Impact of Manipulation and Exercise Therapy on Sacroiliac Joint Dysfunction

Mukesh kumar ,Ph.D research scholar JJTU University and Principal Sriganganagar college of allied health sciences

Background: The sacroiliac joint dysfunction (SIJD) has been found to be the primary culprit for lower back pain (LBP), but it is still overlooked and treated as LBP. There are no guidelines or appropriate therapeutic protocols for SIJD. Thus, there is a need for an effective treatment strategy for SIJD.

Objective: To compare exercise therapy (ET), manipulation therapy (MT), and a combination of the 2 (EMT) in terms of their effectiveness in treating SIJD.

Study Design: A comparative, prospective, single-blind randomized controlled trial.

Setting: Physiotherapy department, Tantia University, Sriganganagar, Rajasthan, India.

Methods: A total of 51 patients with lower back or buttock pain resulting from SIJD were randomly assigned to 1 of 3 study groups: ET, MT, or EMT. The ET group received posterior innominate self-mobilization, sacroiliac joint stretching, and spinal stabilization exercises. The MT group underwent posterior innominate mobilization and SIJ manipulation. Lastly, the EMT group received manipulation maneuvers followed by exercise therapy. Pain and disability were assessed at 6, 12, and 24 weeks after the interventions.

Results: All 3 groups demonstrated significant improvement in pain and disability scores compared to the baseline ($P < 0.05$). The difference among these therapeutic protocols was found to be a function of time. At week 6, MT showed notable results, but at week 12, the effect of ET was remarkable. Finally, at week 24, no significant difference was observed among the study groups.

Limitations: A major limitation of the present study is lack of a control group receiving a type of intervention other than the experimental protocols. Another limitation is the short duration of follow-ups.

Conclusions: Exercise and manipulation therapy appear to be effective in reducing pain and disability in patients with SIJD. However, the combination of these 2 therapies does not seem to bring about significantly better therapeutic results than either approach implemented separately.

sacroiliac joint dysfunction (SIJD) is pain in the lower back caused by alteration in the normal joint motion ascribable to hypomobility or hypermobility (1). SIJD has been found to be the primary cause of lower back pain (LBP) in 15 to 40% of patients (2-6). Pain in the sacroiliac joint (SIJ) region can additionally cause groin and thigh pain. Tenderness in the SIJ upon palpation is a reliable sign that the SIJ is the source of pain (6). SIJ functionality is affected by different pathological changes, the commonest of which seem to be related to biomechanical inefficiencies (7).

Standard physical therapy interventions can be employed to correct the underlying pathology and to alleviate the symptoms in SIJD. Such interventions in- clude repetitive exercises, manual joint mobilization, manipulation, sacroiliac belts, massage, patient edu- cation, aerobic conditioning, and electrotherapeutic modalities (6,8-9).

Although exercise therapy is provided as a valu- able method in LBP treatment (10-14), few studies have been concerned with the efficacy of this option in SIJD. Moreover, manipulation has some therapeutic effects such as stretching of the soft tissues around the joint, improving range of motion, reducing edema and muscle spasm, correcting joint defects, and controlling pain (15,16).

In spite of the high prevalence of SIJD, there are no guidelines or appropriate therapeutic protocols for this syndrome. Physicians usually refer to it as LBP only. In- deed, SIJD is still overlooked as a potential contributor to LBP. Furthermore, only a few studies have sought to compare the effectiveness of different therapeutic mo- dalities (6,17). This motivated us to evaluate supportive care by comparing the effects of exercise therapy and manipulation on pain intensity and disability in patients with SIJD in Iran. Moreover, this trial aimed to provide a more detailed insight into the short- and long-term effects of the 3 treatment choices under investigation on the clinical features of SIJD.

