeutic aquatic exercise in management and treatment of LBP [18,19]. Authors suggested that exercise therapy and therapeutic aquatic exercise, including abdominal stabilization exercise, weight relief treatment, flexibility exercise seems to be slightly effective at pain reduction and functional improvement for chronic LBP [18].

Water immersion decreases axial loading of the spine and, through the effects of buoyancy, allows the realisation of movements that are normally difficult or impossible on land [19]. Buoyancy reduces stress on joints, muscles and enables greater range of movement via supporting the weight of the body and warm water increases muscle efficiency [14,20]. The hydrostatic pressure and depth allow the patients to perform exercise more easily. Water viscosity and surface tension creates resistance to all active exercises and strengthen the muscles [21]. A desired exercise

intensity can be achieved by adjusting the velocity of movement in the water [22]. Water-based physical activity enhances balance and coordination while stimulating, visual, vestibular, and perceptual systems [14]. By utilizing the unique properties of water (buoyancy, resistance, flow and turbulence) a graded exercise programme from assisted to resisted movements can be created to suit the patients' needs and function [19].

Pain has profound and wide-ranging effects on motorfunction. People who experience chronic pain have altered movement patterns [23]. Patients with chronic LBP that have lower physical activity levels had higher levels of disability [24]. LBP and disability affect the reduction of ROM in hip flexion. SLR test is neurodynamic tests that check the mechanical movement of the neurological tissues as well as their sensitivity to mechanical stress or compression in lumbosacral nerve root irritation. Abnormal neurodynamic responses and consequently symptoms in patients with chronic radiculopathy may be due to a pathomechanic problem [25]. It sounds that water exercises enhance ROM and function of the core stabilizer muscles by increasing neuromuscular coordination of agonist and antagonist muscles [15]. Sensory input from water pressure and temperature may decrease feelings of pain [22]. Exercise in water takes the weight off a painful joint while also providing greater flexibility and range of motion of the spine, enhanced and reduces stress on the back pain and also, neutralization of the gravity pressure by floating during this stretching, lumbar intradiscal pressure decreases [7].

In addition to the water features mentioned sufficiently in the literature, hydrotherapy program that had a positive effect on pain and disability reduction during 10 training sessions is probably due to the following reasons:

The patient's horizontal and vertical floating relaxes and reduces overload, discharging the weight of the patient's torso resulting in the body being in the postural correction, the body alignment along the line of gravity and maintaining posture and the neutral spine position and relaxation of vertebral muscles. Next, attaching a weight cuff to the patient's ankle and noodle in the arms creates a good stretch over the spine, which reduces disc pressure on the thecal sac, nerve

320 roots and creates the needed intervertebral distance. Isotonic movements with the weight cuff help
321 further this release in addition to strengthening the body's core muscles. In the later stages, the
322 patient exercises in various directions (flexion, hyperextension and lateral flexion) due to the release
323 of the disc, the strengthening of the muscles, especially core muscles, and enhanced balance and
324 coordination of muscle groups to stabilize the spine, spinal joint mobilization, deep tissue
325 mobilization and finally movement of the nucleus pulposus towards the central region. And it's,
326 also, called neurodynamic treatments for LBP.

327 Possible reasons for the lack of significant effects on the pain intensity and disability in the
328 second 10 sessions may be the type of exercises and the focus on these exercises on muscle
329 strength, flexibility and mobility, which emphasizes maintaining the desired condition. Although
330 this difference was not significant, it seems that the 10 sessions training program only helps to
331 reduce the pain intensity and disability effects, and the follow-up sessions help to adjust and
332 maintain the patient's good posture along with low pain and disability and there is a need to
333 continue the practice. Probably the reason for the slight improvement in LBP symptoms in the
334 control group seems to be due to resting, decrease daily activity, and stop daily bad habits in patients,
335 that's the first step in the treatment of LBP.

336 Some limitations of the present study should be highlighted. The duration of hydrotherapy's
337 exercises was short. Long-term changes due to this protocol were not examined. Our sample size
338 was relatively small to detect significant improvements in outcomes. Patients were not blinded,
339 although investigators were blinded. All participants may be somewhat interested in hydrotherapy,
340 so they would expect positive effects of hydrotherapy and report less pain intensity and disability.
341 The tests are self-administered measurement; more accurate tests such as the EMG registration may
342 be more appropriate for patients. No socio-demographic and psychological factors measurement
343 that potentially impacts on the results such as educational background, occupation or
344 socioeconomic status, fear, anxiety, stress, depression and lower self-esteem were investigated.

Also, nutrition habits were not assessed in the present study. Further fully powered studies were required to investigate efficacy and its validity.

Conclusions

Symptom of NSLBP improved by hydrotherapy program developed based on McKenzie and Williams therapy in 10 sessions. In the second 10 sessions of the training program, which focused on strength and mobility, the exercises only help to stabilize the patients' condition. According to the present study, hydrotherapy is suggested for patients suffering from chronic LBP. Hydrotherapy method-based McKenzie and Williams can be a safe and effective method for patients with chronic LBP. Therapists can use this method for specific groups and according to the patient's needs.