Methods

This study was conducted as a single-blind random- ized controlled trial (i.e., where the data analyzer was blind to the study) with 6-, 12-, and 24-week follow-ups in the Sports Medicine Department of Rasoul Akram Hospital in Tehran during the period spanning De- cember 2013 to February 2016. Patients with LBP were recruited from musculoskeletal clinics of Rasoul Akram Hospital. The patients who met the following criteria were included in the study: LBP or buttock pain last- ing for at least 3 months, age over 20 years, no history of spine and hip surgery in the year prior to the study, no pregnancy, no osteoporosis (T-score < 2.5 in bone densitometry) or bone fractures, no pain radiating below the knees, not receiving physical therapy in the lower back and buttocks over the preceding 3 months, non-injection of corticosteroids or anesthetics in the SIJ during the previous month, absence of sacroileitis or sacroiliac infection, and testing positive in at least 3 of the following:

- Gaenslen’s Test
- Standing Forward Bending Test
- Patrick’s Test
- Gillet Test
- Yeoman’s Test

- Thigh Trust Test and other sacroiliac tests.

The participants were excluded if they had intensi- fied pain, were involved in other treatments for pain relief, and discontinued the intervention protocol for any reason.

The 56 eligible patients were divided into 3 groups. The written informed consent of all the patients was obtained prior to inclusion in the study. The computer-generated randomization was applied by a staff member blind to the study. Of the total number of eligible patients, 19 were allocated to the “exercise therapy” (ET) group, 18 to the “manipulation therapy” (MT) group, and 19 to the “exercise plus manipulation therapy” (EMT) group. All the patients were requested not to receive other treatments for 24 weeks.

Study Protocol

The patients in the ET group were instructed by a sports medicine specialist how to perform the exercises at home on a daily basis. They were also asked to visit the hospital once a week until week 12 for supervised exercises. After that, they did not perform exercises until week 24. The exercises were posterior innomi- nate self-mobilization, sacroiliac joint stretching, and spinal stabilization. A brief description of each exercise follows.

1) Self-mobilization Exercises

Posterior innominate self-mobilization was done in a supine position. The patient grasped behind the flexed knee and gently moved it toward the trunk. This exercise rocked the innominate in a posterior direction.

2) Sacroiliac Joint Stretches

These exercises were performed in both right side- lying and left side-lying positions. The patient was in the side-lying position, with the upper hip being flexed 70 to 80 degrees and the knee flexed about 90 degrees. The patient’s trunk was then rotated toward the upper side as far as was comfortable. The patient was instruct- ed to lift the top leg into hip abduction and internal rotation and resist the researcher or the partner for 5 seconds. The patient was instructed to breathe and ex- hale as the trainer gently over-pressured the trunk rota- tion. The patient was then instructed to relax the hip and leg and allow the leg to drop toward the floor. As the patient relaxed, a gentle overpressure was applied to the foot as the patient was allow- ing the hip and leg to drop further to the floor. This exercise was done 5 times a day with 2 minutes of rest between the sequences.

3)Spinal Stabilization Exercises

These exercises were in four phases. Each new phase began every three weeks.

Phase 1

- Supine abdominal draw-in
- Abdominal draw-in, with one knee drawn to the chest
- Abdominal draw-in, with the heels sliding backward one after the other
- Abdominal draw-in, with both knees drawn to the chest
- Supine twist
- Prone bridging on elbows

- Side bridging on elbows
- Prone cobra
- Quadruped opposite arm-leg lift

Phase 2

- Abdominal draw-in with feet on the medicine ball plus abdomi- nal draw-in with feet on the ball and added movement
- Prone bridging on elbows with single-leg hip extension
- Quadruped opposite arm-leg lifts, with cuff or dumbbell weights

Phase 3

- Prone bridging, with the feet on the ball
- Side bridging with single-leg hip abduction
- Quadruped opposite arm-leg lifts on “half foam rollers”
- Twisting while seated on medicine ball

Phase 4

The exercises in Phase 4 were performed dynamically, meaning that the therapist threw a soccer ball-size medicine ball to the pa- tient who was trying to stay in the position pertinent to the exercises in Phase 3.

It should be noted here that each exercise was to be repeated 10 times a day.In the MT group, 2 manual maneuvers of posterior innominate rota- tion were implemented: i.e., posterior innominate mobilization and SIJ manipulation as shown in Figs. 1 and 2,, respectively. It is to be noted that the former is low-velocity and low-amplitude, while the latter is high- velocity and low-amplitude. The maneuvers were performed in the first session by the sports medicine specialist with 8 years of experience in manipulation. Immediately afterward, the Standing Forward Bending Test (18) and Gillet Test (19) were administered, with the negative results indicating the effectiveness of the manipulation for rotating innominate posteriorly. In the case of positive results, both maneuvers were repeated immediately, and then the aforementioned tests were administered again. If the test results were still positive, the respec- tive patients were excluded. The patients testing nega- tive were asked to refer back to the therapist at the designated follow-up times.

In the EMT group, first the manipulation maneu- vers depicted in Figs. 1 and 2 were performed. If these maneuvers proved effective, the exercises for the ET group were taught to the patients, who were asked to do the prescribed exercises at home on a daily basis. They were additionally requested to visit the hospital once a week until week 12 to receive supervised exer- cises. Following this period, they were asked to only perform unsupervised home-based exercises until week 24.

Outcome Measures

The outcomes were pain and functionality. These were evaluated both subjectively and objectively be-fore the treatment and at 6, 12, and 24 weeks. Sub- jectively, pain was evaluated using the Visual Analog Scale (VAS), and functionality was assessed using the Oswestry Disability Index (ODI) and the Roland-Morris Back Pain Questionnaire. The reliability and validity of the Persian version of the functionality questionnaires has been confirmed in the literature (20). Functionality was also objectively evaluated via the “timed up and go” and “self-paced walk” tests (21).

Statistical Analysis

Data analysis was performed using SPSS 23 (IBM Corporation, NY, USA, 2015). The normality of the distribution of the continuous variables was determined using the Shapiro-Wilk test. The data pertinent to these variables are shown as either mean ± SD or median, as appropriate. The categorical variables were analyzed using the chi-squared test. Pretreatment differences among the 3 groups were determined using ANOVA. Repeated-measures analysis was used for evaluating the time effect in the follow-ups. To determine the treatment effect, the data were analyzed using either a random effects mixed model or a generalized estimat- ing equations model, as appropriate. The Tukey's test was used for pairwise comparisons of the study groups. To assess the intra-tester reliability of objective tests, 10 healthy subjects had repeated measurements 7 days apart in a pilot study. The test-retest reliability of the "timed up and go" and "self-paced walk" tests was assessed using interclass correlation coefficients (ICC) at the 95% confidence level. The ICCs between the first and second measurements were 0.90 and 0.95 for "timed up and go" and "self-paced walk" tests,respectively.

For all tests, statistical significance was set at an α level of < 0.05 (2-tailed).

Results

Of the 56 patients who met the inclusion criteria,51 patients were subjected to the final assessment, equaling a dropout of about 9%. More particularly, 2 patients in the ET group were excluded because of their irregular visits and failure to do home-based exercises at weeks 12 and 24. In addition, 1 patient in the MT group refused to complete the study protocol due to the disappearance of pain. Finally, 2 patients in the EMT group preferred to try other treatments since there was no improvement in their pain. Therefore, ultimately 17 patients remained in each group for analysis .

Of the 51 patients being analyzed, 12 (23.5%) were men and 39 (57.6%) women. Gender distribution was not significantly different from 1 group to another (P= 0.28).

The mean age of the patients was 46.8 years (rang- ing 23-60 years). There was no statistically significant difference in age distribution among the 3 groups (P= 0.22).

The mean weight of the participants ranged from 51 to 98 kg. No significant differences were noted in weight distribution between the study groups (P = 0.84).