371 **Authors' contribution:**

372 Conceptualization, methodology and data collection: Masoud Mirmoezzi, Khadijah Irandoust,
373 Morteza Taheri

374 Writing—original draft preparation: Masoud Mirmoezzi, Khadijah Irandoust, Cyrene H'mida,
375 Morteza Taheri

376 Writing—review and editing: Khaled Trabelsi, Nesa Paryab, Achraf Ammar, Pantelis T. Nikolaidis,
377 Beat Knechtle, Hamdi Chtourou

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379 **Statement**

380 All authors read and approved the final version of the manuscript.

381

382 **Conflict of interest**

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384

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Table 1: Contents of the hydrotherapy program (main part) used in this study

The first 10 sessions
	$3 \times 1 \times 3 \text{ min}^a$	$3 \times 1 \times 3 \text{ min}^a$	$3 \times 1 \times 2 \text{ min}^a$	$3 \times 1 \times 2 \text{ min}^a$

	$3 \times 1 \times 1 \text{ min}^a$	$2 \text{ min} \times \text{PTB}^b$	$2 \text{ min} \times \text{PTB}^b$	$2 \text{ min} \times \text{PTB}^b$

	$2 \text{ min} \times \text{PTB}^b$			
The second 10 sessions
	$3 \times 1 \times 5 \text{ min}^a$	$3 \times 1 \times 5 \text{ min}^a$	$6 \text{ min} \times \text{PTB}^b$	$6 \text{ min} \times \text{PTB}^b$

	$6 \text{ min} \times \text{PTB}^b$	$6 \text{ min} \times \text{PTB}^b$	$6 \text{ min} \times \text{PTB}^b$	$6 \text{ min} \times \text{PTB}^b$

^a Sets×Repetitions×Time. ^b Time×PTB (to the Pain Threshold and Bilateral). Abbreviations: min: minutes; s: Seconds. The exercise sessions lasted about one hour. The rest between sets was 30 seconds.

485 **Table 2:** Comparison of baseline characteristics between patients in hydrotherapy exercises and
486 control groups

	Hydrotherapy (n=14)	Control (n=14)	p-value
Demographics			
Age, mean (SD)	42.99 (4.55)	39.12 (6.12)	0.068
Gender	Male:9 (64.29)	Male 7 (50)	0.071
	Female: 5 (35.71)	Female: 7 (50)	
Height, mean, cm (SD)	172.22 (6.64)	174.41 (5.87)	0.364
Weight, mean, kg (SD)	71.11 (7.54)	73.44 (5.90)	0.370
Body mass index, mean, kg/m2 (SD)	23.99 (1.84)	24.22 (2.08)	0.759
Measurement for Back pain			
Numeric Pain Rating Scale, mean (SD)	6.57 (1.02)	5.9 (1.77)	0.251
Roland-Morris Disability Questionnaire, mean (SD)	10.9 (5.52)	10.75 (5.83)	0.644
Straight Leg Test, mean, degree (SD)	38.8 (14.6)	39.4 (15.1)	0.527

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Table 3: Comparison on the mean change in the duration of before 1st season (baseline), 10th season and 20th season

Outcome variables	Baseline Mean±S.D. ^a	10 th season Mean±S.D. ^a	20 th season Mean±S.D. ^a	p-value	Effect size ^b
(1) NPRS				0.001 ^c	
Hydrotherapy group	6.57±1.02	3.79±1.37	3.43±1.55	< 0.001 ^d	0.815
Control group	5.90±1.77	5.64±1.28	5.57±0.85	0.377 ^d	
(2) RMDQ				< 0.001 ^c	
Hydrotherapy group	10.9±5.52	6.8±4.85	6.52±4.51	< 0.001 ^d	0.541
Control group	10.75±5.83	10.13±5.9	10.2±5.66	0.544 ^d	
(3) SLRT				0.015 ^e	
Hydrotherapy group	38.8±14.6	85.4±12.1	87.1±10.9	< 0.001 ^f	0.717
Control group	39.4±15.1	41.7±14.4	43.6±16.2	0.671 ^f	

^a S.D. = standard deviation of the mean.

^b Effect size is calculated by Kendall's W=X²/N(K-1).

^c p-value is calculated by Mann–Whitney U statistics for between-groups comparison.

^d p-value is calculated by Friedman statistics for within-group comparison.

^e p-value is calculated by Two-way repeated measure ANOVA between-groups comparison.

^f p-value is calculated by Two-way repeated measure ANOVA for within-group comparison

Figure 1: CONSORT flow chart indicating flow of subjects through the trial. Abbreviation: NPRS, Numeric Pain Rating Scale; RMDQ, Roland-Morris Disability Questionnaire; SLRT, Straight Leg Test

Figure 2: Comparison on the mean change in the duration between groups.