Following the classification developed by the American College of Sports Medicine, a moderate physical activity of less than 90 minutes per week was deter- mined as an activity factor of less than 1.5 (22). Sixty- two percent of the patients had this rating. In terms of physical activity, the statistical difference among the 3 groups did not reach significance (P = 0.76).

Table 1 presents the time effect of the 3 interven- tional methods. For all groups, the subjective measures showed significant improvement in each follow-up compared to the baseline (P < 0.001). However, the ob- jective measures revealed dramatic improvement only until week 12.

Table 2 compares the study groups in terms of the outcome parameters measured at 4 points in time. As the table shows, except for the ODI, there was no sta- tistically significant difference among the 3 methods at baseline. At week 6, MT showed a higher score than the other two methods, and at week 12, ET yielded better results. However, at week 24, there was no significant difference among the 3 methods.

The Tukey's Pairwise Analysis Results

ET vs. MT

All the outcomes in the MT group were better than in the ET group at week 6. However, at weeks 12 and 24, ET was as effective as MT in two of the parameters (i.e., the objective functional tests) (P < 0.001) and more effective in terms of the other parameters (P = 0.024).

Table 1. The time effect of the 3 interventional methods as demonstrated by the outcome measures of the study.

	Baseline	Week 6	Week 12	Week 24	Treatment effect
Pain (VAS)					
ET	5.5	3.64	0.35	2.23	
MT	4	0.64	2.47	2.82	<0.001
EMT	4.7	2.35	0.47	2.64	
ODI					
ET	28.52	23.52	11.17	19.64	
MT	23.58	11.94	20.17	22.17	<0.001
EMT	28.52	18.47	12.17	22.11	
Roland-Morris					
ET	9.52	7.41	1.35	3.58	
MT	6.64	1.47	5.35	6.05	<0.001
EMT	10.12	4.17	1.64	4.41	
Timed up and go					
ET	12.58	12.11	10.35	11.76	
MT	11.7	10	11.05	11.52	0.087
EMT	11.88	10.7	9.58	11.7	
Self-paced walk					
ET	25.17	24.35	22	24.05	
MT	24	21.94	23.17	23.41	0.139
EMT	26.29	24.58	23.11	23.35	

Table 2. A comparison of the study groups in terms of the outcome parameters measured at 4 points in time.

Variable	ET	MT	EMT	P value
Pain (VAS)				
Baseline	5.52	4	4.7	0.064
Week 6	3.64	0.64	2.35	< 0.001
Week 12	0.35	2.47	0.47	< 0.001
Week 24	2.23	2.82	2.64	0.037
ODI				
Baseline	28.52	23.58	28.52	0.006
Week 6	23.52	11.94	18.47	< 0.001
Week 12	11.17	20.17	12.17	< 0.001
Week 24	19.64	22.17	22.11	0.075
Roland-Morris				
Baseline	9.52	6.64	10.12	0.063
Week 6	7.41	1.47	4.17	< 0.001
Week 12	1.35	5.35	1.64	< 0.001
Week 24	3.58	6.05	4.41	0.066
Timed upand go				
Baseline	12.58	11.7	11.88	0.451
Week 6	12.11	10	10.7	< 0.001
Week 12	10.35	11.05	9.58	0.053
Week 24	11.76	11.52	11	0.544
Self-paced walk				
Baseline	25.17	24	26.29	0.114
Week 6	24.35	21.94	24.58	0.01
Week 12	22	23.17	23.11	0.395
Week 24	24.05	23.41	23.35	0.164

ET vs. EMT

No significant difference was observed between the ET and EMT groups in all measures at weeks 12 and 24 (P > 0.05). However, at week 6, EMT proved more efficient than ET in subjective tests, VAS, and the objec- tive test of "timed up and go" (P = 0.032).

MT vs. EMT

Adding exercise therapy to manipulation did not reduce the intensity of pain (P = 0.123). However, the EMT group produced better results than the MT group in terms of Roland-Morris score at weeks 4 and 12 (P = 0.024), ODI at weeks 4 and 24 (P = 0.023), and function- ality objective tests at weeks 12 and 24 (P < 0.001).

Discussion

To the best of our knowledge, this work is one of the first studies comparing different therapeutic mo- dalities for SIJD in Iran. The results showed that all the 3 methods (i.e., ET, MT, and EMT) can reduce pain and disability compared to the baseline. It is noteworthy that this positive effect persisted for 24 weeks in the subjective tests and for 12 weeks in the objective tests although the results from the objective tests are more valid to the researchers. A possible explanation for the more enduring results of the subjective tests is that a rewarding experience with the tests made the patients answer the questions favorably.At week 6, MT yielded better results than ET in terms of pain relief, showing the quicker positive ef- fect of the former. This could be due to its analgesic effect, either from structural (23-25) or neurological processes (26,27). Another plausible explanation is the antispasmodic effect of manipulation as confirmed by Orakifard et al (15). The quick onset of MT results in this study echoes the findings of Kristin and colleagues (28), who demonstrated the positive role of 4 manual high- velocity and low-amplitude techniques in reducing pain and disability in patients with SIJD over a period of 2 weeks. A previous study of the authors of this study (16) showed that 2 high-velocity and low-amplitude tech- niques of posterior innominate rotation followed by daily low-velocity and low-amplitude self-mobilization techniques for 1 month could improve pain and func- tionality in the patients with SIJD.

In line with the present study, Hidalgo's (29) sys-tematic review demonstrated moderate to strong evi- dence supporting the greater utility of manipulation compared to sham treatment in controlling chronic non-specific LBP in the short run. Similarly, another systematic review, by Ruddock (30), supported the positive effect of spinal manipulation on chronic non- specific LBP compared to sham therapy. On the other hand, another systematic review by Assendelft et al (31), suggests that manipulation is not particularly more beneficial than other conventional methods like exercise therapy, needling, and analgesics in treating chronic LBP; however, this later review suggests that manipulation is more effective in controlling pain in acute LBP.

In a review of the studies into the effect of ma- nipulation on acute LBP, Chaitow (32) approves of the findings of Assendelft et al's (31) study and argues that it is not reasonable to dismiss spinal manipulation as a clinical treatment option for acute LBP.

In our study, after week 6, MT was not superior to ET in treating chronic LBP, and indeed it was less effec- tive. The possible reason why MT was more effective at week 6 was explained above.

At week 12, ET showed better outcome than the other treatment modalities, confirming that ET takes more time to begin to be effective because neuromus- cular adaptation in muscles needs at least 6 weeks to take place (23).

At week 24, there was no significant difference among the 3 treatment groups. This could be attributed to the fact that the effect of ET declined in the interval between week 12 and week 24, when the patients did not perform any exercise. Indeed, the sustainability of the effect of prescribed exercises depends on their continuity.

A systematic review conducted by Standaert et al(33) concluded that although various methods are used, there is hardly any evidence to support that exercise therapy and manipulation are equally effective in re- ducing chronic LBP and improving performance.

Given the positive effect of ET and MT when imple- mented alone, we expected that a combination of these 2 modalities would be more effective. However, we ob- served that EMT results were better than the outcome brought about by ET only at week 6. This is because, as already discussed, the positive effect of MT appears at week 6, but the effect of ET needs more time to appear. In other words, MT adds no extra positive effect to that of ET after week 6. However, Hidalgo's review (29) re- ported moderate evidence for the effectiveness of EMT compared to ET in terms of pain relief, improvement in functionality, and quality of life in both the short run and the long run.

As for the comparison between MT and EMT, contrary to our expectation, the EMT group did not outperform the MT group at week 6 in any of the measures. A plausible explanation for this could be that the patients in the EMT group, who received ET after MT, were not so motivated to perform ET due to the faster pain relief emanating from MT. However, at week 12, EMT yielded significantly better results than MT in all measures. Moreover, at week 24, there was no difference between MT and EMT because, as previously stated, between weeks 12 and 24, the subjects did not keep to any of the therapeutic protocols.

A comparison between the ET, MT, and EMT groups in UK BEAM (United Kingdom back pain exercise and manipulation) trial team's study (34) showed that the patients receiving exercise therapy benefited little at month 3, and nothing at month 12; those in the manip- ulation group gained little to moderate advantage at month 3, and little at month 12; and finally the patients who received both exercise therapy and manipulation improved moderately at month 3, and little at month12. According to that study, manipulation yielded bet- ter results in chronic LBP, and the authors also found that in most parameters evaluating pain and disability (i.e., Roland disability, Von Korff pain score, SF-36, and fear avoidance beliefs), the most satisfying results were observed at month 3, but those results did not persist until month 12. These findings are in line with the re- sults of the present study.

It is to be noted at this juncture that the bulk of the past research seems to have been concerned with the effect of ET on LBP (13,35-42) rather than on SIJD. With this in mind, the authors hope that the present study could be a trigger for more research into this syndrome.

Limitations

A major limitation of the present study is lack of a control group receiving a type of intervention other than the experimental protocols. Another limitation is the short duration of follow-ups.

Conclusion

The present study was aimed at comparing ET, MT, and EMT in terms of their effectiveness in treating SIJD. All 3 treatment options succeeded in relieving pain and improving functionality for a period of 24 weeks compared to baseline. Furthermore, the therapeutic effect of MT appeared more quickly (at week 6), but ET proved more effective in improving functionality at week 12. In addition, no significant difference was ob- served between ET, MT, and EMT after 6 weeks. Overall, it can be concluded that manipulation can be an effec- tive approach to reducing pain in the SIJ.

Suggestions

In the present study, we examined the combined effect of self-mobilization, SIJ stretching, and spinal sta- bilization exercises on the alleviation of SIJD symptoms. A possible avenue of research would be to study the role of exercise type in reducing pain and disability and to draw a comparison among these exercises. Addition- ally, it would be interesting to evaluate the long-term effects of different therapeutic methods.

References

1. Cohen I, Rainville J. Aggressive exercise as treatment for chronic low back pain. Sports Medicine 2002; 32:75-82.
2. O'Sullivan PB, Beales DJ, Beetham JA, Cripps J, Graf F, Lin IB, Avery A, Tucker B.. Altered motor control strategies in subjects with sacroiliac joint pain during the active straight-leg-raise test. Spine 2002; 27:E1-E8.
3. Liliang PC, Lu K, Liang CL, Tsai YD, Wang KW, Chen HJ. Sacroiliac joint pain after lumbar and lumbosacral fu- sion: Findings using dual sacroiliac joint blocks. Pain Medicine 2011; 4:565-570.
4. DePalma MJ, Ketchum JM, Saullo TR. Etiology of chronic low back pain in pa- tients having undergone lumbar fusion. Pain Medicine 2011; 5:732-739.
5. Sembrano JN, Polly DW, Jr. How often is low back pain not coming from the back? Spine 2009; 34:E27-32.
6. Al-subahi M, Alayat M, Alshehri MA, Helal O, Alhasan H, Alalawi A, Takrouni A, Alfaqeh A. The effectiveness of phys- iotherapy interventions for sacroiliac joint dysfunction: A systematic review. J Phys Ther Sci 2017; 29:1689-1694.
7. Timm KE. Sacroiliac joint dysfunction in elite rowers. J Orthop Sports Phys Ther 1999; 29:288-293.
8. Jonely H, Brismee JM, Desai MJ, Reoli R. Chronic sacroiliac joint and pelvic girdle dysfunction in a 35-year-old nulliparous woman successfully managed with mul- timodal and multidisciplinary approach. J Man Manip Ther 2015; 23:20-26.
9. Luukkainen RK, Wennerstrand PV, Kauti- ainen HH, Sanila MT, Asikainen EL. Effi- cacy of periarticular corticosteroid treat- ment of the sacroiliac joint in non-spon- dylarthropathic patients with chronic low back pain in the region of the sacroiliac joint. Clin Exp Rheumatol 2002; 20:52-54.

10. Standaert CJ, Friedly J, Erwin MW, Lee MJ, Rechtine G, Henrikson NB, Nor- vell DC. Comparative effectiveness of exercise, acupuncture, and spinal ma- nipulation for low back pain. Spine 2011; 36:S120-S130.
11. Sung PS. Multifidi muscles median fre- quency before and after spinal stabili- zation exercises. Arch Phys Med Rehabil 2003; 84:1313-1318.
12. Souza GM, Baker LL, Powers CM. Elec- tromyographic activity of selected trunk muscles during dynamic spine stabili- zation exercises. Arch Phys Med Rehabil 2001; 82:1551-1557.
13. Hayden JA, van Tulder MW, Malmivaara AV, Koes BW. Meta-analysis: Exercise therapy for nonspecific low back pain.Annals Intern Med 2005; 142:765-775.
14. Simopoulos TT, Manchikanti L, Gupta S, Aydin SM, Kim CH, Solanki D, Nampia- parampil DE, Singh V, Staats PS, Hirsch JA. Systematic review of the diagnostic accuracy and therapeutic effectiveness of sacroiliac joint interventions. Pain Physician 2015; 18:E713-E756.
15. Orakifard N, Kamali F, Mohammadi M, Piroze S. Sacroiliac joint manipula- tion effect on the pain of compression and reflex Hafman. Birjand University of Medical Sciences. 2011 18:302-311. http://idml.research.ac.ir/
16. Nejati P, Karimi F, Safarcherati A. The ef- fect of manipulation in sacroiliac joint dysfunction. Journal of Isfahan Medical School 2016; 34:1218-1224.
17. Hansen HC, McKenzie-Brown AM, Cohen SP, Swicegood JR, Colson JD, Manchikanti L. Sacroiliac joint interven- tions: A systematic review. Pain Physician 2007; 10:165-184.
18. Vincent BS, Gibbons P. Inter-examiner and intra-examiner reliability of the standing flexion test. Manual Therapy 1999; 4:87-93.
19. Meijne W, van Neerbos K, Aufdem- kampe G, van der Wurff P. Intraexam-iner and interexaminer of the Gillet Test.J Manipulative Physiol Ther 1999; 22:4-9.
20. Mousavi SJ, Parnianpour M, Mehdian H, Montazeri A, Mobini B. The Oswes- try Disability Index, the Roland-Morris Disability Questionnaire, and the Que- bec Back Pain Disability Scale: Transla- tion and validation studies of the Iranian versions. Spine 2006; 31:E454-E459.
21. Bennell K , Dobson F, Hinman R. Mea- sures of physical performance assess- ments: Self-Paced Walk Test (SPWT), Stair Climb Test (SCT), Six-Minute Walk Test (6MWT), Chair Stand Test (CST), Timed Up & Go (TUG), Sock Test, Lift and Carry Test (LCT), and Car Task. Arthritis Care Res (Hoboken) 2011; 63:350-370.
22. Swain DP, Brawner CA, Chambliss HO, Nagelkirk PR, Bayles MP, Swank AM. ACSM’s Resource Manual for Guide- lines for Exercise Testing and Prescrip- tion. Seventh edition. Wolters Kluwer, Lippincott Williams & Wilkins, Balti- more, MD, pp. 340.
23. Bogduk N, Jull G. The theoretical pa- thology of acute locked back: A basis for manipulative therapy. Man Med 1985; 1:78-82.
24. Shekelle P. Spine update: Spinal manip- ulation. Spine 1994; 6:858-861.
25. Triano J. Biomechanics of spinal manip- ulative therapy. Spine J 2001; 1:121-130.
26. Pickar J, McLain R. Responses of mecha- nosensitive afferents to manipulation of the lumbar facet in the cat. Spine 1995; 20:2379-2385.
27. Pickar J. Neurophysiological effects of spinal manipulation. Spine J 2002; 2:357-371.

28. Kirstin A, Shearar, Christopher J, Colloca A, Horace LW. Randomized clinical trial of manual versus mechanical force ma- nipulation in the treatment of sacroiliac joint syndrome. J Manipulative Physiol Ther 2005; 28:493-501.
29. Hidalgo B, Detrembleur C, Hall T, Ma- haudens PH, Nielens H. The efficacy of manual therapy and exercise for differ- ent stages of non-specific low back pain: An update of systematic reviews. J Man Manip Ther 2014; 22:59-74.
30. Ruddock J K, Sallis M H, Ness A, Perry R E. Spinal manipulation vs sham ma- nipulation for nonspecific low back pain: A systematic review and meta-analysis. J Chiropr Med 2016; 15:165-183.
31. Assendelft WJ, Morton SC, Yu EI, Sut- torp MJ, Shekelle PG. Spinal manipula- tive therapy for low back pain. Cochrane Database Syst Rev 2004; 1:CD000447.
32. Chaitow L, Comeaux Z, Dommerholt J, Ernst E, Gibbons P, Hannon J, Lewis D, Liebenson C. Efficacy of manipulation in low back pain treatment: The validity of meta-analysis conclusions. J Bodyw Mov Ther 2004; 8:25-31.
33. Standaert CJ, Friedly J, Erwin MW, Lee MJ, Rechtine G, Henrikson NB, Norvell DC. Comparative effectiveness of exer- cise, acupuncture, and spinal manipu- lation for low back pain. Spine (Phila Pa 1976) 2011; 36:S120-S130.
34. UK BEAM Trial Team. United Kingdom back pain exercise and manipulation (UK BEAM) randomised trial: Cost ef- fectiveness of physical treatments for back pain in primary care. BMJ 2004; 329:1381.
35. Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain: A motor control evaluation of transverses abdominis. Spine 1996; 21:2640-2650.
36. Rainville J, Hartigan C, Martinez E, Limke J, Jouve C, Finno M. Exercise as a treatment for chronic low back pain. Spine J 2004; 4:106-115.
37. Smidt N, de Vet HC, Bouter LM, Dekker J, Arendzen JH, de Bie RA. Bierma. Ef- fectiveness of exercise therapy: A best- evidence summary of systematic re- views. Aust J Physiother 2005; 51:71-85.
38. Mior S. Exercise in the treatment of chronic pain. Clin J Pain 2001; 17:S77-S85.
39. Cohen I, Rainville J. Aggressive exercise as treatment for chronic low back pain. Sports Med 2002; 32:75-82.
40. Turk DC, Dworkin RH, Allen RR, Bellamy N, Brandenburg N, Carr DB, Cleeland C, Dionne R, Farrar JT, Galer BS, Hewitt DJ, Jadad AR, Katz NP, Kramer LD, Man- ning DC, McCormick CG, McDermott MP, McGrath P, Quessy S, Rappaport BA, Robinson JP, Royal MA, Simon L, Stauffer JW, Stein W, Tollett J, Witter J. Core outcome domains for chronic pain clinical trials: IMMPACT recommenda- tions. Pain 2003; 106:337-345.
41. Koumantakis GA, Watson PJ, Oldham JA. Trunk muscle stabilization training plus general exercise versus general ex- ercise only: Randomized controlled trial of patients with recurrent low back pain. Phys Ther 2005; 85:209-225.
42. Ghiasi F, Mehraeen M. The effect of William's exercise on non-specific and chronic referral low back pain. J Kerman- shah Univ Med Sci 2009; 12:330-342.